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Renewable Energy Strategies in Conservation Areas: Challenges, Opportunities, and Policy Implications

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Abstract:- Indonesia's National Energy Policy aims to harness renewable energy resources while balancing biodiversity conservation. Renewable energy technologies such as solar, wind, hydro, marine, geothermal, and bioenergy offer sustainable solutions but pose environmental challenges. This paper focuses on the renewable energy potential in conservation areas like Raja Ampat, which boasts rich marine biodiversity. The study emphasizes the need for specific regulations to ensure the sustainable deployment of these technologies. Using a systematic literature review, we identified research trends, challenges, and solutions for renewable energy development over the past decade, focusing on Raja Ampat's unique ecological context. The methodology involved a comprehensive search of major academic databases from 2014 to 2024, selecting peer-reviewed articles pertinent to renewable energy, conservation, and sustainable development. The review highlights key trends in renewable energy technologies, policy approaches, and the importance of ecosystem-based assessments for marine energy projects. Challenges include limited access and infrastructure, high initial costs, and the need for local expertise. Solutions proposed involve financial incentives, capacity building, and strict environmental policies to balance energy development with conservation. This study provides a foundation for future research and policy development, offering practical guidance for implementing renewable energy projects in conservation areas. With appropriate policies and strategic partnerships, Raja Ampat can be a model for integrating renewable energy and conservation, contributing to sustainable development and improved quality of life for local communities.

Keywords: Renewable energy, Conservation areas, Raja Ampat, Biodiversity, Sustainable development, Energy Policy, Systematic literature review.

1. Introduction

Indonesia's National Energy Policy has provided a general framework for utilizing renewable energy resources. Developing renewable energy technologies presents opportunities and challenges for biodiversity conservation. Energy sources such as solar, wind, hydro, marine,

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geothermal, and bioenergy offer clean and sustainable energy options, but their deployment requires careful consideration to minimize adverse impacts on marine ecosystems (Inger et al., 2009). However, specific regulations and guidelines for the sustainable utilization of energy resources still need development and adjustment (Siswandi, 2017). Indonesia's renewable energy policy, regulated by Law No. 30/2007, mandates an increase in the provision of New and Renewable Energy (EBT). The derivative policy in the form of the National Energy Policy (KEN), stipulated through Government Regulation No. 79 of 2014 and managed by the National Energy Council (DEN), targets the utilization of EBT of 23% by 2025 which has progressed to reach 31% by 2050. Presidential Regulation No. 4/2016 has become a reference for renewable energy through various incentives.

Renewable energy is not only beneficial for energy generation but also energy storage, increasing the efficiency and reliability of renewable energy systems (Wang et al., 2019). Currently, China is actively exploring the prospects and development path of the renewable energy industry, utilizing vast energy resources for sustainable energy production (Wang et al., 2023). Hou et al. (2018) explained that integrating renewable energy into the energy mix can help transition away from fossil fuels, which is in line with global efforts to anticipate climate change.

In developing the renewable energy sector, it is necessary to start by evaluating the environmental implications of energy extraction. The study conducted by Pezy et al. (2019) emphasizes the importance of an ecosystem-based approach to assessing the impacts of marine renewable energy projects. These assessments are critical to inform the decision-making process and ensure the sustainable development of marine energy resources. Careful planning is required to determine suitable areas for marine renewable energy installations to minimize conflicts with existing marine activities (Mateescu et al., 2018). There are various renewable energy technologies, such as wave and wind power generation, that allow for maximized energy production while minimizing environmental impacts (Astariz & Iglesias, 2017). This can be done through strategic site selection for co-located renewable energy projects. Such strategies are intended to achieve ambitious renewable energy targets and reduce dependence on conventional energy sources (Tirsu & Uzun, 2018). Stablo & Ruppert-Winkel, 2012 emphasized that integrating energy conservation measures into renewable energy policies can have great potential to improve the sustainability of the overall energy system.

Conservation areas such as Raja Ampat in Indonesia are archipelagos consisting of many coral islands, with four main islands namely Waigeo Island, Batanta Island, Salawati Island, and Misool Island. On these four main islands, the people mostly work as fishermen. The main attraction of Raja Ampat is its waters, which are on the list of the ten best waters in the world due to the richness of flora and fauna and the preservation of marine nature. The Raja Ampat Islands, which are part of the Bird's Head Seascape, have the largest coral reef biodiversity in

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the world (Veron et al., 2009; Allen & Erdman, 2009, 2012; Mangubhai et al., 2012). Conservation of these coral reefs is of global importance, as Raja Ampat waters contain 574 species of corals, 699 species of mollusks, and 1,437 species of fish (Donnelly et al., 2002; Veron et al., 2009; Allen & Erdman, 2009, 2012). Raja Ampat is home to 540 coral species, 1,511 fish species, and a variety of other marine organisms, making it an important global biodiversity center (Rehbein et al., 2020).

