

CARBON FOOTPRINT REDUCTION STRATEGIES FOR HOSPITALITY INFRASTRUCTURE



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Bentham Books

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ISBN (Online): 979-8-89881-381-9

ISBN (Print): 979-8-89881-382-6

ISBN (Paperback): 979-8-89881-383-3

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First published in 2026.

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CONTENTS

FOREWORD	i
PREFACE	ii
LIST OF CONTRIBUTORS	iv
CHAPTER 1 NANOTECHNOLOGY IN SUSTAINABLE TOURISM AND HOSPITALITY: REDUCING CARBON EMISSIONS AND ADVANCING ENVIRONMENTAL CONSERVATION	1
<i>Mohammad Badruddoza Talukder</i>	
INTRODUCTION	2
Objectives	3
Theoretical Overview	3
<i>Nanotechnology in Reducing Carbon Emissions in Tourism and Hospitality</i>	3
<i>Eco-friendly Practices Promotion with Advanced Nanomaterials</i>	4
<i>The Prospects of Nanotechnology in Sustainable Tourism Models</i>	4
CARBON NANOTUBES [CNTS] AND THEIR ROLE IN THE MITIGATION OF CARBON EMISSIONS	5
Sustainable Construction & Transportation	5
NANOPARTICLES OF TITANIUM DIOXIDE [TiO₂] AND THEIR ROLE IN THE MITIGATION OF CARBON EMISSIONS IN SUSTAINABLE TOURISM AND HOSPITALITY	6
Titanium Dioxide Nanoparticles	6
Benefits of Sustainable Tourism and Hospitality	6
GRAPHENE AND ITS POSSIBLE ROLE IN THE REDUCTION OF CARBON FOOTPRINTS IN SUSTAINABLE TOURISM AND HOSPITALITY	8
Application of Graphene in Solar Energy Systems	8
Graphene-based Batteries and Supercapacitors for Energy Storage	8
Effects of Carbon Dioxide Application Reductions	9
SILVER NANOPARTICLES AND THEIR POSSIBLE ROLE IN THE REDUCTION OF CARBON FOOTPRINTS IN SUSTAINABLE TOURISM AND HOSPITALITY	9
Silver Nanoparticles in Water Purification Systems	9
Energy Efficiency and Reduced Carbon Footprint	10
Sustainable Water Management	10
QUANTUM DOTS NANOPARTICLES AND THEIR POSSIBLE ROLE IN THE REDUCTION OF CARBON FOOTPRINTS IN SUSTAINABLE TOURISM AND HOSPITALITY	11
Quantum Dots	11
Quantum Dots in LED Lighting	11
Savings in Energy and Reduction of Emissions from Carbon	11
Conceptual Framework	12
Findings	14
DISCUSSIONS	14
RECOMMENDATIONS	15
CONCLUSION	16
FUTURE STUDIES	16
REFERENCES	17
CHAPTER 2 EVOLUTION OF SOLID WASTE MANAGEMENT: FROM DISPOSAL TO SUSTAINABILITY IN REDUCTION OF CARBON FOOTPRINT	23
<i>Krishan Arora</i>	

INTRODUCTION	24
SYSTEM OF SOLID WASTE MANAGEMENT	25
SOLID WASTE CATEGORIZATION AND ITS TREATMENT METHODS	27
Treatment Methods	27
GENERAL HAZARDOUS OF WASTE MANAGEMENT	28
HEALTH HAZARDOUS	28
WASTE CATEGORIZATION AND DAILY WASTE GENERATION	29
Waste Categorization	29
DAILY WASTE GENERATION	29
CHALLENGES AND OPPORTUNITIES	30
CONCLUSION	30
REFERENCES	30
CHAPTER 3 REDUCING CARBON FOOTPRINT IN THE HOSPITALITY INDUSTRY THROUGH CULTURALLY ROOTED STRATEGIES: LESSONS DERIVED FROM VISHWAKARMA VASTUSHASTRAM	32
<i>Abhishek Kumar, Arnab Gantait and Prama Chatterjee</i>	
INTRODUCTION	33
RESEARCH OBJECTIVES	34
METHODOLOGY	35
BACKGROUND OF THE STUDY	35
Global Impact of Greenhouse Gas Emissions	35
Tourism and Its Environmental Footprint	35
Challenges in Hospitality Infrastructure Development	36
INTRODUCTION TO VISHWAKARMA VASTUSHASTRAM	37
Definition and Origins of Vastushastram	37
Foundational Contributors of Vastushastram	37
Scientific and Practical Relevance of Vastushastram	37
Philosophical and Psychological Aspects of Vastushastram	38
Vastushastram and its Relevance to Sustainability	38
FINDINGS	39
Building Infrastructure Development Principles of Vastushastram	39
<i>The Principle of Orientation</i>	39
<i>The Principle of Site Planning</i>	39
<i>The Principle of Measurement of Building</i>	40
<i>The Principle of Six Canons of Vedic Architecture</i>	40
<i>The Principle of Building Aesthetics</i>	40
Environmental Principles of Vastushastram	40
<i>The Principle of Geometrical Pattern</i>	40
<i>The Principle of Sunlight</i>	41
<i>The Principle of Magnetic Poles</i>	41
<i>The Principle of Geopathic Zones</i>	41
<i>The Principle of Concentric Zones</i>	41
Vastushastram and Sustainable Development of Building Infrastructure	42
Findings from Vastushastram Principles for Sustainable Hospitality Building Infrastructure Development	43
<i>Practical Implications for Material Usage</i>	43
<i>Practical Implications for Design Efficiency</i>	43
<i>Practical Implications for Harmonizing with Nature</i>	44
<i>Insights into Resource Optimization and Environmental Considerations</i>	44
RECOMMENDATIONS FOR THE HOSPITALITY INDUSTRY	44

Application of Spatial and Material Principles for Hospitality Infrastructure	44
Sustainable Material Selection and Waste Management Strategies	45
Integrating Ancient Sustainable Principles into Day-to-day Operations	45
Recommendations for Incorporating Ancient Vastushastram Knowledge into Modern Hospitality Infrastructure Development Standards	46
<i>Orientation and Spatial Planning</i>	46
<i>Material Selection</i>	46
<i>Environmental Integration</i>	46
<i>Waste Management</i>	47
<i>Community and Cultural Connection</i>	47
INTEGRATION OF THE ANCIENT INDIAN KNOWLEDGE SYSTEM OF VASTUSHASTRAM INTO THE MODERN HOSPITALITY INFRASTRUCTURE DEVELOPMENT STANDARDS - CHALLENGES AND SOLUTIONS	47
Variations of Standardization and Metrics	48
Compatibility with Urban Settlements	48
Availability of Sustainable Materials	48
Hotel Operational Constraints	48
Knowledge Gaps and Biased Perception	48
LIMITATIONS OF THE STUDY	49
CONCLUSION	49
REFERENCES	50
CHAPTER 4 CARBON NANOTUBES FOR HYDROGEN STORAGE AND CARBON DIOXIDE CAPTURE FOR HOSPITALITY INFRASTRUCTURE DEVELOPMENT	53
<i>Kamarun Muhsina, Sarmin Rahman and Mohammad Badruddoza Talukder</i>	
INTRODUCTION	54
The Significance of Hydrogen Storage in Renewable Energy Systems	54
Importance of Carbon Nanotubes (CNTS) In Hydrogen Storage	54
Relevance of CO2 Capture in Reducing the Carbon Footprint of Hospitality Infrastructure	55
Objectives of the Chapter	55
CARBON NANOTUBES: STRUCTURE AND PROPERTIES	56
HYDROGEN STORAGE MECHANISMS IN CARBON NANOTUBES	57
INTEGRATION IN HOSPITALITY INFRASTRUCTURE	58
Applications of Hydrogen Storage and CO2 Capture in Energy Systems for Hotels and Resorts	59
Designing Eco-friendly Hospitality Spaces with CNT-Enabled Technologies	59
Reducing Emissions in Hospitality Operations Through CNT-Based CO2 Capture	59
EXPERIMENTAL TECHNIQUES FOR EVALUATING HYDROGEN STORAGE IN CNTS	60
COMPARATIVE PERFORMANCE OF CNTS WITH OTHER HYDROGEN STORAGE MATERIALS	61
CHALLENGES IN CARBON NANOTUBE-BASED HYDROGEN STORAGE	61
Hydrogen Uptake Efficiency at Room Temperature	62
Structural Stability and Durability	62
High Production Costs and Commercial Viability	62
Need for Production Efficiency and Scalability	62
STRATEGIES FOR ENHANCING HYDROGEN STORAGE IN CNTS	62
Doping CNTS with Metal Nanoparticles	62
Chemical Functionalization and Activation	62
Hybrid Materials	63
Theoretical Modeling Approaches	63

APPLICATIONS OF CNT-BASED HYDROGEN STORAGE	63
Mobile Applications	63
Stationary Energy Storage	64
Hydrogen Production and Distribution Technologies	64
MARKET READINESS FOR CNT TECHNOLOGIES IN THE HOSPITALITY	
INDUSTRY	64
COLLABORATION BETWEEN MATERIAL SCIENTISTS AND HOSPITALITY	
DEVELOPERS	65
FUTURE PROSPECTS AND RESEARCH DIRECTIONS	65
Advances in CNT Synthesis	65
Integration of CNTs with Energy Conversion Technologies	65
Large-scale Applications and Commercial Adoption	66
FINDINGS	66
CONCLUSION	66
REFERENCES	67
CHAPTER 5 INNOVATIVE NANOPARTICLE SOLUTIONS FOR CARBON FOOTPRINT	
REDUCTION IN AGRI-TOURISM AND SUSTAINABLE HOSPITALITY INDUSTRY	70
<i>Shoeb Akhter and Udwab Kundu</i>	
INTRODUCTION	71
OBJECTIVES	72
THEORETICAL OVERVIEW	73
Nanotechnology for Sustainable Development	73
Reduction of Carbon Footprints through Nanotechnology	73
Nanoparticle Applications in Energy Efficiency	73
Nanotechnology in Agritourism and Sustainable Hospitality	73
Emerging and Revolutionary Applications of Nanoparticles in the Reduction of Carbon	
Footprint	74
Nanotechnology Improved Agricultural Productivity in Agritourism	74
Water Management and Nanoparticles	75
Nanotechnology in Eco-friendly Pesticides and Fertilizers	75
Economic and Environmental Benefits of Nanoparticles in Agritourism	76
Waste Management and Nanotechnology	76
Nanoparticles in Energy Efficiency and Storage	76
Energy Efficiency and Nanoparticle Integration in Agri-tourism Venues	77
Nanoparticles in Sustainable Hospitality for Carbon Footprint Reduction	78
Budgets of the Sustainable Building Approach of Agri-tourism	79
Enhancing Energy Efficiency and Minimizing the Carbon Footprint	80
Carbon Footprint Reduction and Environmental Benefits of Nanotechnology in Agri-	
tourism	80
FINDINGS	82
DISCUSSIONS	82
Recommendations	83
CONCLUSION	83
Conceptual Framework	84
Future Studies	84
REFERENCES	86
CHAPTER 6 LOW-CARBON DINING OPTIONS IN THE HOTEL RESTAURANTS	91
<i>Manoj K. Dash</i>	
INTRODUCTION	91
What is a Food Footprint?	92

