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The Role of Green Materials and Renewable Energy, and Energy Efficiency Adoption in Driving Sustainability Performance in Agritourism Facilities

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ABSTRACT

Agritourism is gaining momentum as a model for sustainable rural development, yet its environmental footprint remains a pressing concern. This study examines how the adoption of green materials, renewable energy, and energy-efficient technologies shapes the overall sustainability performance of agritourism facilities in India. Grounded in Environmental Management Theory and guided by the need for eco-friendly operations, the study investigates both the direct effects of these practices and the mediating role of environmental impact reduction (EIR) in improving sustainability outcomes. Data were collected from 312 valid respondents across five eco-certified agritourism farms using a standardised questionnaire. Seven hypotheses were tested using SmartPLS 4 for Partial Least Squares Structural Equation Modelling (PLS-SEM). Findings confirm that all three sustainable practices significantly reduce environmental impact, with energy efficiency demonstrating the strongest effect. Environmental impact reduction was further confirmed as a significant mediator linking each practice to overall sustainability performance. The study makes both theoretical and practical contributions. Theoretically, it positions the reduction of environmental impact as a vital intermediate mechanism in agritourism sustainability research. Practically, it equips agritourism operators, rural planners, and policymakers with evidence-based direction for prioritising green infrastructure, clean energy, and energy-efficient operations.

Keywords: Agritourism; Environmental sustainability; Eco-tourism; Sustainable Green Materials; Sustainable Performance

1. INTRODUCTION

Farm tourism is not a new phenomenon. According to (Barbieri, 2013), in some parts of Europe, this phenomenon has existed for over a century. He identifies several other changes that have occurred in British farming within the past 50 years; these changes include a reduction in labour force, restructuring of farms, an increase in specialization and intensification activities, as well as falling farm incomes (llbery et al., 1998). Often, the inability to achieve sufficient levels of income has led farmers to adopt diversification away from agriculture and into pluriactivity. For this purpose, Bowler et al. (1996) propose a model for decision making for growth in farm business. Mostly driven by its financial advantages, farm tourism offers a symbiotic connection for places where neither tourism nor farming could be justified on its own. Despite being at the stage of searching for its identity, agritourism has gone through many names and definitions which have something common the term "rural" and which all center around the activities carried out by visitors in the rural environment during the relatively short time period of its existence.

The worldwide transition to sustainable development has profoundly impacted several industries, including tourism. Agritourism, an expanding speciality that merges agricultural activities with tourism, is distinctly poised to enhance environmental sustainability through its rural, nature-integrated businesses (Simão & Partidário, 2012). The growth of agritourism also poses environmental issues, such as energy use, resource depletion, and trash production. In the growing field of agritourism, improving sustainability results depends on include renewable energy sources and environmentally favorable products. Agritourism companies have been driven to use sustainable building materials and energy-efficient technologies as growing knowledge of environmental consequences and the need to reduce carbon emissions calls for (Solangi, Alyamani, & Magazzino, 2024).

While solar and biomass renewable energy sources reduce dependency on fossil fuels, thereby promoting ecological balance, sustainable materials minimise environmental footprints (Al-Madani et al., 2024; Iwuanyanwu & Gil-Ozoudeh, 2024). Furthermore, the use of energy efficiency is a necessary stimulus for reducing running costs and greenhouse gas emissions, so improving the sustainability of agritourism businesses (Celestin et al., 2024). Together, these green technologies increase environmental and financial sustainability, thereby creating agritourism sites as conscientious stewards of natural resources in a climate undergoing change (Javed et al., 2024 ; Gedik & Avinc, 2020). The potential of hemp fiber as a sustainable and ecologically benign replacement for conventional raw materials in the textile industry is examined in this work. It turns out that sustainable building techniques together with renewable energy can assist in making the rural tourism destinations more environmentally friendly, efficient in resources usage and sustainable. The findings aim at assisting legislation and tourism agents to utilize sustainable techniques for both environmental and economic gains.

Sustainable development of agritourism facilities requires such key measures as utilization of green materials, renewable energy and energy-efficient techniques. The following are some of the examples of green construction materials: bamboo, recycled wood, mud bricks. Renewable energy sources such as solar and biogas are capable of decreasing the greenhouse gas emissions and dependence on oil and other fossil fuels (Panwar et al., 2011). Energy-efficient practices like smart irrigation and LED lighting are contributing to increasing the sustainability of operation (Zuo & Zhao, 2014). The above mentioned changes in agritourism allow saving resources, lowering costs and align with tourists' desire for sustainable travel.