The development of renewable energy facilities can threaten critical marine ecosystems. Studies identifying existing and planned renewable energy facilities within conservation areas emphasize balancing energy development with biodiversity conservation (Gasparatos et al., 2017). True renewable energy development should support marine biodiversity, especially in ecologically sensitive areas such as Raja Ampat. Prioritize biodiversity conservation and sustainable development practices in marine energy project planning. It can be argued that through a holistic, ecosystem-based approach, renewable energy policy development can harness the potential of marine renewable energy while safeguarding marine ecosystems to meet the needs of future generations.

On the one hand, renewable energy systems are essential for providing sustainable and reliable power in remote and underdeveloped areas such as Raja Ampat. On the other hand, challenges such as limited access to traditional energy sources and the high cost of centralized power grid expansion may encourage the exploration of renewable energy strategies (Akella et al., 2007). Another aspect is the integration of hybrid energy systems by combining wind, solar, and diesel power to ensure sustainable electricity supply, especially in coastal areas (Kasaeian et al., 2019). The use of mini-grids in small islands and rural areas can improve energy access and economic development (Eras-Almeida & Egido-Aguilera, 2019). The transition to renewable energy in remote communities can reduce energy poverty and the environmental impact of traditional energy sources such as diesel generators (Setyowati, 2020). Eras-Almeida & Egido-Aguilera, (2020) argued that off-grid technologies as renewable energy solar power generation systems such as stand-alone solar PV or solar photovoltaic systems and mini-grids offer reliable and affordable energy services. To find viable renewable energy solutions, Peñalvo-López et al. (2019) suggested a method that considers the energy situation, renewable power generation potential, demand-side management, and socio-economic factors.

Implementing renewable energy systems in remote areas requires a multidimensional assessment that considers technical, economic, and social factors. Based on a study conducted by Hjallar, (2023), the importance of evaluating energy needs, consumption patterns, geographical constraints, and community needs to adopt renewable energy solutions. Hybrid renewable energy systems offer energy independence and sustainability, reduce dependence on diesel generators, minimize greenhouse gas emissions, and improve energy security (Ibrahim et al., 2018; Lal et al., 2011). Integrating renewable energy sources in remote areas

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provides an opportunity to improve energy access and promote economic development (Arriaga et al., 2013). Technologies such as solar, wind, and micro-hydro power build reliable and environmentally friendly energy systems, which contribute to long-term sustainability and resilience (Arriaga et al., 2013). The strategic deployment of renewable energy systems in remote areas such as Raja Ampat holds significant promise for addressing energy challenges, opening up economic opportunities, and supporting sustainable development outcomes.

Through the development of renewable energy, globally and locally it is very important as an effort to achieve sustainable development goals and can even improve people's living standards (Elavarasan et al., 2020). Renewable energy can reduce greenhouse gas emissions and the negative impacts of conventional energy sources (Bhaskar & Sendilvelan, 2017). In conservation areas such as Raja Ampat, challenges such as limited accessibility, high investment costs, and lack of understanding by local communities could potentially hinder the adoption of renewable energy (Grantham et al., 2013; Rashid, 2024; Nuraini et al., 2021).

The availability of abundant natural resources such as sunlight, wind, and water provides a strong basis for renewable energy development in Raja Ampat. With this renewable energy, it can reduce dependence on fossil fuels and on the other hand can increase energy security (Salim & Alsyouf, 2020). Renewable energy-based ecotourism development provides dual benefits in environmental conservation and local economic empowerment (Tjilen et al., 2022). Renewable energy development in Raja Ampat must consider the sustainability of marine and coastal ecosystems, which are important assets for the livelihoods of local communities (Rude et al., 2015). Through the implementation of policies towards the wise management of natural resources and the marine environment, it is important to maintain ecosystem balance and support the sustainability of the tourism and fisheries sectors (Atmodjo et al., 2019). Collaboration between the government, non-governmental organizations, and local communities is essential to create policies that support the development of renewable energy and sustainable ecotourism (Nuraini et al., 2021).

2. Objectives

Raja Ampat, with its abundant natural resources and enormous potential for renewable energy development, can be a model for renewable energy implementation for the welfare and sustainability of the region. This article will review the literature on challenges, opportunities, and policy implications in renewable energy development in Raja Ampat, demonstrating that with the integration of renewable energy technologies, sustainable utilization of natural resources, and active participation of all stakeholders, Raja Ampat can achieve sustainable development and a better quality of life. This systematic literature review aims to identify research trends, challenges, and solutions in renewable energy development over the past ten

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years and explore how Raja Ampat can apply these findings to support sustainable development and improve the quality of life of local communities.