Ways to Reduce Carbon Footprint in a Restaurant May Include:	96
When Looking for Low-Carbon Dining Options in a Hotel Restaurant, the Following Tips May be Adopted	97
Here are Key Factors that Make Certain Foods “Low Carbon”	98
Environmental Sustainability	99
Improved Brand Image and Reputation	99
Cost Savings	99
Healthier Menu Options	100
Compliance with Sustainability Trends and Regulations	100
Increased Customer Loyalty	100
Support for Local Economies	100
Contribution to Global Sustainability Goals	100
PLANT-BASED PROTEINS	101
LOCALLY SOURCED VEGETABLES AND FRUITS	101
WHOLE GRAINS	101
NUTS AND SEEDS	102
SUSTAINABLE SEAFOOD	102
LOCAL AND SEASONAL HERBS	102
Here are some Examples of Low-Carbon Indian Dishes	102
Here’s Why Low-Carbon Foods can Often be More Affordable	103
<i>Minimal Processing</i>	103
<i>Local and Seasonal Availability</i>	103
<i>Less Dependence on Animal Products</i>	103
<i>Less Energy Consumption</i>	104
<i>Economies of Scale for Staples</i>	104
<i>Fewer Middlemen and Shorter Supply Chains</i>	104
<i>Longer Shelf Life of Unprocessed Foods</i>	104
<i>Government Subsidies for Staple Crops</i>	105
<i>Less Marketing and Branding</i>	105
<i>Self-Sufficiency and Community Production</i>	105
<i>Less Use of Water and Fertiliser</i>	105
<i>Here are some Effective Strategies to Educate Young People About Low-Carbon Foods</i>	106
CONCLUSION	108
REFERENCES	109

CHAPTER 7 EVOLUTION OF ELECTRIC UTILITY VEHICLES – A TRANSFORMED HOSPITALITY OPERATION FOR A SUSTAINABLE FUTURE	113
<i>Geetha Manoharan and Sanjeev Kumar</i>	
INTRODUCTION	113
HISTORY OF ELECTRIC VEHICLES	116
INNOVATION AND SUSTAINABILITY FOR HOTELS	117
TYPES OF ELECTRIC VEHICLES	118
Hybrid Electric Vehicle	119
Plug-in Hybrid Electric Vehicle (PHEV)	119
Fuel Cell Electric Vehicle (FCEV)	120
Electric Vehicle in Hospitality	121
Enable EV Charging and Services	121
ADVANTAGES OF E-VEHICLE	123
Minimize Operational Expenses	123
Minimal Maintenance Costs	123

Zero Tailpipe Emissions	123
Tax and Financial Benefits	124
Use of Fuel and Petrol is Ruining Our Earth	124
Driving Electric Vehicles is Peaceful and Straightforward	124
The Ease of Charging from Home	124
Is there any Noise Pollution?	125
DISADVANTAGES OF E-VEHICLE	125
INCENTIVES OF ELECTRIC VEHICLES IN INDIA	125
STRATEGIES ON SUSTAINABILITY	126
A Greeting with Greater Ecological Friendliness	126
Minimizing Carbon Footprints	126
Enhancing Visitor Experience	126
Moving Forward Together	126
Extending Beyond Hotel Premises	127
Economic Advantages	127
The Next Step for Travel	127
FUTURE OF ELECTRIC VEHICLES FOR HOSPITALITY OPERATIONS	127
Technological Developments	128
Government Rules	128
Building Infrastructure	128
Consumer Demand	128
Innovation in Battery Technology	128
DISCUSSION AND CONCLUSION	129
REFERENCES	130
CHAPTER 8 BOOSTING RURAL TOURISM THROUGH SUSTAINABLE WASTE	
MANAGEMENT: A STEP TOWARDS GREEN TOURISM	134
<i>Piali Haldar and Eshani SadhuKhan</i>	
INTRODUCTION	134
RURAL TOURISM	136
GREEN TOURISM	137
SUSTAINABLE WASTE MANAGEMENT: CHALLENGES AND OPPORTUNITIES	138
SUSTAINABLE WASTE MANAGEMENT [REUSE, REDUCE, RECYCLE]	140
Benefits of Sustainable Waste Management	142
CASE STUDY: SUSTAINABLE WASTE MANAGEMENT	142
Case 1: Eastern Part of the Himalayan whiz cities of Sikkim, India [Gangtok and Namchi]	142
Environmental Impact Assessed Through the Life Cycle Assessment [LCA] Methodology	143
Case 2: VMC [Vengurla Municipal Project of Waste Management]- Swachcha Bharat	
Paryatan Sthal – [Swachcha Bharat Tourism Centre]	145
VMC Zero Waste Policy [ZWP]	146
Gas Bio-methanation Project [Plant ID-PP-1]	146
Gardening and Plantation at the Waste Management Centre	146
Recommendations	147
CONCLUSION	147
REFERENCES	148
CHAPTER 9 INTEGRATING CIRCULAR ECONOMY AND CARBON FOOTPRINT	
REDUCTION: THE ROLE OF EMPLOYEE TRAINING AND MOTIVATION IN HOTELS ...	151
<i>Regy Joseph and S.Jegadeeswari</i>	
INTRODUCTION	151
CURRENT ENVIRONMENTAL CHALLENGES IN THE HOTEL INDUSTRY	152
IMPORTANCE AND PRINCIPLES OF WASTE MANAGEMENT	154

IMPACT OF EMPLOYEE ENGAGEMENT AND MOTIVATION	155
LINKING CIRCULAR ECONOMY AND CARBON FOOTPRINT INITIATIVES TO	
EMPLOYEE ENGAGEMENT AND MOTIVATION	157
WASTE MANAGEMENT AND RECYCLING PRACTICES	157
REAL-WORLD EXAMPLES OF SUCCESSFUL CIRCULAR ECONOMY AND CARBON	
FOOTPRINT INITIATIVES IN HOTEL FOOD SERVICES	158
BARRIERS TO CIRCULAR ECONOMY AND CARBON FOOTPRINT ADOPTION IN	
HOTEL FOOD SERVICES	159
The Potential Barriers to these Radical Systemic Changes are Considered in this Chapter ...	160
CURRENT ENVIRONMENTAL CHALLENGES IN THE HOTEL INDUSTRY	161
BENEFITS OF IMPLEMENTING CIRCULAR ECONOMY AND CARBON FOOTPRINT	
INITIATIVES IN HOTELS	162
CONCLUSION	163
REFERENCES	163
SUBJECT INDEX	167

FOREWORD

Greenhouse gas emissions that lead to global warming and air pollution are a major threat facing humanity, resulting from worldwide consumption of nonrenewable energy resources (such as fossil fuels).

It is high time to focus the research on the production of renewable energy and storage systems.

In this context, many devices such as supercapacitors, solar cells, fuel cells, and lithium-ion batteries are the major candidates that can ensure sustainability and energy stability for all aspects of life.

This research-oriented book provides extensive research to reduce carbon footprints, with the intention of improving the efficiency of renewable energy production and energy storage in the hospitality sector.

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PREFACE

The hospitality industry is one of the most dynamic and rapidly evolving sectors in the global economy, catering to millions of travelers and guests daily. However, its environmental footprint remains significant, with extensive energy consumption, water usage, food waste, and greenhouse gas emissions. As climate change becomes an urgent global challenge, the hospitality sector must adopt sustainable practices to mitigate its impact. This book, "Carbon Footprint Reduction Strategies for Hospitality Infrastructure," aims to provide a comprehensive guide to reducing environmental impact while maintaining operational efficiency and guest satisfaction.

The necessity for carbon footprint reduction in hospitality infrastructure stems from the industry's dependence on energy-intensive operations, including heating, cooling, lighting, and food production. Hotels, resorts, and restaurants contribute significantly to carbon emissions, necessitating innovative strategies to minimize their ecological impact. Sustainable practices are no longer an option but necessary for businesses seeking to remain competitive, comply with regulations, and enhance their brand reputation.

This book is structured to address key areas where carbon footprint reductions can be effectively implemented. It explores energy-efficient building designs, renewable energy integration, innovative waste management systems, water conservation techniques, and eco-friendly procurement practices. The role of Artificial Intelligence (AI), the Internet of Things (IoT), and other technological innovations in optimizing sustainability efforts is also discussed in depth.

Moreover, this book presents successful sustainability initiatives from leading hospitality brands worldwide, providing readers with practical insights and best practices. Policymakers, hotel operators, architects, and sustainability advocates will find valuable guidance in implementing carbon reduction strategies tailored to their specific operational needs.

As the hospitality industry moves towards a more sustainable future, collaboration between stakeholders, technological advancements, and a commitment to responsible practices will be essential. Through this book, I hope to inspire professionals and academics to contribute to transforming hospitality infrastructure into a model of environmental stewardship and innovation.

Let us embrace sustainability as a compliance measure and a strategic imperative that benefits businesses, communities, and the planet alike.

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CHAPTER 1

Nanotechnology in Sustainable Tourism and Hospitality: Reducing Carbon Emissions and Advancing Environmental Conservation**Mohammad Badruddoza Talukder^{1,*}**¹ *College of Tourism and Hospitality Management, International University of Business Agriculture and Technology, Dhaka 1230, Bangladesh*

Abstract: Among various disciplines, nanotechnology finds a new dimension to mitigate sources of carbon emissions and promote sustainability in the tourism and hospitality sectors. The chapter is based on a qualitative review of existing literature on nanotechnology and sustainable tourism from academic journals. Advanced nanomaterials-carbon nanotubes, titanium dioxide, and silver nanoparticles, contribute to damage prevention or better operational effectiveness when combined with quantum dots applications. The contribution of environmental C decreases significantly as the weight and amount of material consumed in construction and transportation decrease with CNTs because fuel consumption gets reduced. Sustainable development is brought about where greening occurs and where energy-efficient coatings reflect solar heat and contribute to improving air quality by degrading pollutants. Lessened cooling demands and the capacity for more green behaviour in tourism facilities are what these applications create. Graphene will lead towards enhanced renewable energy systems and, more specifically, improve solar panel efficiency and energy storage, allowing these establishments to become net-zero energy and entirely reduce their fossil fuel use. Clean water will be purified with little energy and chemicals at low operating costs and emissions levels. Future studies in nanotechnology concerning tourism and hospitality should be most concerned with scalability, cost barriers, and regulatory frameworks to ensure broader adoption and long-lasting impacts. High-efficiency LEDs can modernize lighting systems, reducing power consumption with no toxic materials. Therefore, all these applications complement the goals of reducing carbon footprints with those of green initiatives and sustainable tourism models. Thus, future research in nanotechnology tourism and hospitality should mainly revolve around scalability, cost barriers, and regulatory frameworks that ensure wider adoption and more enduring impacts of nanotechnology in tourism and hospitality.