The long-term viability of agritourism will be assured through sustainability since this will ensure that the development of tourism will not lead to the depletion of agricultural resources or the environment in which it operates (Firgo & Pennerstorfer, 2025). Agritourism takes place in rural and environmentally sensitive places and thus using sustainable practices will help reduce negative impact on the environment while making the experience more enjoyable to tourists. The use of green construction materials, renewable energy systems, and energy-saving technology leads to low-impact structures, energy savings, and reduced greenhouse gas emissions. Not only does this contribute to the global environmental goals, but it also makes the tour more appealing to eco-tourists who want to go on ethical tours. In addition, sustainability is good for local people through increased agricultural diversity and resilience (Barbieri, 2013; Sharpley & Vass, 2006).

Agritourism depends on sustainability as it helps to protect the natural surroundings, thereby guaranteeing the maintenance of soil fertility, water quality, and biodiversity for next generations (Sharpley & Vass, 2006). Farms display good land management by employing environmentally friendly products and techniques, therefore reducing habitat damage. Furthermore, environmentally conscious travellers are looking for locations that exhibit real environmental dedication; research reveal that sustainable operations raise visitor happiness and willingness to spend (Barbieri, 2013). From an operator's point of view, using green technologies such solar-powered systems and energy-efficient appliances results in long-term cost efficiency by lowering energy bills and maintenance charges (Zuo & Zhao, 2014). At last, green certifications such as those set by the Global Sustainable Tourism Council are establishing standards of excellence in agritourism; obtaining these badges not only verifies eco-credentials but also distinguishes farms in a competitive market (Font & Barrios, 2017).

Moreover, effective policies and technological innovations facilitate the broader adoption of sustainable practices, leading to long-term environmental and economic advantages (Li, Badulescu, & Badulescu, 2025; Mukhtar et al., 2025). The advancements collectively enhance the development of robust agritourism infrastructure, ensuring alignment between environmental sustainability, project efficiency, and economic viability (Nwaogbe et al., 2025; Bigiotti et al., 2024). Although there is increasing interest in sustainability in the tourism and agricultural sectors, the existing literature remains fragmented in its approach to eco-innovations in agritourism (Barbieri, 2013; McAreavey & McDonagh, 2011). Previous research predominantly investigates green materials, renewable energy, or energy-efficient technologies separately, primarily concentrating on urban hospitality or broader rural development scenarios (Caillol, 2025; Panwar et al., 2011; Garba et al., 2024). Nonetheless, there exists a scarcity of empirical research that examines these three sustainability strategies in conjunction within the framework of agritourism facilities, particularly in developing nations or rural ecosystems (Bigiotti et al., 2024; Barbieri & Mahoney, 2009; Barbieri, 2013). Moreover, although numerous studies acknowledge the environmental advantages of green infrastructure and clean energy technologies (Iwuanyanwu & Gil-Ozoudeh, 2024; Solangi et al., 2024) the intermediary function of environmental impact reduction as a connecting mechanism between sustainable practices and enhanced sustainability performance has yet to be thoroughly examined (Moazzem et al., 2021; Mukhtar et al., 2025). Only a few studies have been conducted to find out that how making efforts to reduce any negative effect on the environment, such as emissions, waste, and energy usage, could act as a channel to make eco-investments lead to better sustainability results (Celestin et al., 2024; Al-Madani et al., 2024). This research gap highlights the necessity of more empirical and modeling-based research in agritourism using techniques like PLS-SEM (Hair et al., 2019).

1.1. Objective of the Review

To assess the influence of incorporating eco-friendly materials on the sustainability outcomes of agritourism establishments.

To explore the role that renewable sources ofenergy and energy efficiency policies play in reducing the environmental impactof agritourism activities.

To examine the mediating role of the reduction in environmental impacts between overall sustainability performance of agritourism facilities and sustainable practices such as green building, renewable energy, and energy efficiency.

2. LITERATURE REVIEW

The rapid growth of tourism in the late 20th century has strained natural resources, often while ignoring social and environmental problems. (United Nations, 2015) The United Nations started international projects including Agenda 21 and the Sustainable Development Goals (SDGs) in response to enable fair progress (Yudina et al., 2016). Currently, sustainable tourism is acknowledged as an essential component of sustainable development, striving to mitigate environmental damage while fostering economic and social advancement responsibly (Lubowiecki-Vikuk et al. 2021). Rural tourism, based on sustainable practices and resource conservation, is significantly contributing to economic growth and enhancing living conditions in rural areas (McAreavey & McDonagh, 2010; Saxena et al., 2007).