3. Methods

A literature search was conducted on major academic databases, including Google Scholar, ScienceDirect, and JSTOR. Keywords used in the search included Raja Ampat, renewable energy, energy policy, sustainable development, conservation, and tourism development. The search was conducted to identify articles published in the last ten years, from 2014 to 2024. The combination of keywords ensured comprehensive coverage, with a focus on studies relevant to renewable energy development in conservation areas such as Raja Ampat juxtaposed with other regions.

Inclusion criteria ensured that only a sample of relevant, high-quality articles were included in this review. The articles met the following criteria: published in peer-reviewed journals, published within the last ten years (2014-2024), and focused on renewable energy development, energy policy, or sustainable development in conservation areas or remote areas. Exclusion criteria included: articles that were not available in full text, articles that were not relevant to the geographic (Raja Ampat) or topic focus, and articles that were not peer-reviewed or published in less reputable sources.

The selection process consisted of a) conducting an initial search using predetermined keywords to search for articles in academic databases, b) screening titles and reading abstracts and then filtering by title and abstract to evaluate their relevance, c) conducting a full-text evaluation based on articles that passed the initial screening were read in full to ensure that they met the inclusion criteria.

Selected articles were systematically analyzed to identify research trends, challenges, and solutions in renewable energy development in the Raja Ampat region. This analysis included: a) research trends, by identifying key research foci in the literature, such as the most discussed types of renewable energy technologies (e.g., solar, wind, ocean energy) and policy approaches reviewed; b) challenges, by identifying technical, financial and social barriers that hinder the implementation of renewable energy in remote areas such as Raja Ampat; c) opportunities, by discovering the potential use of innovative technologies, international cooperation, and socio-economic benefits of renewable energy.

Based on the findings from the articles analyzed, they were synthesized to provide a comprehensive picture of the state of renewable energy development in Raja Ampat. The synthesis stage includes a) identifying research gaps by highlighting areas that have not been researched or require further research; and b) policy recommendations, by developing policy recommendations based on the findings to support the implementation of renewable energy in Raja Ampat.

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Literature sources used in this review include a range of reputable academic journals and publications. Some of these are a) Google Scholar, which was used to search for articles and identify frequently cited sources in relevant research areas; b) ScienceDirect, which provides access to scientific journals covering technical and policy studies on renewable energy; c) JSTOR, which provides articles covering historical, social, and policy aspects of renewable energy development.

With this methodology, this literature review aims to provide a comprehensive overview of renewable energy development in Raja Ampat, identify existing challenges, and suggest opportunities and solutions that can be applied in the region.

4. Results

Raja Ampat, a region known for its stunning natural beauty and rich marine biodiversity, has significant potential to develop renewable energy sources that benefit local communities and sustainable tourism. Solar energy is one of the renewable energy sources that can be utilized in Raja Ampat. With its tropical climate and abundant sunlight throughout the year, Raja Ampat is an ideal location to install solar panels to generate electricity for homes and tourism facilities scattered throughout the island (Setyawan et al., 2018). In addition, wind energy is another viable renewable energy option in Raja Ampat, as several areas in the region have sufficient wind speed to support wind power generation. Strategic placement of wind turbines in these locations could help meet local energy needs sustainably (Beale et al., 2019).

In addition, the vast expanse of ocean in Raja Ampat provides opportunities to harness ocean energy, including wave and tidal energy. The vast waters of the region offer significant potential for developing sustainable energy sources that are environmentally friendly and stable in the long term (McLeod et al., 2009). By utilizing these renewable energy sources, Raja Ampat can reduce dependence on fossil fuels, reduce environmental impacts, and contribute to the global transition to clean energy. In addition to its renewable energy potential, Raja Ampat is also well known for its conservation efforts and the diversity of marine species that inhabit its waters. Various studies have highlighted the importance of marine protected areas and conservation initiatives in Raja Ampat, emphasizing the need to protect rich coral reefs, fish populations, and iconic species such as the reef manta ray and oceanic manta ray (Rude et al., 2015 Atmodjo et al., 2019).

Designating protected areas and implementing conservation strategies are essential in preserving Raja Ampat's marine ecosystems for future generations and supporting sustainable tourism practices. Raja Ampat's unique geography and biodiversity have attracted researchers and conservationists to study and monitor various aspects of the region's ecosystems. Research on reef manta rays has provided insights into their site fidelity, movement patterns, and population dynamics in Raja Ampat waters, highlighting the importance of protecting these

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majestic creatures and their habitats (Siburian, 2023; Yuanike et al., 2019). In addition, research on the biodiversity of hard corals, echinoderms, and other marine organisms in Raja Ampat has contributed to our understanding of the intricate relationships within coral reef ecosystems in the region (Anzani et al., 2019; Adesetiani et al., 2021; Septiana et al., 2023).