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Keywords: Carbon emissions, Carbon nanotubes (CNTs), Carbon footprint, Environmental, Graphene, Nanotechnology, Nanoparticles, Quantum dots, Silver nanoparticles, Sustainable, Titanium dioxide, Tourism and hospitality.

INTRODUCTION

Tourism and hospitality are among the fastest-growing sectors in the world at present, significantly contributing to the economy and the exchange of culture [1]. However, it is the highest among environmental degradation factors, especially from high carbon emissions, exhaustive resource consumption, and waste generation [2].

This recent climate crisis has put the industry under more pressure because of the need to quickly adopt more sustainable practices and reduce environmental footprints [3]. In this challenge, numerous research studies and innovative solutions are emerging, and it is here that nanotechnology has proven very promising in advancing sustainability in tourism and hospitality [4]. This would enable the application of advanced nanomaterials as a key to achieving energy efficiency, minimizing carbon emissions, and promoting environmentally friendly practices throughout the sector [5]. Nanotechnology refers to the manipulation of matter at the atomic and molecular levels. The field application for spatial and environmental sustainability is a newly coined term with great potential [6]. Some of the most phenomenal achievements in this sector include nanomaterials such as carbon nanotubes, titanium dioxide nanoparticles, graphene, silver nanoparticles, and quantum dots [7]. These materials have unique properties, including super strength and lightweight, superior thermal and electrical conductivities, and catalytic efficiency. They are also applicable in various eco-friendly applications [8]. Nanomaterials significantly reduce carbon emissions, thereby altering the sustainability landscape in tourism and hospitality. Carbon nanotubes improve the strength-weight ratio in construction and transport, which reduces energy use and fuel consumption [9]. Titanium dioxide nanoparticles act as coatings that enhance energy efficiency and air quality by reflecting solar heat and degrading pollutants [10].

Furthermore, energy-efficient treatment includes the use of silver nanoparticles in water purification systems, efficient energy storage by graphene for utilized solar energy in hotels and resorts, and energy-efficient lighting by quantum dots within LED technology, followed by thermal insulation made through advanced nano-coatings, which reduce cooling and heating needs. Such an innovative step promotes resource-efficient approaches, reduces carbon footprints, and fosters advancements in environmentally responsible practices within the sector [11]. Nanotechnology is valuable for enhancing resource efficiency and developing

sustainable infrastructure in tourism and hospitality environments [12]. Nano-coatings can increase energy efficiency in buildings by enhancing insulation, decreasing heat loss, and lessening maintenance invasions [13]. These technologies would also be highly valuable in the development of green resorts and hotels in remote or environmentally sensitive regions, where direct construction methods could damage ecosystems. Winter winds of change will blow freshly into the face of the national tourism milieu. Nanotechnology stands at the new frontier of transformation, and the tourism and hospitality industry has a unique opportunity to tap into global sustainability objectives [14]. For example, by utilizing carbon nanotubes, titanium dioxide, graphene, silver nanoparticles, and quantum dots, the industry may reduce carbon emissions, increase energy efficiency, and adopt eco-friendly practices in the coming years [15].

Recognising the pressing demand for sustainable practices in tourism and hospitality, this chapter explores the possibilities that nanotechnology offers to mitigate environmental impact. It thus investigates how high-tech nanomaterials may curb emissions of greenhouse gases, promote environmentally sound operations in tourism establishments, and pave the way for long-term sustainable tourism. Through an exhaustive literature review, this chapter ventures into key areas nanotechnology might promote with innovation and the realization of the broader sustainability goals, and all these are relevant innovations, their respective implications, and possible future benefits. Therefore, the tourism and hospitality industry will have more than a little finger in the pie regarding its commitment to environmental conservation and resilience [16].

Objectives

1. To investigate potential applications of nanotechnology in reducing carbon emissions in tourism and hospitality.
2. To identify the ways advanced nanomaterials may further eco-friendly operations.
3. To study the implications of nanotechnological applications towards developing sustainable tourism models.

Theoretical Overview

Nanotechnology in Reducing Carbon Emissions in Tourism and Hospitality

Nanotechnology presents a novel approach to mitigating carbon emissions in the tourism and hospitality sector [17]. It presents the application of nanomaterials like carbon nanotubes [CNTs] and quantum dots for energy-saving solutions in building construction, transportation means, and lighting systems [18]. CNTs, for example, are used in lighter and more fuel-efficient vehicles and aircraft because

CHAPTER 2

Evolution of Solid Waste Management: From Disposal to Sustainability in Reduction of Carbon Footprint**Krishan Arora^{1,*}**¹ *School of Electronics and Electrical Engineering, Lovely Professional University, Phagwara, Punjab 144402, India*

Abstract: One of the biggest problems nowadays is managing solid waste, particularly in developing nations. There is a growing population there, which increases waste production, especially with regard to food-related things. It is now essential for the sustainable growth of society to handle environmental challenges like solid waste management with judgment. The improper handling of solid waste exposes residents to a number of risks. If we follow the right solid waste management procedures, the enormous amount of recyclables that is produced in India's food waste can be recovered. Solid garbage that is improperly disposed of in landfills and open dumps causes numerous issues for the environment and public health. In particular, incorrectly disposed of food waste releases methane gas, which has a 21-fold higher global warming impact than carbon dioxide. The study's primary goal is to identify the difficulties in controlling trash generation up to the recycling stage. It also looks at the viability of waste management from a technological, financial, and environmental standpoint. This chapter proposes to work on a descriptive cross-sectional study within the context of developing countries, specifically targeting Nepal and India, where growing urban populations and poor infrastructure have created significant waste management challenges. Quantitative data collection procedures will be carried out through the use of semi-structured questionnaires and will be analyzed with SPSS software. To reduce waste and educate people about the risks to their health and the environment, awareness must be raised at every level. Implementing the Monitoring and evaluating programs on waste prevention and updating the status will involve many people in many areas. Everywhere, recycling tactics will be observed. It is helpful in providing a significant amount of information about the quantity and kinds of trash produced, labor and expense, and other relevant factors.

Keywords: Challenges, Cost-benefit analysis, Food behavior, Monitoring and evaluating program, Recycling, Solid waste management.

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INTRODUCTION

Waste is an unwanted or inevitable by-product of human endeavour. The fast population growth has made garbage management one of the biggest issues, particularly in emerging nations. Due to municipal authorities' poor performance and improper performance of their tasks, India's waste management services policy and guidelines are extremely poorly structured. Disposing of rubbish has become a major issue for developing nations like India in recent times. Three ways are employed to dispose of 90% of waste: composting, incineration, and landfilling. Waste is also thrown into vacant land. The paucity of landfills, rising population, and financial constraints make landfilling an inappropriate method. The annual production of around 22,000 tons of air pollutants from burning solid trash at open dumps exposes people directly to harmful levels of pollution. Because leachate is produced at poorly maintained landfill sites, groundwater becomes contaminated. The second technique is incineration; both the people and the environment are at risk from both procedures [1]. Finally, composting is thought to be a better way to manage garbage, but in developing nations, large-scale composting facilities have failed since there aren't enough straightforward scientific techniques. After analysis, it was determined that none of these methods would be effective in managing solid waste. Trash disposal through recycling is a technique that can be expensive and have an effect on our country's economy. Activities like gathering, moving, processing, discarding, recycling, and keeping an eye on waste products are all included in waste management [2].

In an integrated system, waste disposal is especially important for solid waste. Priority should be given to recycling and trash minimization. The collection of rubbish until it is separated is the local government's responsibility. Waste can be divided into four categories: compostable, reusable, non-biodegradable, and biodegradable. Since waste management has grown to be a global concern and a political priority, it is necessary to ascertain its current state. We encounter numerous obstacles in our quest to ensure sustainability in waste management on a worldwide scale [3]. It is necessary to create Sustainable Development Goals (SDGs). In order to achieve the SDGs on a global scale, specific activities must be taken. There is a connection between garbage and the climate. Major environmental issues are now present in Indian cities [4]. A lot of solid garbage is dumped in open spaces, which will worsen environmental problems and put locals in danger. Generating, storing, collecting, transferring, processing, and disposing of MSW are standard procedures. Due to inadequate preparation, the six processes—storage, transmission, and processing—are not being followed correctly, which makes them more complex and expensive. The environment and human health are affected in many ways by careless disposal [5]. The chapter treats solid waste management practices in developing countries, with a particular

eye on Nepal and India because of their somewhat similar socio-economic and environmental challenges related to municipal waste management. Even though Nepal is not yet a benchmark in solid waste management, emerging community-based and policy-directed initiatives hold lessons for other developing countries.

Under the umbrella of urbanization and poor waste handling infrastructure, put together in the context of developing countries, this chapter emphasizes the evolution and associated modern challenges in the field of solid waste management, especially in Nepal and India. These two nations work as representatives because they undergo common socioeconomic constraints and developments in environmental concerns. By analyzing their systems, this chapter seeks to bring to light what is lacking in present-day practices regarding waste management and to point to some sustainable processes that would actually help in reducing the overall carbon footprint.

SYSTEM OF SOLID WASTE MANAGEMENT

Rapid urbanization, population expansion, poor infrastructure, and scarce resources present serious problems for Nepal's and India's solid waste management systems. Solid waste collection, transportation, and disposal are problems in both nations, which contaminates waterways, degrades the environment, and poses risks to public health. In many parts of Nepal, informal waste collection and crude disposal techniques are common, which exacerbates the issue of waste accumulation. Similar to this, a significant amount of solid waste in India goes untreated and frequently ends up in open dumps or rivers despite efforts to adopt trash segregation and recycling schemes. In order to solve this urgent problem and lessen its detrimental effects on the environment and public health, both countries are realizing more and more the significance of sustainable waste management techniques, such as neighbourhood-based programs, technology developments, and legislative changes [5].

Although Nepal's solid waste management system is developing, it still faces obstacles because of things like inadequate infrastructure and resources. This is an explanation of the many phases of a perfect solid waste management system, with an emphasis on its implementation in Nepal.