Examples of green materials are bamboo, recycled lumber, and straw bales. They are construction materials that reduce environmental impact through low embodied energy, renewable resources,and non-toxic nature. Green materials assist in saving resources and reducing carbon footprints. Renewable energy is natural sources that can be regenerated within the human timeline including solar, wind and biogas technologies, thus decreasing the reliance on fossil fuels and emissions of greenhouse gases (Panwar, Kaushik, & Kothari, 2011). Energy efficiency refers to actions such as the use of LED lighting, highly efficient heating, ventilation, and air conditioning systems and energy-saving control technologies to minimize operating cost and energy wastage; it involves using energy in an optimized manner to achieve an intended purpose or function.

There is a conspicuous paucity of integrated research that investigates green materials, renewable energy, and energy efficiency in agritourism. Existing research frequently focusses on sustainable building, renewable energy in rural tourism (Panwar, Kaushik, & Kothari, 2011), and energy-efficient technology in hospitality (Zuo & Zhao, 2014). However, few studies have examined how these three components combine to improve overall sustainability performance in farm-based tourism. This gap hinders the availability of practical information for agritourism businesses pursuing holistic eco-innovation initiatives. This study is thus justified in bridging different information by evaluating the combined impacts of material selection, renewable energy adoption, and efficiency measures on environmental, economic, and social outcomes in agritourism facilities.

The ability to enhance sustainability performance within agritourism firms relies mainly on green materials and renewable energy technology. The use of such buildings can greatly minimize their environmental footprint and increase efficiency through the use of energy-efficient designs and environmentally friendly building materials (Nwaogbe et al., 2025). Together with innovative energy management systems, the adoption of renewable energy, for instance, solar and wind, can help in minimizing greenhouse gas emissions (Raj, Prabakaran, & Selvakumar, 2025) through reduced dependency on coal.

"Energy efficiency means the portion of energy input into a machine or system that is used effectively and not lost to useless heat or other wastage," Islam & Hasanuzzaman (2020) assert. Simply expressed, energy efficiency means preserving the same degree of service or quality while providing the same outputs with less energy. Many academics have looked at building energy efficiency and methods of measuring it (Bigiotti et al., 2024). The study focuses on measurements of sustainable energy efficiency in Viterbo, Italy's rural agri-spanace. Energy audits, life cycle assessment (LCA), and life cycle cost (LCC) analysis help to analyze eco-friendly changes like solar systems and heat pumps. Emphasizing the use of green materials and renewable energy in lowering environmental impact, the results show a 51% drop in energy usage and an 81% cost savings.(Kumdorkrb & You, 2025). This work presents a novel optimization technique for agrivoltaic (AgV) systems considering environmental impact, energy output, and financial returns. It shows, using fractional programming, mixed crop-solar PV land use maximises income while lowering emissions. The results show AgV's possible efficiency in land-use compared to conventional single-use methods. (Moazzem et al., 2021) This work uses Life Cycle Assessment (LCA) to examine how environmental effects of clothing products could be lowered. Through analysis of key processes including raw material procurement, manufacturing, transportation, use, and waste, the writers identify areas needing significant development. The results provide possibilities for waste minimising strategies, energy-efficient technologies, and sustainable material choices to lower the whole environmental impact of textile products.

2.1. Hypothesis development

2.1.1. Green Materials and Environmental Impact Reduction

The adoption of green materials has become an essential strategy for enhancing environmental sustainability within agritourism facilities. Green materials refer to environmentally friendly construction and operational materials that minimize resource consumption, reduce waste generation, and lower greenhouse gas emissions throughout their life cycle. The use of recycled materials, biodegradable products, sustainably sourced timber, and eco-friendly packaging contributes significantly to reducing environmental degradation and conserving natural resources. According to research, sustainable building materials can substantially decrease carbon footprints while promoting efficient resource utilization in tourism-related infrastructure. Agritourism facilities that integrate green materials into their operations are better positioned to reduce pollution, preserve ecosystems, and align with sustainable development objectives (Iwuanyanwu & Gil-Ozoudeh, 2024; Ringel, 2021). Consequently, green material implementation is expected to contribute positively to environmental impact reduction.

H_1: The implementation of Green Materials is a crucial factor in reducing the environmental impact of agritourism facilities.

2.1.2. Renewable Energy and Environmental Impact Reduction

Renewable energy adoption has emerged as a key sustainability practice within tourism and hospitality sectors. Renewable energy sources such as solar, wind, biomass, and geothermal energy offer cleaner alternatives to conventional fossil fuels and significantly reduce greenhouse gas emissions. Agritourism facilities often possess extensive land resources that facilitate the installation of renewable energy systems, particularly solar photovoltaic panels and biomass energy technologies. Studies have shown that organizations adopting renewable energy technologies achieve substantial reductions in environmental pollution while enhancing operational sustainability and energy security (Al-Madani et al., 2024; Pata, 2021). By decreasing dependence on non-renewable energy sources, agritourism enterprises can improve environmental performance and contribute to climate change mitigation efforts. Therefore, renewable energy implementation is expected to have a significant effect on environmental impact reduction.