Sustainable tourism development in Raja Ampat is another important aspect that requires attention to ensure the preservation of natural resources and the well-being of local communities. Promoting community-based ecotourism, homestay initiatives, and strategic planning for tourism infrastructure, such as modern port design and central business district development, are crucial to balancing economic growth with environmental conservation (Firmandhani et al., 2019). By implementing sustainable tourism practices and involving local communities in the management of tourism activities, Raja Ampat can increase its attractiveness as a major tourist destination while maintaining its ecological integrity, and the cultural heritage and traditional practices of Indigenous communities in Raja Ampat play an important role in shaping the region's identity and conservation efforts. Various studies have highlighted the importance of local knowledge, such as the traditional marine resource management system known as "sasi", in marine conservation and sustainable resource use in Raja Ampat. Raja Ampat can foster a harmonious relationship between human activities and the natural environment by recognizing and incorporating local knowledge into conservation strategies and ecotourism initiatives. In conclusion, Raja Ampat is at a tipping point where promoting renewable energy sources, marine conservation efforts, sustainable tourism practices, and preservation of cultural heritage are critical to ensuring the long-term sustainability of the region. By leveraging natural assets, scientific research, and community engagement, Raja Ampat can become a model for integrated coastal management, biodiversity conservation, and green energy transition in a rapidly changing world.

5. Discussion

Renewable energy development strategies are essential for energy and environmental sustainability. Various studies and scientific articles have highlighted various approaches and strategies that can be applied to renewable energy development. One of the approaches emphasized is renewable energy-based electrification as a solution for various economic sectors Sulaiman et al. (2021). This suggests that the use of renewable energy in electricity can be the foundation for a more sustainable energy transformation. SWOT analysis of renewable energy potential, such as micro-hydro power plants, also provides important insights in formulating effective development strategies (Pramudita et al., 2021). Aggressive strategies that include increasing investment, building supporting business centers, maintaining market dominance, and involving the role of regions and communities can be the foundation of sustainable renewable energy development. In addition, diversification of energy sources is also the focus of renewable energy development strategies. Various studies have highlighted

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that in addition to fossil fuels, renewable energy such as solar, biomass, and water have great potential to meet people's electricity needs (Sartika et al., 2023).

Various renewable energy sources can create a more sustainable and environmentally friendly energy system. Renewable energy development also involves very important economic aspects. The economic analysis of the application of solar power plants for households highlights the policies implemented to accelerate the development of new renewable energy (Sumariana et al., 2019). Policies that support renewable energy development are essential to create an investment environment conducive to developing renewable energy infrastructure. Increasing community competence through training and designing solar panel electrical installations is also a relevant strategy in renewable energy development (Yana et al., 2021). Increasing people's understanding and skills in using renewable energy can be a strong basis for the widespread adoption of renewable energy technologies. In addition, the design and economic analysis of the application of solar power plants (PLTS) for villas in Bali shows the importance of collaboration between the government and the tourism sector in supporting renewable energy development (Irawati et al., 2021). Integrating renewable energy into the tourism sector can provide dual benefits, supporting sustainable tourism while reducing the carbon footprint. Policymakers also play an important role in renewable energy development.

Studies on the prospects of renewable energy development in ASEAN countries emphasize the importance of accurate data in planning and implementing renewable energy policies (Takayasa et al., 2021). The involvement of policymakers in identifying potential sites, designing appropriate policies, and evaluating project proposals are important steps in encouraging investment in the renewable energy sector. Introducing renewable energy to various stakeholders, including students, communities, and women's organizations, is also an effective strategy to support renewable energy development (Prasetiyo et al., 2022; Candra et al., 2020; Harrison et al., 2021). Education and awareness of the potential of renewable energy can open up new opportunities to utilize environmentally friendly energy sources.

In addition, the development of renewable energy technology is also the focus of renewable energy development strategies. The utilization of technologies such as solar panels, wind turbines, and biogas is essential in creating a sustainable energy system (Indrawati et al., 2021; Salsabila, 2023). Innovative solutions can be created to meet increasing energy needs by continuing to develop renewable energy technologies. Renewable energy development can also be integrated into the agriculture, fisheries, and livestock sectors to create an integrated renewable energy-based agricultural system. A more efficient and sustainable agricultural system can be created by utilizing renewable energy in the agricultural sector. In the Indonesian context, the potential for renewable energy is enormous, including solar, wind, water, geothermal, bioenergy, and ocean energy. By utilizing the abundant renewable energy potential, Indonesia can accelerate the transition to clean and sustainable energy. Overall, the

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renewable energy development strategy involves various aspects ranging from policy, technology, and education to cross-sector collaboration. By implementing a holistic and integrated strategy, renewable energy development can be crucial in creating a sustainable and environmentally friendly energy system.