- **Waste Generation:** Every day, Nepal produces thousands of tons of solid garbage, and this number only rises as the country's population and consumption habits change.
- **Waste Collection:** In Nepal, picking up waste can be difficult, particularly in isolated regions. In cities, people can use municipal collection services or pay private waste collectors. Here, separate bins are given for recyclables,

Reducing Carbon Footprint in the Hospitality Industry through Culturally Rooted Strategies: Lessons Derived from Vishwakarma Vastushastram

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Abstract: The hospitality industry, as a rapidly growing sector, faces increasing pressure to adopt sustainable practices and reduce its carbon footprint. Given its significant energy consumption and environmental impact, sustainable infrastructure development is critical. The present study is an attempt to explore the potential of integrating traditional Indian architectural wisdom, specifically from the ancient text “*Vishwakarma Vastusastram*”, with modern sustainable building practices to address these challenges. Through a qualitative textual analysis of “*Vishwakarma Vastusastram*” and its English translations, the research identifies key principles that align with contemporary sustainable building standards, such as LEED, BREEAM, and other green certifications. The study focuses on three core aspects: sustainable material usage, efficient design, and harmony with nature. These principles emphasize the use of locally sourced, eco-friendly materials, strategic spatial alignment, and the incorporation of natural elements like green spaces and water features, which collectively contribute to reducing energy consumption and carbon emissions. The findings of this study suggest significant areas of convergence between *Vastusastram* principles and modern sustainability frameworks, offering a culturally rooted yet practical approach to sustainable hospitality infrastructure development. This article provides actionable strategies for integrating these ancient principles into modern construction, including modular designs, sustainable material substitutes, and training for stakeholders. This research highlights the relevance of traditional Indian knowledge in addressing contemporary environmental challenges, proposing a fusion of ancient and modern practices as a pathway to reducing the carbon footprint in the hospitality industry while enhancing guest satisfaction and operational efficiency.

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Keywords: Carbon footprint reduction, Hospitality industry, Indian knowledge systems, Sustainable infrastructure, Vishwakarma vastusastram.

INTRODUCTION

Global warming has become a persistent global issue that demands a significant reduction in the carbon footprint [1]. The hospitality industry is an emerging industry that is expected to reduce its carbon footprint and incorporate sustainable practices during infrastructure development and operations management. The infrastructure of a hospitality unit plays a crucial role in determining its energy consumption and environmental impacts [2]. Traditional knowledge found in Indian Knowledge Systems, such as ancient texts like “Vishwakarma Vastushastram”, encapsulates valuable practices and lessons for architectural practices. In this study, the researchers use a qualitative approach through textual analysis of “Vastushastram” texts while focusing on the original text and scholarly research articles that highlight sustainability lessons mentioned in the “Vastushastram”. Further, the researchers have tried to explore how these ancient principles can be adapted to modern hospitality infrastructure development and make recommendations for developing strategies to facilitate the integration of the ancient Indian Knowledge System of Vastushastram into future hotel building infrastructure. The research aims to discover sustainable infrastructure concepts in “Vishwakarma Vastushastram”, identify key principles that align with sustainable building practices, and propose actionable strategies for reducing the carbon footprint of the hospitality building infrastructure. Findings from the textual analysis suggest that Vastushastram principles are relevant to modern hospitality infrastructure developments, and their adaptation can be facilitated by focusing on three major aspects: material usage, design efficiency, and harmony with nature during the construction of future hospitality building infrastructure.

“Vastushastram” principles emphasize the use of locally sourced sustainable construction materials and incorporating natural elements in building infrastructure design that promises to reduce non-renewable energy consumption in hospitality infrastructure development and operation, spatial alignment, and strategic placement of areas based on human activities in alignment with cardinal directions to maximize residents' satisfaction and overall well-being [3]. The present study provides information about the practical implications of the “Vastushastram” principles in future hotel development projects, such as adding green spaces, open areas, and water features, and repurposing construction materials in landscaping and other purposes to ensure sustainable infrastructure development and hospitality operation while maximizing guest experience and satisfaction. Further recommendations are given for ensuring cost-efficient integration of Vastushastram principles with global sustainable building

infrastructure development systems like LEED (Leadership in Energy and Environmental Design), BREEAM (Building Research Establishment Environmental Assessment Methodology), EDGE (Excellence in Design for Greater Efficiencies) green building certifications, and the Building Resilience Index (BRI) highlighting representation of Vastushastram principles of orientation, sustainable and locally sourced material usage, construction waste management strategies and integration of green spaces to capture carbon emissions supports mutual reinforcement.

In this study, the researchers have also identified several key challenges. These included differences in traditional building infrastructure measurement metrics and contemporary building infrastructure measurement metrics, urban development challenges, and material availability. To address these, they propose practical solutions such as adopting “Vastushastram” principles to vertical constructions, replacing traditionally prescribed natural materials with their sustainable substitutes, and using modular designs along with training and sensitization of all concerned stakeholders to facilitate seamless integration of Vastushastram principles in modern hospitality infrastructure development.

RESEARCH OBJECTIVES

The objective of the paper is to explore the ancient Indian Knowledge System of “Vastushastram” with emphasis on the following points:

1. To identify the sustainable principles for building infrastructure development in “Vastushastram”.
2. To develop guidelines for hospitality infrastructure developments based on findings from “Vastushastram”.

It must be noted that this chapter does not attempt to encourage the use of “Vastushastram” in hospitality infrastructure developments without prior investigation of ancient texts of “Vastushastram”; it only tries to explore the ancient texts of “Vastushastram” to make recommendations for sustainable development of hospitality building infrastructure. The paper emphasizes integrating lessons from ancient knowledge systems like “*Vastushastram*,” refined over centuries through experimentation and practice, to address contemporary environmental challenges. It aims to propose innovative, culturally rooted strategies that align traditional architectural wisdom with modern sustainability practices. By leveraging these time-tested principles, the research seeks to mitigate the environmental risks associated with modern hospitality infrastructure. The ultimate goal is to foster harmony between tradition and sustainability, offering practical solutions that reduce carbon footprints while promoting

CHAPTER 4

Carbon Nanotubes for Hydrogen Storage and Carbon Dioxide Capture for Hospitality Infrastructure Development

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Abstract: The tourism and hospitality industry faces growing pressure to adopt environmentally friendly practices, particularly in energy use and carbon emissions. This study seeks to identify the dual role of carbon nanotubes (CNTs) in hydrogen storage and carbon dioxide (CO₂) capture as a transformative solution for hospitality infrastructure development. Hydrogen is a clean energy source that is widely known for its potential as a carrier of energy. Carbon nanotubes are a significant technological advancement for hydrogen storage and offer substantial potential due to their extraordinary properties. Keeping hydrogen storage safe remains a considerable challenge for its practical use. Carbon nanotubes have unique structural and physical properties and have been developed as a strong hydrogen storage material. This chapter presents nanotubes' role in hydrogen storage, their combination methods, and the materials that make them suitable for use. Moreover, it highlights the importance of enhancing carbon nanotube features, such as diameter, substituent, and defect density, to improve hydrogen storage capacity. For instance, single-walled carbon nanotubes perform better than multi-walled carbon nanotubes because of their higher surface area and fewer structural obstructions. Again, this chapter analyzes factors that influence storage capacity, including temperature, pressure, the distinction between physical and chemical adsorption processes, and the nanotube structure. Metal hydrides and metal-organic frameworks are used to experiment with and evaluate carbon nanotubes for hydrogen storage. Regardless of their potential, carbon nanotubes face challenges. This chapter aims to overcome these obstacles, preview future commercial uses, and conclude with the perceptions of potential developers who must overcome challenges for large-scale placement. Lastly, this chapter offers a complete description of the possible use of carbon nanotubes for hydrogen storage, mentioning their current abilities and future possibilities within the context of a sustainable energy landscape,

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and combines theoretical perspectives to examine the practical applications of economic feasibility and environmental profits of CNT technologies in reforming the hospitality industry for a sustainable future.

Keywords: Carbon, Energy, Hydrogen storage, Nanotubes, Performance, Practical use, Sustainable, Technological advancements.

INTRODUCTION

The advent of hydrogen is a key factor in the development of clean, renewable energy [1]. Hydrogen has long been known as the lightest, most ubiquitous element in the universe and a high-energy source by weight, with the promise of lower carbon emissions when used as a fuel. The good news is that hydrogen combustion does not produce water pollution, unlike combustion of fossil fuels, which produces water and other pollutants. It can integrate into energy sectors such as transportation, industry, and electricity generation [2]. Increasingly, however, as fuel cell development continues, hydrogen is a viable alternative to fossil fuels for simultaneously decarbonizing hard-to-electrify sectors. However, efficient storage methods for hydrogen have yet to be developed, thus limiting its potential as a clean energy source due to its low energy density per unit volume and the difficulties in handling and transporting it.

The Significance of Hydrogen Storage in Renewable Energy Systems

A study demonstrated that hydrogen storage plays a crucial role in supporting the use and scale of hydrogen as an energy carrier [3]. In renewable energy systems, hydrogen storage plays a dual role: it enables the efficient use of surplus energy from intermittent sources such as solar and wind, and it provides a stable, storable fuel supply for applications where direct electrification is not practical. In addition, excess renewable electricity can be converted into hydrogen through electrolysis for storage and later used to generate electricity or as a fuel to balance supply and demand. Long-term energy storage is needed for grid stability and reliability [4], and effective hydrogen storage solutions enable it. In addition, hydrogen acts as a medium of energy storage. It enables the penetration of renewables into demanding sectors such as heavy industry and long-haul transport, which have historically relied on high-energy-density fuels. The result is that constructing a resilient and sustainable energy infrastructure depends on the development of efficient hydrogen storage technologies.

Importance of Carbon Nanotubes (CNTs) In Hydrogen Storage

Due to their unique structural properties, carbon nanotubes (CNTs) have enormous potential as hydrogen storage materials [5]. These inorganic nanotubes

have a high surface area, a tubular structure, and tunable porosity, which can be used to store large amounts of hydrogen via adsorption. In contrast to typical storage techniques, such as high-pressure tanks or cryogenic storage, CNTs could enable hydrogen storage at more reasonable pressures and temperatures [6]. This trait promises a new generation of safer and more efficient hydrogen storage options for mobile applications. CNTs can also be chemically modified to improve hydrogen uptake and, as such, constitute a versatile material for optimizing storage performance. CNTs are an attractive solution to the challenges of hydrogen storage because the material can support ongoing advancements in synthesis and functionalization techniques to meet the demands of next-generation energy systems.

Relevance of CO₂ Capture in Reducing the Carbon Footprint of Hospitality Infrastructure

The significance of carbon dioxide (CO₂) capture in reducing the carbon footprint of neighborhood foundations cannot be overstated, as the sector is a significant contributor to global greenhouse gas emissions [7]. CO₂ capture advances, especially those leveraging advanced materials such as carbon nanotubes (CNTs), offer viable solutions for mitigating emissions from energy-intensive operations such as heating, cooling, and power generation. By coordinating CO₂ capture systems in hotels and resorts, the hospitality industry can effectively reduce CO₂ emissions, balance outflows, and improve indoor air quality [8]. This is not only because it aligns with global sustainability objectives but also because it meets the growing customer demand for eco-friendly housing. Moreover, embracing CO₂ capture innovations positions neighborliness businesses as pioneers in climate activity, cultivating a competitive edge while contributing to a more sustainable future.

Objectives of the Chapter

This chapter provides a comprehensive overview of the potential of carbon nanotubes for hydrogen storage, focusing on their structural properties, hydrogen adsorption mechanisms, and experimental methods for evaluating their performance. The objectives of this chapter are to:

1. Provide a comprehensive overview of carbon nanotubes' (CNTs) potential for hydrogen storage in the hospitality industry.
2. Review experimental methods used to evaluate CNT performance in the hospitality industry.
3. Identify the current challenges and limitations facing CNTs in hydrogen storage applications.