H_2: The implementation of Renewable Energy has a crucial role in the reduction of the environmental impact of agritourism facilities.

2.1.3. Energy-Efficient Practices and Sustainability Performance

Energy-efficient practices involve the optimization of energy consumption through technological innovations, operational improvements, and resource management strategies. Examples include LED lighting systems, smart energy management technologies, efficient heating and cooling systems, water-saving equipment, and energy-monitoring mechanisms. Such practices reduce operational costs while minimizing environmental impacts associated with excessive energy consumption. Previous studies have demonstrated that energy efficiency initiatives significantly enhance sustainability outcomes by improving resource productivity and reducing environmental burdens (Pérez-Lombard et al., 2008; Cagno et al., 2013). Within agritourism facilities, energy-efficient operations contribute directly to sustainable performance by balancing economic, environmental, and social objectives. Therefore, energy-efficient practices are expected to positively influence sustainability performance.

H_3: Energy Efficient Practices play a vital role in improving the sustainability of agritourism facilities.

2.1.4 Mediating Role of Environmental Impact Reduction between Green Materials and Sustainability Performance

The Resource-Based View (RBV) suggests that environmentally responsible resources and capabilities create sustainable competitive advantages. Green material adoption serves as an organizational capability that reduces environmental damage through lower emissions, reduced waste generation, and efficient resource utilization. These environmental improvements subsequently contribute to enhanced sustainability performance. Prior research indicates that environmental impact reduction acts as an important mechanism through which sustainable practices translate into superior organizational sustainability outcomes (Barbieri, 2013; Leonidou et al., 2015). Therefore, environmental impact reduction is expected to mediate the relationship between green material adoption and sustainability performance in agritourism facilities.

H_4: Environmental impact reduction significantly mediates the relationship between sustainability Green Material adoption and sustainability Performance in agritourism facilities.

2.1.5 Mediating Role of Environmental Impact Reduction between Renewable Energy Adoption and Sustainability Performance

Renewable energy implementation directly contributes to lowering carbon emissions and reducing environmental degradation. These environmental improvements create pathways through which renewable energy investments generate broader sustainability benefits, including enhanced environmental reputation, operational resilience, and long-term economic performance. Research has consistently shown that environmental improvements resulting from renewable energy adoption positively influence overall sustainability outcomes (Bilgili et al., 2017; Al-Madani et al., 2024). Thus, environmental impact reduction is likely to serve as a mediating mechanism between renewable energy adoption and sustainability performance (Apergis & Payne, 2014).

H_5: Environmental impact reduction significantly mediates the relationship between Adopting

2.1.6 Mediating Role of Environmental Impact Reduction between Energy-Efficient Practices and Sustainability Performance

Energy-efficient practices reduce resource consumption and operational emissions, leading to significant environmental improvements. These reductions in environmental impact subsequently contribute to improved sustainability performance by enhancing ecological stewardship and operational effectiveness. According to sustainability and environmental management literature, organizations achieve better sustainability outcomes when environmental improvements are effectively integrated into operational strategies (Pérez-Lombard et al., 2008). Therefore, environmental impact reduction is expected to mediate the relationship between energy-efficient practices and sustainability performance (Bohdanowicz, 2006).

H_6: Environmental impact reduction significantly mediates the relationship between energy efficiency Practices and sustainability performance in agritourism facilities.

2.1.7 Environmental Impact Reduction and Sustainability Performance

Environmental impact reduction represents an essential dimension of sustainable development and is widely recognized as a precursor to sustainability performance. Reduced emissions, lower resource consumption, improved waste management, and enhanced ecosystem conservation collectively contribute to the environmental, social, and economic dimensions of sustainability. In agritourism facilities, minimizing environmental impacts strengthens stakeholder trust, improves destination attractiveness, and enhances long-term viability. Previous studies have confirmed a strong positive relationship between environmental performance and overall sustainability outcomes (Barbieri, 2013; Leonidou et al., 2015). Therefore, environmental impact reduction is expected to significantly influence sustainability performance.

H_7: Environmental impact Reduction significant impact on the sustainability performance of agritourism facilities.