5.1.Challenges in Renewable Energy Implementation

The implementation of renewable energy in conservation and tourism areas faces several challenges that must be overcome to apply clean energy technologies. One of the main challenges faced is the existence of barriers to adopting renewable energy technologies, as was the case in India Luthra et al. (2015). Factors such as lack of awareness of the benefits of renewable energy, technical limitations, and financial aspects are often barriers to implementing renewable energy in conservation and tourism areas. In addition, the impact of renewable energy development on biodiversity and conservation areas is a significant concern when implementing this technology. Studies have highlighted that developing renewable energy infrastructure, such as wind and solar power plants, can threaten globally essential conservation areas (Rehbein et al., 2020).

The balance between renewable energy development and biodiversity conservation is a challenge that must be addressed in the context of clean energy implementation in conservation areas. In addition, renewable energy implementation in tourism areas also faces challenges related to sustainability and environmental impacts. Studies have highlighted that renewable energy development in the tourism sector must consider the visual and environmental impacts of clean energy infrastructure, which can affect the tourist experience and the tourism industry (Tverijonaite et al., 2019). Therefore, careful planning and cross-sector collaboration are vital in addressing this challenge.

In addition, financial sustainability is also an essential factor in the implementation of renewable energy in conservation and tourism areas. Studies have highlighted that securing sufficient funding for renewable energy projects is often a significant barrier to adopting these technologies (Alola & Alola, 2018). Collaboration between the government, private sector, and financial institutions is needed to create a sustainable funding model for clean energy projects. In addition, integrating renewable energy with sustainability policies and practices within the tourism sector is also a challenge that needs to be addressed. Studies have highlighted harmonizing renewable energy development and sustainable tourism practices requires coordination between relevant stakeholders (Calderón-Vargas et al., 2021).

Developing policies that support integrating renewable energy with sustainable practices in the tourism sector is essential in overcoming this challenge. In addition, participatory and inclusive approaches are vital to overcoming the challenges of renewable energy implementation in conservation and tourism areas. Involving various stakeholders, including local communities, non-governmental organizations, and the private sector, in the planning and implementing of renewable energy projects can increase acceptance and support for these clean technologies (Hermawati & Rosaira, 2017). Cross-sector collaboration and participation from

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various parties are effective strategies for facing complex challenges in renewable energy implementation.

In addition, ongoing monitoring and evaluation are important aspects of addressing the challenges of renewable energy implementation in conservation and tourism areas. Studies have highlighted the importance of monitoring the performance of renewable energy projects, including the environmental, social, and economic impacts of implementing these clean technologies (Edl & Dzikuć, 2023). By conducting regular evaluations, emerging issues can be identified, and necessary improvements can be made to increase the effectiveness of renewable energy projects. By considering these challenges and implementing the right strategies, renewable energy development in conservation and tourism areas can be one of the solutions to achieve environmental and economic sustainability. Cross-sector collaboration, active stakeholder participation, careful planning, and continuous monitoring are crucial to overcoming challenges and creating a sustainable environment through renewable energy.

Some of the critical challenges in implementing renewable energy in Raja Ampat include:

5.1. Access and Infrastructure

In the context of limited access and infrastructure being a significant obstacle in developing conservation and tourism areas, several references can provide relevant insights into this challenge. One reference is a study that identified tourism potential in a village by highlighting poor access to the location of Kurniawan's tourist destination (2021). This shows that limited access can hinder the development of tourism potential in an area. In addition, tourism destination stakeholder analysis can also provide a critical perspective regarding the involvement of various parties in setting policies, supporting funding, and maintaining tourism infrastructure (Raharjana et al., 2019). Strong stakeholder engagement can be vital in overcoming the challenges of limited access and infrastructure in developing tourism areas.

The institutional design of self-management of tourism areas is also essential in overcoming access and infrastructure barriers. Tourism area management involving village-owned enterprises (BUMDes) and paying attention to community participation and management sustainability can be an effective strategy for optimizing tourism infrastructure (Guntur, 2024). A sustainable management system can be created by directly involving the community and paying attention to better access needs.

Mass tourism optimization strategies in conservation areas can also provide insight into efforts to manage access and infrastructure amid increasing tourist visits (Siswantoro et al., 2012). An optimized tourism management strategy can help overcome the challenges of limited access and infrastructure by considering environmental sustainability and natural resource conservation. The utilization of mangrove conservation areas for tourism has also been the focus of several studies, highlighting the potential for tourism development in the area (Pratama & Rahmawati, 2017). However, it should be noted that tourism development can impact the environmental system in conservation areas, so it needs to be done carefully to maintain environmental sustainability.