Innovative Nanoparticle Solutions for Carbon Footprint Reduction in Agri-tourism and Sustainable Hospitality Industry

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Abstract: Nanotechnology provides solutions to both the environmental and economic challenges related to agri-tourism and sustainable hospitality. This chapter addresses how nanoparticles may influence their design and application in technologies and practices promoting agri-tourism and sustainable hospitality while fast-pacing carbon mitigation and enhancing sustainability, on account of their unique characteristics: extremely high surface-area-to-volume ratio, exceptionally high reactivity, and energy efficiency. Nanoparticle applications can take place for marvelous things such as making resources highly efficient, cutting emissions, and reducing operational costs, such as providing good nano-coatings in terms of thermal insulation, nano-fertilizers that augment production, and nano-enhanced solar panels for renewable energy. Successfully utilized nanotechnology advancements include water purification, biodegradable packaging, and waste management. Although these successes have been achieved, several challenges remain, and key issues include high production costs, regulations, and uncertainties in long-term environmental impacts. This chapter critically studies the economic and environmental advantages of nanoparticle-based innovations and highlights how they will improve sustainable practices in the agri-tourism and hospitality sectors. Nanotechnology will thus help these industries to evolve towards carbon neutrality, ecosystem balance, and economic resilience by overcoming the limitations posed by research, collaboration, and policy reform. The conclusions also imply that nanotechnology is not only a means by which the environment gets preserved, but also that it can enable economic growth in several arenas and throw a bridge to a more sustainable and profitable future for the agri-tourism and hospitality sectors worldwide.

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Keywords: Agri-tourism, Agriculture, Carbon footprint, Environment, Innovation, Nano, Nanotechnology, Nanoparticles, Sustainable hospitality, Tourism.

INTRODUCTION

Nanotechnology is indeed a tool for changes in sectors that show high promise for sustainability [1]. The integration of nanotechnology in agriculture and tourism will devise newer and innovative measures of increasing demand for sustainable practices that instead support further economic growth and development [2].

Carbon footprints have recently inspired innovations across the sectors, especially agriculture and tourism. Among these, nanotechnology emerges as a leading enabler of sustainability [3]. Nanoparticles have begun to take shape as revolutionary tools to address the challenges of carbon footprints while increasing operational efficiency in agri-tourism and the hospitality sector [4].

Nanoparticles have many important roles in sustainability, such as energy efficiency, waste reduction, and reductions in emissions [5]. Nanoparticles are furthermore attuned to applications concerning energy efficiency, water conservation, waste management, or better agricultural practices because of their special characteristics. The environmental impact created by the conventional agricultural and hospitality sectors is a factor that, with a global focus, has now become a key issue of concern. In particular, these are agri-tourism and hospitality [6]. They foster economic development, but also are quite damaging to the earth concerning carbon emissions, resource deprivation, and waste generation. The type of agri-tourism is that which poises agricultural activities with tourism [7]. The idea of sustainable hospitality can be brought to reality by the very opportunity presented by using innovative technologies such as nanotechnology. One such area of interest is the applications of nanoparticles—diverse materials with self-proclaimed sizes at the nanometer scale [1-100 nm]—increasingly recognized as effective agents in contributing to low carbon footprints and sustainable development within these industries [8].

Nanoparticles show other astonishing properties such as high surface-area-to-volume ratios, high reactivity, and the ability to permeate biological and environmental systems at a molecular level, which enable them to improve efficiency in several processes such as waste treatment, energy conservation, and enhancement of agricultural and hospitality practices [9]. In agri-tourism, using nanoparticles involves improving soil health and optimizing irrigation processes, reducing water consumption, which is important for maintaining eco-friendly farm operations while receiving guests. Apart from that, nanoparticles can contribute to the productivity of crops to achieve the dual aims of converging

ecology and economy in agri-tourism locales [10]. As for the hospitality sector, which involves hotels and resorts and includes all forms of accommodation services, nanoparticles showed the advantage of lowering energy consumption, as insulation material enabled lower heating and cooling costs [11]. Additionally, they can make purification of water and filtration of air from waste management systems, as these nanoparticles can help in reducing emissions and, most importantly, play a role in keeping the operations sustainable in environmentally conscious hospitality [12]. Nanostructure applications in both sectors reduce the dependency on non-renewable resources and contribute to practices that complement the growing worldwide call for carbon-neutrality programming in tourism and hospitality. However, the widespread use of nanoparticles presents several difficulties. Cost of production, regulation, and a limited comprehension regarding long-term health and environmental effects are some of the important barriers to usage [13]. Off-take, the integration of nanomaterials should be an alternative way for achieving a lower carbon footprint and adopting sustainability in both the agri-tourism and sustainable hospitality sectors [14]. The expansion of such fields will be accompanied by an increase in demand for new and sustainable solutions, which will be important for addressing environmental challenges that arise with their growth [15].

With this chapter, the understanding consolidates how to employ novel nanoparticle solutions for reducing the carbon footprints of agri-tourism and sustainable hospitality. Here, one engages with the recent advances in the usage of nanoparticle technology that takes an entire section to articulate the technological promise for revolutionary change in environmental impact while enhancing economic development in the two sectors. The section will also include the barriers and hindrances that are retarding the activation of these technologies and methods of overcoming these obstacles to a greener and sustainable future for the agri-tourism and hospitality industries worldwide.

OBJECTIVES

1. To study novel applications for nanoparticles in reducing the carbon footprints of the agri-tourism and hospitality sectors.
2. To study the environmental and economic advantages that nanoparticle solutions bring with them regarding the greening of sustainable agri-tourism practices.
3. To study how the application of nanoparticles increases energy efficiency whilst reducing carbon footprints pertaining to operations in agri-tourism and hospitality.

CHAPTER 6

Low-Carbon Dining Options in The Hotel Restaurants

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Abstract: Environmental impact is considerably associated with human dietary habits and principles. Of late, it has become known that eating sensibly at hotel restaurants, at home, or at get-togethers can help build a sustainable environment and impact our future generations. Low-carbon dining options are a part of carbon-neutral tourism, which is the order of the day. Carbon emissions are rarely seen when one dines at a food outlet due to a lack of awareness. Information transfer never actually happens for many reasons. Stille is an attempt to understand how the carbon footprint on menus influences customers' actual choices across. Diners rarely recognize a general lack of knowledge about the climatic impact of food choices, as this practice is hardly known to them beforehand, either from peers, parents, or education at the school or university level. It is suggested that the effectiveness of carbon footprint information might depend on the gastronomic setting and its population. While many customers claim the information influenced their choices, this cannot be confirmed solely from sales figures.

Keywords: Carbon footprint, Carbon neutrality, Climatic impact, Gastronomic settings, Low-carbon foods, Sustainable tourism.

INTRODUCTION

In common parlance, a carbon footprint, or foodprint, refers to the greenhouse gases emitted by growing, rearing, farming, processing, transporting, storing, cooking, and disposing of the food we eat. Among all food types consumed, animal-based foods, especially red meat, dairy, and farmed shrimp, are generally associated with the highest greenhouse gas emissions [1]. In contrast, a pure vegetarian diet leaves a minimal carbon footprint, while a vegan diet has the lowest. One can reduce the foodprint by a quarter just by cutting down on red meats such as beef and lamb. The carbon footprint of a vegetarian diet is about

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half that of a meat-lover's diet [2]. Changing the foods one eats can significantly reduce one's carbon footprint. It also reduces pollution, preserves the environment, and slows global warming. Many of these changes will also save money, improve health, and even keep you fit. Hotels and restaurants across the globe must raise this awareness among their customers in various ways.

What is a Food Footprint?

Several researchers say food production is responsible for roughly 25% of the world's greenhouse gas emissions. They are produced in the process of growing, rearing, farming, processing, and transporting the foods we eat, without knowing the consequences or aftereffects. These greenhouse gases make up a food's "carbon footprint". Foodprint calculators are now available online, helping estimate the CO₂ of any food and understand how different food choices impact the planet. Switching to more plant-based foods, or even just reducing the amount of meat and dairy we consume, can significantly reduce our carbon footprint. Air freight of cheese increases the overall GHG emissions by about 50%. A 2023 study found that a meat-eater's diet produces around 10 kg of greenhouse gases every day, compared with just 2.5 kg of a vegan diet, representing a massive 75% reduction [3]. Are the following the basic steps in reducing food footprints

1. Avoid using plastic food packaging.
2. Can stop eating meat, particularly red meat.
3. Never dispose of leftover food.
4. Always give preference to seasonal fruits and vegetables.
5. The best cookware also helps in decreasing footprints.
6. Give priority to organic foods, which are free from pesticides, chemicals, and preservatives.
7. Before having a rethink on food miles, the more miles food travels, the greater its carbon footprint.
8. Buy only regional (locally available) and seasonal food ingredients, if possible.
9. Avoiding Tea Bags because they are heat-sealed with a type of plastic. It is always recommended to use loose tea leaves.

Openly speaking, diners go to any renowned restaurant for dining, no matter the cost, thus orders are placed beyond stomach capacity. As a result, food remains unutilised and ends up in the dustbins without a second thought. The servers also never caleftoverut using leftover food, because diners are already paying for it; hence, within seconds, it's just dumped in the bin. Another example is that, because of convenience, servers in a restaurant setup always use teabags instead of loose tea leaves, even though this has many advantages. Normally, teabags are heat-sealed with a type of plastic that cannot be composted, whereas loose tea

leaves are 100% plastic-free and can be composted more quickly [4]. The diners are also pleased to receive sealed teabags, which harm the environment. Almost all hotels and restaurants use single-use plastics to wrap fruits, vegetables, and other items before putting them in a refrigerator, which causes environmental pollution and takes 100 years or more to decompose after being thrown out. They finally gather at the bottom of the ocean floor, causing long-term water pollution. Instead of cling film, beeswax wraps can be used as a substitute.

A standard restaurant loads its menu with 80% non-vegetarian items, which are highly priced and more profitable to the company. Very few dishes are only featured in the menu, which is just a discouragement to the vegetarian diners but preferring plant-based is one of the most effective ways to shrink the food carbon footprint.*A 2023 study found a meat-eater's diet produces around 10kg of greenhouse gasses every day, compared with just 2.5 kilograms of a vegan diet; that's a massive 75% reduction. In fact, avoiding meat and dairy is widely agreed to be the single most significant way to reduce the planet's environmental impact [5].

When food travels from farm to fork, a certain amount of CO₂ remains as a footprint in the environment due to transport from the manufacturing site to the serving site. In the restaurant industry, customers are pleased to order imported food items, *e.g.*, Australian lamb, American apples, French Cheese, Russian caviar, Scandinavian salmon, *etc.*, and pay a hefty price. But the staff at the hotel restaurant do feel proud to serve those products at a premium price, even though it harms the environment. Very few restaurants in the country mention food miles only on their menus [6] to send a clear message, but the elite diners ignore it and never bother to ask the staff about food miles or their side effects. Any food that travels by air carrier emits more carbon than the same food transported by water—the fewer the food miles, the less the carbon emissions. Different forms of transportation produce different amounts of greenhouse gases per ton of goods shipped one mile. In comparison to cargo ships, freight trains produce 1.6 times as many emissions; trucks, 10 times as many emissions; and international air freight, 47 times as many emissions (Fig. 1).