3. RESEARCH METHODOLOGY

This paper investigates how sustainability performance in agritourism facilities all throughout India is affected by green materials, renewable energy, and energy efficiency. Primary data were gathered from February 1 to March 30, 2025 using a standardized questionnaire. Using purposive and snowball sampling techniques, respondents with an emphasis on agritourism experts and guests who have personally experienced sustainable agritourism facilities across different regions of India. The survey was shared online via active Facebook and WhatsApp groups, as well as offline at chosen eco-tourism farms including Our Native Village, Navdanya Biodiversity Farm, The Goat Village, Bamboo Saa Farm & Resort, and Dewalokam Organic Farmstay.

Participants were evaluated based on two questions: (1) Have you engaged in farm tourism in any of the farm in India? Have you had the opportunity to experience sustainable farm tourism in this region? A total of 400 individuals were approached, and following validation, 312 responses were determined to be complete and appropriate for analysis. The final dataset comprised a variety of roles, including farm managers, sustainability officers, and operations staff, sourced from five carefully chosen eco-tourism farms recognised for their green infrastructure and renewable practices. The analysis employed Structural Equation Modelling (SEM) to explore the connections between green material usage, renewable energy adoption, energy efficiency, and sustainability performance.

Table 1. Sustainable Practices Adopted by Selected Agritourism Farms in India

S.No	Farm	Location	Sustainable Practices
1	Our Native Village	Karnataka (near Bangalore)	100% solar powered; built with green materials; recognized eco-resort; open to academic collaboration
2	Navdanya Biodiversity Farm (Bija Vidyapeeth)	Uttarakhand	Organic + sustainability leadership; green materials; solar; biodiversity & energy education
3	The Goat Village	Uttarakhand (Nag Tibba & other sites)	Built with stone, mud, bamboo; solar-powered; flagship agritourism eco model
4	Bamboo Saa Farm & Resort	Udaipur, Rajasthan	Uses bamboo architecture; solar energy; energy efficient operations; combines farm + luxury tourism
5	Dewalokam Organic Farmstay	Kerala	Family-run sustainable organic farm; solar + biogas + green buildings; high visitor engagement

Source: Author's own creation/work

3.1. Measurement of the variables

All variables were measured through a five point Likert scale where 1 represents Strongly Disagree while 5 represents "Strongly Agree," using standardized measurement tools developed based on past research literature. This study focused specifically on the individual employee. Although Adopting Renewable Energy consists of 4 scale items, the Sustainable Green Materials Assessment consists of 3. Energy Efficiency Practices consist of 4 scale items; Energy Impact Reduction consists of 4 scale items; and Sustainable Performance consists of 4 scale items.

3.2. Data Analysis Technique

This is the tool used to evaluate the data and a powerful tool when it comes to PLS-SEM and is highly recommended for complex models with a lot of constructs and indicators (Hair et al., 2019). The measurement model was analyzed through CFA, which stands for Confirmatory Factor Analysis. In analyzing the relationship between latent constructs, correlation analysis was used to verify the structural paths among the variables and structural equation modeling (SEM). The measurement model was validated following some critical requirements. All of the exterior loadings were confirmed to be above the recommended level of 0.70. This means that the reliability of the objects has been proven. Reliability, which is one of the requirements to prove the internal consistency, is proven by all of the Composite Reliability (CR) values being above the recommended value of 0.60. Also, Average Variance Extracted (AVE) above the recommended value of 0.50 (Hair et al., 2019; Fornell & Larcker, 1981). Each latent construct showed convergent validity.

4. DATA ANALYSIS

4.1. Participant's Profile

The research got 312 real participants engaged in agritourism from all around India. The sample consisted of 57.1% men and 42.9% females. The majority of participants were between the ages of 25 and 44, with a large proportion possessing postgraduate (44.2%) or undergraduate (35.9%) credentials. Respondents included farm owners/managers (40.4%), agritourism personnel (31.4%), and other stakeholders including government officials and consultants. The majority have 2 to 10 years of expertise in agritourism. Participants were geographically diversified, with representation from North, South, East, and West India, resulting in a broad and balanced demographic profile.