In addition, implementing collaborative governance policies in tourism area governance can also be a strategy for overcoming access and infrastructure barriers (Maarif, 2023). Collaboration between local governments, tourism promotion agencies, and non-profit

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organizations can help improve tourism infrastructure and overcome limited access constraints. Renewable energy, such as solar power plants for village street lighting, can also improve access and infrastructure in remote areas (Wati, 2023). By utilizing renewable energy, an environmentally friendly energy system can be created and support the development of better tourism infrastructure. Also, community-based homestay tourism business development strategies can be a model for overcoming access and infrastructure barriers in tourism areas (Ali et al., 2018). By involving local communities in developing tourism businesses, better access and infrastructure that supports sustainable tourism growth can be created.

Community empowerment in conservation area management and tourism is also an essential strategy for overcoming access barriers and limited infrastructure (Meidiana et al., 2020). By involving communities in managing natural resources and tourism infrastructure, a sustainable system can be created, and better access needs can be addressed. In the context of successfully implementing natural resource conservation policies, effective leadership is also essential in overcoming access and infrastructure barriers (Dewi et al., 2022). With strong and collaborative leadership, management strategies can be created that consider the environment's sustainability and infrastructure that supports tourism.

By considering various relevant aspects from the references provided, various strategies and approaches can be identified that can be used to overcome access and infrastructure barriers in conservation and tourism development. A sustainable and inclusive tourism environment can be created by involving various stakeholders, designing supportive policies, and paying attention to environmental sustainability.

5.2. Funding

In the context of high initial costs for installing renewable energy technologies, often an obstacle, relevant references can provide deep insights into this challenge. One such reference is a study that discusses renewable energy investment strategies and opportunities for further research Wüstenhagen & Menichetti (2012). This research highlights that substantial private investment is needed to achieve the public policy goals of increasing the share of renewable energy and preventing dangerous climate change. In addition, references that discuss sustainable solutions for green financing and investment in renewable energy projects can also provide a critical perspective regarding the declining costs of renewable energy technologies (Taghizadeh-Hesary & Yoshino, 2020). For example, the price of solar PV modules has fallen by about 80% since the end of 2009, and the price of wind turbines has fallen by 30-40%.

Analyzing the financing conditions for renewable energy technologies can also provide valuable insights into reducing initial installation costs (Egli & Steffen, 2018). The effects of these financing conditions can contribute to reducing renewable energy's levelized cost of electricity (LCOE). In addition, the study of renewable energy financing and its impact has also become relevant in the context of high initial costs for clean energy technology installations (Mazzucato & Semieniuk, 2018). The financing of renewable energy projects and the factors that influence such financing can be vital in overcoming the constraint of high initial costs.

A crowdfunding approach for renewable energy projects can also be a strategy for overcoming the challenge of high initial costs, especially in remote areas (Lam & Law, 2016). Funding

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through community participation can help reduce the initial cost burden of installing renewable energy technologies. In addition, research on local government attitudes and behaviours in renewable energy development can also provide insight into efforts to finance clean energy projects in remote areas (Rakowska & Ozimek, 2021). The involvement of local governments in supporting the financing of renewable energy projects can be an essential strategy in overcoming the constraint of high initial costs. Studies on the linkages between green finance, renewable energy investment and carbon markets can also provide relevant perspectives on clean energy project financing (Tian-yu & Ke, 2023). Understanding the relationship between different aspects of finance and investment in renewable energy can help identify solutions to overcome high initial costs.

The approach to predicting the country's financial capacity for renewable energy projects can also be a strategy for overcoming the constraints of high initial costs (Setyowati, 2020). The financing potential of renewable energy projects in remote areas can be identified by considering economic and financial factors. In addition, research on the financing efficiency of the renewable energy industry can also provide essential insights into the financing of clean energy projects (Steffen, 2018). Understanding the factors influencing renewable energy project financing can help identify strategies to reduce initial installation costs. By considering various relevant aspects of the references provided, it is possible to identify different strategies and approaches that can be used to address the challenge of high initial costs for renewable energy technology installations, especially in remote areas. Involving various stakeholders, designing supportive policies, and considering innovative financing solutions can create an enabling environment for clean energy development in various locations, including remote areas.

5.3. Human Resources:

Based on the references provided, the study by Fouche & Brent (2019) entitled "The Journey to Renewable Energy for Sustainable Development at the Local Government Level: The Case of Hessequa Municipality in South Africa" can be particularly relevant to the challenge of limited local expertise and skills in renewable energy technologies. This research conducted with Hessequa Municipality in South Africa will likely explore the practical aspects of implementing renewable energy projects at the local government level. This could show how local governments can address skill shortages and skill gaps in sustainable energy development.