CHAPTER 7

Evolution of Electric Utility Vehicles – A Transformed Hospitality Operation for a Sustainable Future**Geetha Manoharan^{1*} and Sanjeev Kumar²**¹ School of Business, SR University, Warangal, Telangana 506371, India² School of Hotel Management and Tourism, Lovely Professional University, Phagwara, Punjab 144402, India

Abstract: Signifying a turning point toward a more sustainable future, Electric Utility Vehicles (EUVs) are effecting a significant change in the hotel sector. This initiative aims to boost operational efficiency, rethink the visitor experience, and promote environmental stewardship, while incorporating modern technologies. By switching to EUVs, hotels can substantially reduce their carbon footprint and meet customer demand for environmentally friendly operations. By enabling hotels to spend on enhancing guest facilities and supporting regional sustainable projects, this change lowers running and maintenance costs, therefore benefiting the economy. The hotel's usage of EUVs, which promote community involvement and sustainable transportation education, supports its position as a conscientious corporate citizen, as technology is at the forefront of sustainability. This chapter will introduce the utility of electric vehicles for a sustainable future.

Keywords: Carbon footprint, Eco-friendly, Efficiency, Electric vehicle, Sustainability.

INTRODUCTION

Fuel cell electric cars, plug-in hybrid electric cars, and pure electric cars are three types of electric vehicles that use electric drive systems. Rather than a combustion engine, electric automobiles run their electric motor from a rechargeable battery pack. The car's rechargeable batteries have to be recharged regularly. Apart from running the vehicle, these batteries run the lights and wipers [1]. The fact that this kind of vehicle produces no harmful exhaust is its primary benefit. It is less expensive and lacks the usual liquid-fuel components found in conventional gasoline-driven vehicles, as well as the maintenance. Certain automakers have

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developed hybrid models that operate on both gasoline and electricity. This is a novel concept; hence, people know nothing about it. The demand for EVs is expected to increase over the coming months, and more people will benefit from driving them. EV charging matters to hospitality because it attracts eco-minded guests, meaning more travellers now seek out accommodations that support sustainable choices. Hotels with EV chargers can appeal to this growing demographic and drive bookings from environmentally conscious guests [2]. It enhances Guest Experience and Loyalty: EV charging stations allow guests to charge overnight or during their stay, increasing convenience and encouraging longer stays. Many hotels have seen repeat visits and higher guest satisfaction after installing EV chargers. It supports Revenue and Sustainability Goals; charging fees can create an additional revenue stream. At the same time, EV infrastructure demonstrates a hotel's commitment to reducing its carbon footprint, an attractive feature for today's conscious travellers.

According to a study, the need for a variety of cultural experiences and improved access to travel has fuelled the exponential growth of the global tourism and hospitality businesses in recent decades [3]. Concerns about the potential effects of increased travel on the environment led to a paradigm shift toward environmentally friendly living. "Green tourism" is a spectrum of practices aimed at mitigating the negative impacts of tourism on the environment, society, and culture. This includes advocating environmental responsibility, raising community engagement, and supporting conservation. Conversely, green hospitality emphasizes eco-friendly hotel operations, such as ethical sourcing, waste reduction, and energy efficiency. One of the main issues green travel and hospitality seek to address is the carbon footprint of travel. The sector is recognizing the importance of reducing greenhouse gas emissions through carbon offset programs and encouraging greener modes of transportation, including electric cars. Moreover, sustainable building designs, renewable energy sources, and energy-efficient technologies might help hotels reduce their overall environmental impact. Another vital component of green travel is water conservation. Low-flow fixtures and effective irrigation systems are two water-saving strategies used by lodging facilities to save water use and preserve surrounding ecosystems. In the travel and hospitality sectors, fulfilling sustainability targets depends on waste management. This drives the encouragement of recycling, the creation of composting systems, and the reduced use of single-use plastics.

By urging consumers to dispose of waste correctly, establishments support the circular economy and help slow down environmental damage. Community engagement determines the success of initiatives encouraging green travel. Cooperation with nearby communities helps equitably distribute economic

benefits and fosters a sense of shared responsibility for environmental preservation. Furthermore, helping to preserve local identity is respecting local knowledge and increasing cultural awareness. According to another study, green tourism and hospitality represent a significant shift toward a more sustainable and responsible business model [4].

Through eco-friendly practices, reduced carbon footprints, water conservation, responsible waste management, and local engagement, the tourism and hospitality sectors can significantly help preserve the environment. Based on a 2019 study by [5], VR is viewed as a suitable medium for experience development and refinement, and has recently witnessed a rapid rise in societal awareness. Still, given the rapid growth of research and use cases in the hotel industry, it is imperative to identify a more precise research path that aligns with the scattered studies across many sectors. It's time to go beyond the limits of the technology dimension and investigate deliberate VR design approaches. This research note urges more user-centric VR studies and advancements to help define the future path of VR implementations in the hotel and tourism sector. To do this, the authors advise applying a design methodology, with an emphasis on the early stages of the design process, to identify and understand the client's concerns precisely. Analysis of the customer's demands and wants should start from the core, free from VR technology. One realizes that the emphasis should be on the user's goal rather than on technology.

Using advanced technology theory [6], aims to investigate tourists' perceptions and attitudes towards Electric Vehicles (EVs) in the National Capital Region of Delhi. The proportional equation model was applied to an online survey of 226 respondents to investigate the relationship among factors such as perceived enjoyment, compatibility, ease of use, interest, price, image, and performance. The study suggests that improving content satisfaction and environmental protection may help in the more widespread adoption of electric vehicles. Lower costs and better visibility increase the value of an EV. Although perceived usefulness and satisfaction positively affect consumer behavior and willingness to use electric cars, perceived ease of use affects consumers' happiness. Although perceptions of pleasure, environmental quality, cost, image, and performance are influenced by factors such as experience, environmental awareness, age, and gender, they can make users happy and willing to use electric vehicles.

The results highlight several practical suggestions for companies and legislators to increase EV adoption in popular tourist destinations [7]. The potential advantages of EV adoption, such as better environmental sustainability, a more positive perception of technology, and greater visitor satisfaction, may be motivating and inspiring. It is essential to prioritize comfort and ease in EV design to improve the

Boosting Rural Tourism through Sustainable Waste Management: A Step towards Green Tourism

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Abstract: The growing industry of rural tourism has a positive impact, including increasing the income of rural residents, but there is a negative impact also, *i.e.*, increasing environmental pollution due to increasing tourism activities in rural areas. The waste generated by the tourists is polluting the soil, air, and water. One of the major pollutants generated due to increasing rural tourism is non-biodegradable materials. Normally, the tourist tends to leave waste here and there after consumption. Currently, over 400 million tonnes of plastic waste is generated annually. It is anticipated that worldwide 1,100 million tonnes of primary plastic will be produced by 2050. There is an urgent need to manage waste by reducing, reusing, and recycling plastic waste to control pollution. This article proposed some solutions to limit and restrain the consumption of single-use plastic and boost rural tourism through sustainable waste management generated in rural areas.

Keywords: India, Recycle, Reduce, Reuse, Rural tourism, Waste management.

INTRODUCTION

Rural tourism is increasingly becoming the major choice among city dwellers as a centre for relaxation [1]. It has become an economic activity in developing countries like India. The great landscape and wide range of possibilities like river rafting, mountaineering, tracking, swimming, and spending a day with rural communities are some of the attractive features attracting domestic as well as foreign tourists to rural areas. The growing rural tourism has a positive impact, like increasing the income of rural people, but there is a negative impact also, *i.e.*, increasing environmental pollution due to increasing tourism activities in rural areas [2]. To protect the environment, the Ministry of Environment, Forest and

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Climate Change [MoEFCC] declared a ban on single-use plastic on July 1, 2022, to protect the environment. Single-use plastic is a type of disposable plastic that is used only once before being recycled or thrown away. As a result, single-use plastic like straws, cups, plates, bags, water bottles, soda bottles, coffee stirrers, earphones, and most food packaging are used. According to a survey report, Singapore, Australia, and Oman are the top three countries in the world for single-use plastic garbage, with India ranking 94th out of the top 100. India generates 5.6 million metric tons [MMT] of waste from single-use plastics yearly, of which 11.8 MMT are produced domestically and 2.9 MMT are imported. The amount of waste generated per person is 4 kg [3]. Because the single-use plastic bags are less expensive, *i.e.*, 10-15 paise more than paper bags, which cost around 25-30 paise, they are in high demand. Up to five trillion plastic bags are used annually worldwide, and one million plastic bottles are purchased every minute. Approximately 50 percent of the plastic manufactured globally is intended for single-use products.

Currently, we generate over 400 million tonnes of plastic waste annually. By 2050, it is anticipated that 1,100 million tonnes of primary plastic will be produced worldwide. The packaging materials for food and beverage containers consume around 36 per cent of plastics generated; it is estimated that 85 percent of these materials wind up in landfills or as unregulated waste. Table 1 lists the kinds of plastics and how they are used.

Table 1. Types of plastics and usage

Types of Plastics	Usage
Polyethylene terephthalate [PET]	Biscuit trays, water bottles, and dispensing containers
High-density polyethylene [HDPE]	Ice cream containers, freezer bags, milk bottles, shampoo bottles
Low-density polyethylene [LDPE]	Food packaging film, trays, containers, bags
Polypropylene [PP]	Single-use face masks, bottle caps, ice cream tubs, potato chip bags, microwave dishes
Polystyrene [PS]	Cutlery, plates, cups
Expanded polystyrene [EPS]	Hot drink cups, protective packaging

Source: Author Compilation based on [4]

The majority of plastic objects just disintegrate into ever-tinier fragments rather than completely disappearing. Through inhalation and absorption, microplastics can enter the human body and accumulate in organs [4]. Our lungs, livers, spleens, and kidneys have all been discovered to have microplastics in the placentas of newborns. It is yet unclear how much of an influence this will have on human health. Nevertheless, there is strong evidence that chemicals related to

plastics, including flame retardants, plasticizers, and methyl mercury, can enter the body and are connected with health issues.

Although the government is putting effort into reducing the consumption of single-use plastic by implementing rules and regulations and public awareness programs, the demand for single-use plastic is high among travellers, mainly due to convenience and cost-effectiveness. Hence, there is an urgent need to manage plastic waste by reducing, reusing, and recycling plastic waste to control pollution [5]. However, the Ministry of Tourism has taken steps to reduce single-use plastic waste and pollution through an awareness programme. But the level of pollution in rural areas is increasing day by day due to rural tourism activities. This article proposed some solutions to limit and restrain the consumption of single-use plastic and the waste generated in rural areas in India.