Table 2. Demographic Profile

Variable	Category	Frequency (n)	Percentage (%)
Gender	Male	178	57.10%
	Female	134	42.90%
Age Group	Below 25 years	42	13.50%
	25–34 years	86	27.60%
	35–44 years	109	34.90%
	45 years and above	75	24.00%

Education Level	High School	24	7.70%
	Undergraduate Degree	112	35.90%
	Postgraduate Degree	138	44.20%
	Others (Diploma/Certificate)	38	12.20%
Occupation	Farm Owners/Managers	126	40.40%
	Agritourism Staff/Employees	98	31.40%
	Government/NGO Representatives	42	13.50%
	Others (Consultants, Academics)	46	14.70%
Experience in Agritourism	Less than 2 years	58	18.60%
	2–5 years	116	37.20%
	6–10 years	84	26.90%
	More than 10 years	54	17.30%
Region	North India	97	31.10%
	South India	78	25.00%
	East India	63	20.20%
	West India	74	23.70%

Source: Author's own creation/work

4.2. Measurement Model

The measurement model assessment ensures that the constructs used in the current study are reliable and valid. The Build Sustainable Green Materials (SGM) displayed adequate internal consistency with the loadings from the external variables lying between 0.710 and 0.862. The Cronbach's alpha of 0.741 and composite reliability of 0.852 indicate adequacy of reliability, while the AVE value of 0.659 is an evidence for the convergent validity. On the other hand, the build Adopting Renewable Energy (ARE) possessed strong indicator loadings which varied from 0.832 to 0.887. It had a high Cronbach's alpha of 0.891, composite reliability of 0.925, and AVE value of 0.755 as seen in Table 3.The model fit was evaluated using SRMR, d_ULS, d_G, chi-square, and NFI. The SRMR values for the saturated (0.071) and estimated (0.075) models were below the suggested threshold, signifying a satisfactory fit. The d_ULS and d_G values further validated the model's adequacy. Despite the comparatively elevated chi-square values, this phenomenon is typical in PLS-SEM with bigger sample sizes. The NFI values suggested an adequate model fit. The results indicate that the suggested model exhibits adequate goodness-of-fit.

Table 3. Assessment of Reliability and Validity of Latent Constructs

Contract	Scale Items	Outer Loading	VIF	Cronbach's alpha	Composite reliability (rho_a)	Composite reliability (rho_c)	Average variance extracted (AVE)
Sustainable Green Materials	SGM1	0.855	1.707	0.741	0.77	0.852	0.659
	SGM2	0.862	1.634				
	SGM3	0.71	1.306				
Adopting Renewable Energy	ARE1	0.832	2.037	0.891	0.893	0.925	0.755
	ARE2	0.868	2.423				
	ARE3	0.887	2.691				
	ARE4	0.886	2.608				
Energy efficiency Practices	ENEF1	0.837	1.59	0.825	0.834	0.895	0.74
	ENEF2	0.854	2.14				
	ENEF3	0.889	2.234				

Energy Impact Reduction	EIR1	0.876	2.59	0.888	0.89	0.923	0.749
	EIR2	0.883	2.614				
	EIR3	0.816	1.895				
	EIR4	0.887	2.63				
Sustainable Performance	SUPER1	0.88	2.558	0.88	0.882	0.917	0.735
	SUPER2	0.853	2.33				
	SUPER3	0.862	2.253				
	SUPER4	0.833	2.075				

Source: Author's own creation/work

In the case of Energy Efficiency Practices (ENEF), all the required criteria have been met with item loadings varying between 0.837 and 0.889, Cronbach's alpha being equal to 0.825, composite reliability reaching 0.895 and AVE value equalling 0.740. Environmental Impact Reduction (EIR) was confirmed as an excellent instrument for measurements with outer loadings ranging from 0.816 to 0.887, Cronbach's alpha being equal to 0.888, composite reliability of 0.923 and AVE equal to 0.749. In the case of Sustainability Performance (SUPER), considerable item loadings (0.833 to 0.880), Cronbach's alpha equal to 0.880, composite reliability of 0.917 and AVE of 0.735 have been observed. No multicollinearity was found since all the VIF values of the constructions have been lower than 3.3.

4.3. Discriminate Validity

According to what Fornell and Larcker (1981) said, the Fornell-Larcker criteria was used to check discriminant validity. Each component must have larger square roots than its correlations with other components in order to meet this standard. AVE stands for Average Variance Extracted. We can see the outcomes of the Fornell-Larcker test in Table 4. The bold diagonal numbers reveal the square roots of AVEs; the off-diagonal values show the construct correlations. Table 1 indicates that every construct has sufficient discriminant validity as the square root of its AVE (bolded diagonal items) exceeds its correlation with any other latent construct (off-diagonal components). The Fornell-Larcker requirements are satisfied here (Hair et al., 2021). Since each of the constructions shows adequate independence from one another, they are obviously distinct from the others inside the model.

Table 4. Discriminant Validity

	ARE	EIR	ENEF	SGM	SUPER
ARE	0.869				
EIR	0.743	0.866			
ENEF	0.632	0.781	0.86		
SGM	0.727	0.731	0.667	0.812	
SUPER	0.653	0.792	0.651	0.692	0.857

Source: Author's own creation/work

Indicators of dependability also confirmed convergent validity and internal consistency. Convergent validity and internal reliability were confirmed by all constructs attaining Cronbach's alpha values above 0.70, composite reliability (CR) values above 0.80, and AVE values above the 0.50 threshold (Hair et al., 2021).