Furthermore, the study by Petrakopoulou (2017) entitled "Social Perspectives on Renewable Energy Autonomy in Geographically Isolated Communities: Evidence from a Mediterranean Island" can also provide valuable insights into human resource-related challenges in renewable energy projects. This research will likely explore the social dynamics and community engagement in renewable energy initiatives, which could offer strategies to improve local knowledge and skills in the transition to renewable energy in remote communities. In addition, research by Honvári & Kukorelli (2018) entitled "Examining Renewable Energy Investment in Hungarian Rural Settlements: The Gained Local Benefits and the Aspects of Local Community Involvement" can provide a perspective on how local communities are involved in renewable energy investments. Understanding the benefits gained and the role of local community involvement in renewable energy projects can provide valuable lessons in overcoming skill limitations and fostering local expertise in sustainable energy development.

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By drawing insights from this study, it is possible to identify strategies and best practices to address the challenges of limited local expertise and skills in renewable energy technologies. Capitalizing on community engagement, exploring the social dimensions of renewable energy projects, and promoting knowledge-sharing and capacity-building initiatives can be critical approaches to improving human capital in the renewable energy sector.

5.4. Development Opportunities

5.4.1. Sustainable Tourism

Renewable energy development can support sustainable tourism by providing clean energy sources and reducing carbon footprints. Among the references provided, the study by Khan et al. (2021) entitled "Adoption of Renewable Energy Sources, low-carbon Initiatives, and Advanced Logistics Infrastructure - A Step Towards Integrated Global Progress" can be highly relevant to exploring how renewable energy development can support sustainable tourism. This research explores the positive effects of adopting renewable energy and low-carbon initiatives on the environment, which can contribute to sustainable growth and mitigate the harmful consequences of global warming and climate change. Understanding the positive environmental impacts of renewable energy and tourism can provide valuable insights into how renewable energy can be utilized to support sustainable tourism practices.

In addition, the study by Aziz (2023) entitled "Empirical Evidence of Environmental Technology, Renewable Energy and Tourism to Minimize Environmental Damage: Implications of Advanced Panel Analysis" can provide valuable insights into the role of environmental technology and renewable energy in minimizing environmental damage, particularly in the context of tourism. This research explores the importance of environmental innovation and renewable energy in reducing environmental externalities, which can have significant implications for promoting sustainable tourism practices and minimizing the carbon footprint associated with tourism activities.

Furthermore, a study by Susilorini et al. (2022) entitled "The Carbon Footprint of Tourism Villages after the COVID-19 Pandemic. A Challenge for Sustainability: A Challenge for Sustainability" can provide insights into the challenges and opportunities for sustainability in tourist villages, especially in the context of carbon footprint reduction. The research discusses actions taken to reduce carbon emissions and maintain sustainable development in tourist villages, highlighting the importance of addressing the carbon footprint in the tourism sector for long-term sustainability.

By drawing insights from this research, it is possible to explore how developing renewable energy sources can contribute to sustainable tourism practices by providing a clean energy source, reducing carbon footprint, and promoting eco-friendly initiatives in the tourism industry. Understanding the relationship between renewable energy, low-carbon initiatives, and sustainable tourism can pave the way for integrated global progress towards a more sustainable and environmentally conscious tourism sector.

5.4.2. Quality of Life Improvement

Stable and sustainable energy provision can improve the quality of life of local communities and support economic development. Among the references provided, the study by Owusu and Sarkodie Owusu & Sarkodıe (2016) entitled "A review of renewable energy sources,

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sustainability issues and climate change mitigation" could be very relevant to explore how stable and sustainable energy provision can improve the quality of life of local communities and support economic development. This research explores the benefits of renewable energy sources, such as energy security, social and economic development, and climate change mitigation. These are essential to improving living standards and promoting economic growth through sustainable energy practices.

In addition, the study by Cîrstea et al. (2018) entitled "Evaluating Renewable Energy Sustainability with a Composite Index" can provide valuable insights into assessing renewable energy sustainability and its implications for economic development. Understanding the sustainability of renewable energy sources and their impact on economic growth can provide a valuable perspective on how clean energy technologies can improve quality of life and support sustainable economic development.

Furthermore, research by Huang et al. (2022) entitled "Uncovering the Real Charge Carriers in Polythiophene/Manganese Dioxide Cathode-based Aqueous Zinc Batteries" can provide insights into the development of clean and sustainable energy technologies, such as solar, wind and tidal energy, which are critical to improving the quality of life and driving economic development. This research explores innovative energy solutions that can positively impact society and contribute to sustainable development.