This article proposed some solutions to limit and restrain the consumption of single-use plastic and the waste generated in rural areas in India. The first section defines and conceptualizes rural tourism, and the second section gives an overview of green tourism. The third section discusses the challenges and opportunities in implementing sustainable waste management, and the fourth section addresses sustainable waste management through reusing, reducing, and recycling non-biodegradable waste. Then, in section five, the benefits of sustainable waste management are discussed. In section five, two cases on sustainable waste management are discussed. Finally, the chapter ends with recommendations and a conclusion.

RURAL TOURISM

“Rural tourism” gained popularity for leisure and peacefulness among Western urban residents [6]. Reichel *et al.* [2000] have referred to rural tourism as tourism activities located in rural areas. Rural tourism is a form of tourism in which farmers provide accommodation and other conditions for tourists to engage in various recreational activities in typical rural environments, such as farms and pastures. These two definitions represent rural tourism broadly. A few definitions are extracted from prior research, given in Table 2.

Table 2. Definitions of Rural Tourism.

A stereoscopic landscape tourist activity includes rural social resources, agricultural economic resources, and agricultural biological resources [7].
The activity takes place in the village community, and the object is the distinctive production patterns, way of life, and pastoral landscape of the hamlet [8].
It is an approach to tourism that uses the rural landscape and activities as a draw, targets urban dwellers, and aims to satisfy their demands for information, amusement, and a return to nature [9].

CHAPTER 9

Integrating Circular Economy and Carbon Footprint Reduction: The Role of Employee Training and Motivation in Hotels**Regy Joseph^{1*} and S Jegadeeswari¹**¹ *Department of Commerce, Karpagam Academy of Higher Education, Coimbatore, Tamil Nadu 641021, India*

Abstract: Circular economy is a means of production and consumption that comprises retrieving, reprocessing, refurbishing, and revamping the prevailing resources and products as long as possible. This chapter observes Circular economy initiatives in hotel food services and their impact on employee engagement and motivation, especially within diverse teams. The aim of the chapter is to comprehend the sustainable practices within the food service industry and the importance of employee engagement and motivation for employees working in various outlets from different backgrounds. The study includes a selection of hotels that have approved circular economy principles, such as waste reduction, reutilization, sustainable tracking, and assessing their effects on team performance and self-esteem. The chapter shows that hotels practicing a circular economy have higher levels of employee engagement and motivation. They feel more connected and valued while performing sustainable initiatives. Additionally, a diverse team shows enhanced collaboration and creativity, contributing to a positive work environment. The research suggests that hotels can improve employee performance and satisfaction by integrating circular economy practices into their operations. This supports the goal of sustainability practices in the hospitality industry and creates motivated and energized employees. The hotels prioritizing sustainability and diversity are expected to see benefits in employee performance.

Keywords: Current environmental challenge, Employee engagement, Environmental impact, Hospitality initiatives, Recycling, Waste management.

INTRODUCTION

Circular economy and carbon footprint initiatives within the hotel food services industry have the potential to create a win-win situation, providing business

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benefits to the industry and contributing to ecological and environmental goals [1]. Indeed, vague sustainability terms, such as green, environment, or sustainability, have been pointed out as too general and often unclear; instead, the CE concept fosters better comprehension of what is being proposed. Employees are a strategic source to continue CE initiatives in hotel food service and improve their effect on differentiation in consumer behavior. However, the relationship between employees and the environmental impact of the organization is largely unclear in the literature [2]. Do hotel food service employees consider CE programs as a tool for environmental protection to ameliorate impacts on climate change or the depletion of natural resources for future generations, and do they regard it as a differentiating economic strategy to obtain positive impacts on CES in terms of sales? This study investigates the effect of the above-mentioned two perceptions (work engagement and motivation-related measures) on the effectiveness of CE programs, using a sustainability theory lens, the stakeholder theory, and the person-environment fit theory [3].

The relationship between an organization and its stakeholders in the hotel industry is not new, and in the context of the food services sector, it has been referred to as an important driver of business success [4]. However, formal studies examining the link between HRM (Human Resource Management) strategies, including employee management such as motivation, satisfaction, and performance, and CE initiatives in hotels and the food industry have hardly been conducted [5]. Few companies actively seek to integrate principles such as product life cycle extension, responsible waste management, improved productivity throughout the supply chain, industrial symbiosis, eco-design, life-cycle management, and the inclusion of environmental and social performance in quality certifications into their human resource policies, including recruitment, training, and career development. Simultaneously, they set up networks and collaboration between the various functions and levels within the company's SMEs to discuss and rethink what the circular economy means in their industry. HRM and CE in hotels in the field of food services lack considerable attention in the current literature [6].

CURRENT ENVIRONMENTAL CHALLENGES IN THE HOTEL INDUSTRY

The hotel industry is under growing pressure to deal with various environmental issues. The environmental footprint of hotels is substantial and occurs primarily through the consumption of large quantities of energy, water, durable and non-durable goods, and through various services [7]. The industry is expected to worsen these problems in the long run. This paper addresses the implications of the switch to a circular economic model for the hotel industry. A cumulative tourism growth rate is considered a predictor of the ecological footprint of a

tourist destination. By examining the relationship between the rate of tourist growth and the annual ecological footprint, the increasing impact can be explained [8]. The rapid growth of international tourism has impacted destinations in both desired and adverse ways. Some destinations have consolidated and prospered as a result of this development, while others, in many cases, have suffered from negative impacts. The industry is currently facing the challenge of maintaining its success while reducing detrimental social, environmental, and cultural impacts [9]. The call for sustainable tourism development that respects the physical, social, cultural, and economic environment has never been greater, as there is now increased interest, concern, and action in the field of consumerism and sustainability. The importance of a hotel's environmental policy has risen significantly in recent years. Numerous cities have given priority to reducing the use of plastics, including bottles, glasses, and straws. Both the carbon footprint and the food waste associated with hotel functions have become key areas for scrutiny in the strategic planning process affiliated with the sustainability of the hospitality and hotel industries. As a result, a new initiative has been introduced to promote sustainability [10].

Human pressure has altered the hotel sector as well. The primary sources of this pressure are energy consumption, waste generation, and water use. The vast majority of energy involves the consumption of fossil fuels, which are non-renewable and have long-term negative environmental implications. For example, non-degradable plastics such as cling film, foil, earbuds, and microbeads are regularly used by hotels. The reduction in non-biodegradable straws that a hotel has to dispose of is significant. The amount of biodegradable waste generated annually has reached millions of tonnes. This waste can also be converted into useful products such as compost and animal feed. Furthermore, landfill waste is a significant component of the industry's challenges. At an average of 60.4 percent, the hotel industry recycles more of its waste than any other industry or service.

The total quantity of carbon dioxide emissions to the earth's surface currently totals billions of tonnes [11]. Moreover, the production of hotel linen, towels, and uniforms has significant environmental implications. It appears, therefore, that the incidence of "eco-efficiency" and "circular economy initiatives" has increased only to temporarily improve the performance of the hotel and tourism industries. However, the hotel sector uses a minimum of five times the quantity of energy compared to the non-hotel industry per square meter of floor space, which is substantial [12]. At present, the hotel industry is primarily driven by economic pressures, and as a result, the ecological demands of future generations are compromised. Therefore, to cater to the pressures of all stakeholders, it is crucial to provide solid justification for implementing change that can enhance shareholder wealth (Table 1).

SUBJECT INDEX

A

Activation techniques 63
 Active management commitment 160
 Active participation 126
 Adaptability 43
 Adaptation 33, 39
 Adaptive change 146
 Add-on, optional 108
 Addition 4, 54, 59, 61, 99, 118, 120, 139, 140
 substantial 99
 Adoption 1, 15, 17, 64, 67, 82, 129, 130, 157,
 160, 161
 real-world 67
 wider 1
 Agriculture greener 84
 Agriculture sector 142
 Agritourism 70, 73, 74, 75, 76, 79, 80, 81, 83,
 84
 Air freight 92, 93, 98
 avoiding 98
 international 93
 Awareness 23, 91, 92, 106, 115, 116, 138,
 139, 159, 160
 environmental 115, 116
 lack of 91, 138, 139
 societal 115

B

Barriers 16, 72, 82, 159, 160
 regulatory 16
 significant 160
 Basket, single 139
 Batteries 9, 15, 56, 113, 116, 119, 120, 123,
 128, 146
 advanced 76
 lithium-ion 116
 longer-lasting 81
 powering 146
 rechargeable 113
 solid-state 128

 traditional Li-ion 63
 vehicle's 120
 Benefits 43, 57, 76, 78, 82, 84, 99, 106, 107,
 108, 113, 114, 115, 118, 127, 128, 130,
 141, 151, 152, 155, 156, 162
 additional 43
 commercial 162
 ecological 84
 key 99
 numerous 141
 primary 113, 130
 unique 57
 Bonding structure 60
 Bonds 57, 66
 chemical 57
 higher capacity 66

C

Caleftoverut 92
 Campaigns 30
 Canons 40
 Capabilities 60, 163
 Capacity 1, 57, 92, 96, 120, 123, 144, 146,
 147
 engine's 120
 right 96
 stomach 92
 Capital expenditures, substantial 121
 Carbon atoms 8, 56, 57
 arranged 56
 Carbon dioxide 23, 53, 55, 64, 65, 67, 130
 Carbon Dioxide Application Reductions 9
 Carbon dioxide emissions 67, 78, 141, 153
 reduced 78
 reducing 67
 Carbon electrodes 57
 Carbon-emission-free technologies 6
 Carbon emissions 1, 2, 3, 4, 5, 6, 7, 8, 9, 11,
 12, 14, 32, 34, 71
 Carbon emissions impact 10

D

Dairy 91, 92, 93
 Danger 24, 38, 155
 Data collection 158
 De-registration 125
 Debris 27, 29, 45
 demolition 29
 repurposing construction 45
 Decarbonization 36, 44
 Decontamination 59
 Decreasing footprints 92
 Defect density 53
 Degradation 4, 9, 15, 16, 38, 50
 accelerated ecological 38
 minimizing climatic 50
 pollutant 15, 16
 Dependence 6, 9, 12, 15, 43, 59, 75, 76
 fossil fuel 15
 reduced 6
 reducing 6, 12, 43, 59
 Desorption cycles 57, 62
 Destinations 6, 37, 153, 161
 greening tourist 6
 impacted 153, 161
 Destructive impacts 15
 Detrimental effects 25

E

Eco-travellers 9
 Ecological 47, 143, 152
 Ecological advantages 162
 Ecological biodiversity 44
 Ecological demands 153
 Ecological distortion, mitigating 42
 Ecological footprint 152, 153
 annual 153
 Ecological impacts, evaluating 143
 Ecological planning 42
 Ecological responsibilities 35
 Ecological unit 38
 Ecology 36, 44, 45, 72, 137
 local 36
 natural 44, 50
 surrounding 44, 45
 Economic advantages 6, 72, 127, 162
 Economic Benefit 35, 80, 81, 117, 118, 142, 162
 potential 162