4.4. Hypothesis Testing Result

There were statistically significant correlations between the hypothesised constructs, as shown by the results of the hypothesis testing. Sustainable green materials' (SGM) effect on EIR was the focus of the first hypothesis (H1). The use of environmentally friendly materials significantly helps to lessen the environmental effect in agritourism settings, as shown by the positive and significant connection ($\beta = 0.207$, $t = 3.325$, $p = 0.001$).

Table 5. Hypothesis testing result

Hypothesis	Relation	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics (|O/STDEV|)	P values
H1	SGM -> EIR	0.207	0.209	0.062	3.325	0.001
H2	ARE -> EIR	0.31	0.31	0.065	4.752	0
H3	ENEF -> EIR	0.447	0.446	0.066	6.731	0
H4	SGM -> EIR -> SUPER	0.12	0.122	0.039	3.033	0.002
H5	ARE -> EIR -> SUPER	0.18	0.18	0.04	4.458	0
H6	ENEF -> EIR -> SUPER	0.259	0.26	0.054	4.767	0
H7	ENEF -> SUPER	0.259	0.26	0.054	4.767	0

Source: Author's own creation/work

The positive impact of renewable energy sources on reducing environmental damage was further demonstrated by the support of Hypothesis H2, which examined how Adopting Renewable Energy (ARE) affected EIR ($\beta = 0.310$, $t = 4.752$, $p < 0.001$). Energy Efficiency Practices (ENEF) stood out among the three predictors in terms of their direct impact on EIR (H3: $H = 0.447$, $t = 6.731$, $p < 0.001$), highlighting the notable environmental benefits of energy-conserving technologies and activities, as seen in Table 5.

The research also looked at how EIR mediated the connection between the three sustainable behaviours and SUPER, the acronym for Sustainability Performance. All three mediation hypotheses were confirmed by the results. The indirect path from ARE to SUPER (H5: $\beta = 0.180$, $t = 4.458$, $p < 0.001$) and from ENEF to SUPER (H6: $\beta = 0.259$, $t = 4.767$, $p < 0.001$), as well as the indirect influence of SGM on SUPER through EIR (H4), were all significant. In order to translate sustainable practices into better sustainability performance, these results show that reducing environmental effect is a mediating factor. At last, we looked at how ENEF affected SUPER directly in Hypothesis H7. In addition to its indirect influence through EIR, energy efficiency also has an independent impact on improving sustainability outcomes in agritourism businesses, as demonstrated by the results of a significant direct association ($\beta = 0.259$, $t = 4.767$, $p < 0.001$). (Figure 1)

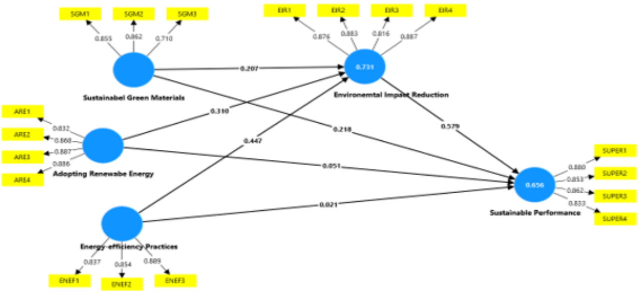

Figure 1. Structural Model showing Parameter estimates. Source: Author's own creation/work

5. CONCLUSION

This paper provides a detailed understanding of the crucial importance of sustainable activities, such as using environmentally friendly materials, using renewable sources of energy, and employing energy-saving technologies, in enhancing the sustainability performance of agritourism businesses. It is found that all three activities contribute significantly to reducing environmental impact, with energy-saving technologies being the most effective one. This paper indicates that an important mediator responsible for converting eco-innovative ideas into tangible sustainability performance outcomes is reducing environmental impact.

The results also confirm that including sustainable green materials, renewable energy technologies, and energy-efficient methods reduces carbon emissions and energy consumption while improving the operational effectiveness and reputation of agritourism companies. These results support the claim that in the rural tourism industry, sustainability is not only a strategic advantage that enhances competitiveness and long-term viability but also an environmental requirement. By means of a mediating construct environmental impact reduction this study improves theoretical understanding and connects different literature often analysing sustainability solutions in isolation. It offers evidence-based support on matching operational management and infrastructure development with global sustainability goals to agritourism operators, policy makers, and rural development partners. To enable the broad application of green technology in agritourism, the study underlines the need of capacity building, stakeholder collaboration, and incentive-driven regulatory systems. Agritourism providers have to change as environmentally conscious tourists affect travel patterns by including sustainability into their basic values and daily activities. Along with solar panels and biogas systems for energy generation, the facility uses bamboo, mud, and recycled wood for building. To maintain environmentally friendly operations, cut costs, and guarantee visitor happiness, the farm uses advanced technology and runs regular staff training sessions.

5.1. Practical Implications

The theoretical consequences of this work are complicated and greatly advance the more general debate on environmental sustainability in the tourist sector. First of all, it deepens and broadens current concepts of sustainability and environmental management by providing empirical evidence that sustainable inputs such as environmentally friendly materials and renewable energy beneficially influence environmental outcomes within the domain of agritourism. Second, the study underlines environmental impact reduction (EIR) as a necessary mediator, therefore highlighting its central function as a basic mechanism by which sustainable activities enhance general sustainability performance. This finding improves theoretical models in environmental behavior and study on sustainable tourism. Thirdly, the study offers a multifarious perspective of sustainability performance by analyzing the direct and indirect effects of material sustainability, renewable energy, and energy efficiency, so improving the knowledge of how different operational factors interact to achieve agritourism sustainability. In the conclusion, the results confirm its relevance in analyzing complex interactions in rural sustainability research and underline its importance in underdeveloped fields like agritourism, so supporting its application in next sustainability studies.

5.2. Theoretical implications

The pragmatic results of this study are much needed for agritourism entrepreneurs, legislators, and rural tourism stakeholders. The findings offer strategic guidance for agritourism facility managers by emphasising the necessity of investing in sustainable materials and renewable energy sources, which may markedly diminish environmental impact and enhance long-term operational efficacy. Secondly, the study highlights the importance of energy-efficient techniques, portraying them as economical and scalable solutions, especially advantageous for agritourism enterprises with constrained financial and technical resources. Thirdly, the results show sustainability as a competitive difference, which lets agritourism businesses attract environmentally concerned visitors by stressing their green credentials including certified hotels and proving their environmental commitment. The study offers information for rural development organizations and legislators to create customized incentives, subsidies, and training courses encouraging the acceptance of sustainable materials and renewable energy in agritourism. The study emphasizes the need of capacity building and staff training in environmentally friendly building methods, energy monitoring, and everyday environmental practices thus guaranteeing that sustainability is included into both infrastructure and the operational culture of agritourism companies.

5.3. Limitation

This study offers important new perspectives on sustainability in agritourism, even if it is important to recognize some constraints. Examining a limited geographic area of five diffferent farms of India with an eye on a small number of eco-tourism farms, As such, the findings could not be generally applicable in places defined by different environmental conditions, laws, and agritourism operations. Second, the data collecting was cross-sectional and based on responses self-reported. Such strategies might be prone to bias as people could provide socially acceptable answers or overestimate their environmental activities. This restriction might compromise the claimed sustainability performance's accuracy. The study concentrated just on three main sustainability elements: environmentally friendly materials, renewable energy, and energy-efficient methods of operation. The study disregarded other important elements such waste management, water use efficiency, and conservation of biodiversity, therefore perhaps limiting the complete evaluation of sustainable solutions.

5.4. Future Research Directions

Future research should include agritourism businesses from more sites to offer more generalizable insights and greater comparisons. Including trash reduction, water conservation, and community involvement among other aspects of sustainability—would help to give a more complete picture of environmentally friendly methods in rural tourism. Furthermore, using longitudinal research might help to evaluate how materials' and green technologies' integration influences performance over time. Furthermore, analysing the influence of facilitating elements such as policy endorsement, personnel education, and visitor consciousness may reveal significant mechanisms for enhancing sustainability results. Insights obtained may prove beneficial for policymakers, tourist planners, and agricultural proprietors aiming to advocate for responsible, low-impact tourism that aligns with environmental and economic objectives.

6. FUNDING STATEMENT

Data were obtained from secondary source. The research has been carried out in accordance with the COPE guidelines

7. AUTHORS CONTRIBUTIONS

Dr. Amit Gusain: Conceptualization, Literature Review, Data Collection, Data Analysis, Interpretation of Results, Writing – Original Draft.

Dr. Monika Yadav: Research Design, Methodology

Dr. Sunita Badhwar: Supervision, Review and Editing, Validation of Findings.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest regarding the publication of this paper.

DATA AVAILABILITY STATEMENT

The datasets generated and/or analyzed during the current study are available from the corresponding author on reasonable request.

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