Economy 2, 24, 64, 66, 72, 83, 100, 107, 113, 118, 137
 country's 24
 local 100, 154
 low-carbon 118
 rural 137
 sustainable hydrogen 66
 viable hydrogen 64
 Ecosystem balance 70
 Ecosystems 3, 30, 36, 74, 79, 80, 82, 83, 114, 117, 137, 143
 damage 3
 disturbed 36
 fragile 143
 preserving 80
 rural 137
 surrounding 79, 114
 Electric cars 113, 114, 115, 116, 117, 119, 123, 124, 125, 126, 127, 128, 129, 130
 hybrid 113
 Energy consumption 4, 10, 11, 12, 17, 32, 33, 41, 43, 44, 45, 72, 74, 80, 140, 153, 158, 161
 cheap 11
 lower 12
 lowering 4, 72
 minimizing 12, 44
 non-renewable 33, 140
 reducing 17, 32, 43
 significant 32

F

Facilities 8, 9, 44, 47, 113, 114, 117, 129, 130, 139
 cooling 44
 enhancing guest 113
 lodging 114, 130
 poor transport 139
 renewable electricity generation 8
 Feasibility 4, 64
 Features 53, 77, 130, 146
 cutting-edge 130
 enhancing carbon nanotube 53
 key 146
 new 77
 Food waste 23, 98, 104, 107, 108, 146, 153, 158, 159, 160, 161
 managing 156
 raw 146

Subject Index

- reducing 104, 107
- Functionalization 56, 57, 61, 62, 63, 66, 67
 - chemical 57, 62, 66
 - surface 61
- G**
- Garbage 23, 24, 25, 27, 28, 29
 - decaying 28
 - hazardous 29
 - solid 23, 24, 25
- Generator 120, 146
 - gas-powered 146
- Geo-biological understanding 39
- Geographic location 29
- Geometrical Pattern 40
- Geopathic Zones 41
- GHG emissions 92
- Grains 98, 99, 100, 101, 103, 104, 105
 - high-protein 101
 - versatile 101
- Graphene 1, 2, 3, 4, 8, 9, 12, 13, 15, 16, 56, 61, 66
- H**
- Harvesting 77, 104
 - solar power 77
- Hospitality 4, 72, 114, 116, 126
 - conscious 72
 - friendly 4
 - green 114, 116
 - responsible 126
- Hotel developments 36, 45, 46, 47, 48, 49
 - modern 45, 48, 49
- Hydrogen storage 56, 63, 65, 66
 - exceptional 66
 - high-efficiency 56
 - low-pressure 63
- I**
- Implications 3, 140, 152, 153, 161
 - long-term negative environmental 153, 161
 - respective 3
 - significant environmental 153
- Incentives 116, 124, 125, 126, 128
 - financial 125
 - special 126
 - tax 116

Carbon Footprint Reduction Strategies 169

- Industries 2, 3, 15, 16, 33, 41, 54, 58, 59, 66, 67, 70, 71, 73, 91, 98, 117, 118, 152, 153, 156, 157, 161, 162
 - accountable 117
 - business 118
 - emerging 33
 - heavy 54
 - hospitality/hotel 98
 - neighborliness 58, 59
- Information transfer 91
- Infrared radiation 41
 - invisible 41
- K**
- Knowledge 32, 37, 38, 42, 91, 109, 115, 117, 118, 129, 137, 138, 160
 - local 115, 117
 - traditional Indian 32
- Knowledge gaps 48, 84
- L**
- Landscape 53, 134, 136, 137
 - cultural 137
 - economic 137
 - pastoral 136
 - settlement 137
 - sustainable energy 53
- Legislation 141, 155
- Legumes 98, 99, 100, 103, 104, 105
- M**
- Maintenance 79, 81, 113, 121, 122, 123, 127
 - analytical software 122
 - continuous 121
 - preventive 108
 - reducing 81
- Mass Production 104
- Material availability 34
- Measurable benchmarks 109
- Measurement accuracy 60
- Mechanical strength 56, 57, 61, 63, 66
 - excellent 61
 - exceptional 8
 - high 66
- Minimal Maintenance Costs 123

N

- Nano-coatings 2, 3, 4, 70, 74, 76, 79, 80, 81, 82, 83
 - advanced 2
 - application 76, 81
 - self-healing 83
- Nanomaterials 2, 3, 4, 5, 7, 8, 9, 13, 15, 61, 72, 76, 79, 80, 81, 84
 - high-tech 3
 - inexpensive 15
 - insulating 80
 - practical 9
 - revolutionary 8
- Nanomaterials 2, 3, 4, 5, 7, 8, 9, 13, 15, 61, 72, 76, 79, 80, 81, 84
 - high-tech 3
 - inexpensive 15
 - insulating 80
 - practical 9
 - revolutionary 8

O

- Operational costs 4, 9, 15, 17, 70, 79, 80, 81
 - lower 9, 17
 - reduced 15
 - reducing 70, 79, 80
- Operational efficiency 6, 15, 32, 48, 59, 67, 71, 76, 101, 113, 129, 154, 162
 - increasing 71
 - maintaining 59
- Organic waste 26, 27, 29, 30, 78, 108, 143, 145, 146, 158
 - separated 146
- Organic waste composting 30
- Ownership 121, 122
 - outsourcing 121

P

- Packaging costs 104, 105
 - reducing 104
- Packaging materials 135, 138, 139
- Photovoltaic panels 76
- Planning 37, 38, 39, 42, 44, 47, 65, 108, 138
 - architectural 47
 - architecture 38
 - disciplined 108
 - infrastructure layout 42

meal 108

- Plastic waste 81, 82, 83, 85, 134, 135, 136, 138, 141, 142, 145
 - reducing 145
 - single-use 136, 138
 - tonnes of 134, 135

R

- Plastic waste 81, 82, 83, 85, 134, 135, 136, 138, 141, 142, 145
 - reducing 145
 - single-use 136, 138
 - tonnes of 134, 135
- Recycle 134, 139, 140, 141, 142, 145, 147, 163
- Reduction 8, 14, 33, 73, 74, 80
 - carbon emission 74
 - direct 73
 - effective 8
 - marked 80
 - significant 14, 33, 73
- Regulatory bodies 100, 147
 - local 147
- Resource optimization 41, 44, 45, 49, 50, 82
 - ensuring efficient 41
 - natural 50

S

- Safe recycling 155
- Safeguard 38, 96
- Safety 15, 83, 63, 125, 129
 - environmental 83
 - high-pressure tank 63
 - legislation favouring 15
 - pedestrian 125
- Silver nanoparticles 1, 2, 3, 4, 9, 10, 12, 15, 16, 74
- Soil pollution 83, 142
 - reducing 83
- Solar energy 2, 44, 97
 - optimal 44
 - utilized 2
- Solid waste 23, 24, 25, 27, 137, 138, 139, 143, 144, 157
 - increasing amount of 27, 137
 - urban 157

Subject Index

Carbon Footprint Reduction Strategies 171

T

Techniques 24, 25, 39, 49, 60, 66, 67, 107
 crude disposal 25
 culinary 107
 direct measurement 60
 experimental 60, 67
 high-sensitivity 60
Textual analysis 32, 33, 35
 qualitative 32
Titanium dioxide 1, 2, 3, 4, 6, 12, 14, 15, 16,
 73, 82
Tourism activities 134, 136, 137, 138, 140
 increasing 134
 rural 136, 138
Tourist destination 137, 153

U

Ultraviolet rays 41
 invisible 41
Unit volume 54, 58
Urbanization 25, 36, 49
 rapid 25, 49

V

Vastushastram principles 33, 34, 37, 40, 43,
 44, 45, 47, 48, 49, 50
 adapting 48
 benefits of 49
 environmental 40
 incorporating 47
 integration of 48, 49
Vermicomposting 146

W

Waste collection 25, 30, 138, 139, 140, 145,
 148
 improper 138
 ineffective 30
 informal 25
Waste management 23, 24, 25, 28, 30, 47, 70,
 71, 73, 78, 115, 117, 136, 138, 141, 142,
 144, 145, 147, 148, 152, 154, 155, 163
 benefits of sustainable 136, 142
 effective 30, 117
 implementing sustainable 136

improper 138
municipal 25
non-biodegradable 141
proper 47, 163
responsible 115, 152
Waste segregation 26, 139, 140, 144, 145
 encouraging 26
Waste stream 29, 30, 141, 162
 expanding 30

Z

Zero tailpipe emissions 123
Zero-waste initiatives 98
Zinc oxide 73, 76, 82
 nanoscale 76



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Sanjeev Kumar

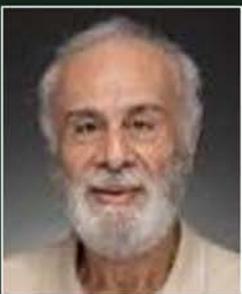
Prof. Dr. Sanjeev Kumar is a Professor in Lovely Professional University Punjab India. He received Undergraduate in Hotel Management from Osmania University, Postgraduate in Tourism Management from Madurai Kamaraj University. He completed Doctor of Philosophy in Hospitality Management in 2019 from Amity University Jaipur India. His research areas lie in food service industry, his research focuses on alcoholic beverages, event management and sustainable management practices, metaverse, AI machine learning and artificial intelligence. Dr. Sanjeev also edited more than 20 books with various international publishers such as IGI Global, Cambridge Scholars, Emerald, CABI, Bentham Science, Taylor & Francis. Dr. Sanjeev is an active researcher and has published numerous research articles in prestigious national and international journals and books.



A.K. Haghi

A.K. Haghi is a retired professor who is currently a research associate at the University of Coimbra, Portugal. He holds a BSc in urban and environmental engineering from the University of North Carolina (USA) and holds two MSc degrees, one in mechanical engineering from North Carolina State University (USA) and another one in applied mechanics, acoustics, and materials from the Université de Technologie de Compiègne (France). He was awarded a PhD in engineering sciences at Université de Franche-Comté (France).

Dr. Haghi has written, co-written, edited, or co-edited more than 1500 publications, including books, book chapters, and papers in refereed journals with over 4600 citations and an h-index of 35, according to Google Scholar database. He has supervised several PhD and MSc theses at the University of Guilan (UG) and co-supervised international doctoral candidates. His leadership in academic publishing includes founding and serving as Editor-in-Chief of prestigious journals. Professor Haghi's extensive educational background and supervisory roles underscore his expertise and contributions to the field of engineering sciences. He has secured UK design patents for multiple inventions.



Ali Pourhashemi

Dr. Ali Pourhashemi is a professor in the Chemical and Biochemical Engineering department at Christian Brothers University. He is involved with teaching, research, and supervising industrial internship programs. Dr. Pourhashemi's primary teaching areas include process design, heat transfer, fluid mechanics, ChE thermodynamics, and the unit operations laboratory courses. He has authored several books and research publications in chemical engineering and related areas and has been involved with various packaging projects. He has a great passion for upgrading and developing new experiments for the undergraduate unit operations laboratory. His administrative experience includes serving as the department chair from 2011-2010.