By drawing insights from this research, it is possible to understand how adopting renewable energy sources and sustainable energy practices can lead to improved quality of life, economic development, and environmental sustainability. Utilizing renewable energy technologies to provide stable and clean energy solutions can positively impact local communities, improve living standards, and sustainably promote economic growth.

5.4.3. Partnership and Investment

Cooperation with international organizations and the private sector can provide the required funding and technology. Based on the given user tasks, the following references from the candidate list can be selected to support the topic of partnership and investment in renewable energy. Liu and Chu (2018) conducted a study on stimulating financing and investment through private capital to promote the development of renewable industries in China through the theme of partnership and investment in renewable energy. In addition, Hutchinson et al. (2021) discuss the challenges and solutions to increase investment in renewable energy generation and provide actionable policy solutions to unlock private sector investment, which is relevant to renewable energy partnership and investment.

Maulidia et al. (2019) assessed the factors that contributed to the successful development of Indonesia's first large-scale wind farm, emphasizing private-public partnerships, which are relevant to the discussion of renewable energy partnerships and investments. Bhattarai (2024) reviewed integrating renewable energy sources into tourism in protected areas to promote eco-tourism and economic growth, highlighting the importance of renewable energy investment in sustainable development. These references provide valuable insights into the role of partnerships and investment in renewable energy, showing how collaboration with international organizations and the private sector can facilitate the provision of funds and technologies needed for sustainable energy projects.

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Developing partnerships in conservation areas such as Raja Ampat significantly impacts various environmental, social and economic aspects. Effective partnerships between the government, private sector, non-governmental organizations and local communities can promote more sustainable natural resource management and improve the welfare of local communities:

1. Environmental Impact: Solid partnerships can aid in preserving sensitive ecosystems and rich biodiversity in conservation areas. Through collaboration, different parties can develop and implement best practices to reduce the negative impacts of human activities on the environment. For example, renewable energy projects funded and supported by the private sector and international organizations can replace more damaging energy sources such as fossil fuels, thereby reducing carbon emissions and pollution (Liu & Chu, 2018).
2. Economic Impact: Partnerships can encourage investment in infrastructure and services that support local economic development. These investments include the financing of renewable energy projects and the construction of sustainable tourism facilities such as eco-lodges and environmental education centers. With these investments, new employment opportunities can be created, increasing incomes and living standards for local communities (Hutchinson et al., 2021). In addition, well-managed tourism can be a sustainable source of income, provided that profits are reinvested in community preservation and development.
3. Social Impact: Partnerships that involve local communities in project planning and implementation can empower communities and increase environmental awareness. The active participation of local communities ensures that projects are developed according to local needs and cultural values, and reduces social conflicts that may arise. Training and education programs provided through partnerships can also improve the skills and capacity of local communities, enabling them to participate more actively in a growing economy (Maulidia et al., 2019).
4. Policy Impact: Strong partnerships can influence the formation of more inclusive and sustainable policies. With the involvement of various stakeholders, the policies created will be more comprehensive and reflect various perspectives. This can include stricter conservation policies, renewable energy incentives, and regulations supporting sustainable tourism. In addition, international partnerships can help transfer technology and knowledge and encourage higher global standards in conservation practices (Bhattarai, 2024).

An example of a Partnership Case in the Raja Ampat Islands is this: Partnerships between local government, NGOs, and the private sector have brought significant positive changes. Marine conservation programs supported by international organizations such as The Nature Conservancy and WWF have helped protect coral reef ecosystems rich in biodiversity. In addition, sustainable tourism initiatives involving local communities have provided new economic opportunities and raised awareness about the importance of environmental conservation (Maulidia et al., 2019). For example, Arborek Village has become a successful example of community-based tourism, where residents directly manage and promote the village as a tourist destination.

These partnerships have also encouraged the development of sustainability policies, such as restricting visitor numbers at sensitive sites and introducing environmentally friendly practices

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in tourism operations (Hutchinson et al., 2021). These positive impacts demonstrate that effective partnerships can be a powerful tool for balancing environmental conservation and economic development in conservation areas. Thus, developing partnerships in conservation areas such as Raja Ampat can positively impact environmental, economic, social, and policy. Through effective collaboration, various stakeholders can work together to protect valuable biodiversity while improving the welfare of local communities and promoting sustainable development.

5.4.4. Policy Implications

Several policies can be considered to achieve effective renewable energy development in Raja Ampat, including financial incentives, capacity building, and environmental policies. These measures aim to attract investment, empower local communities, and protect sensitive ecosystems.

1. Financial Incentives: The government can provide fiscal and non-fiscal incentives to attract investment in renewable energy. Fiscal incentives such as tax breaks, subsidies, and tax credits can reduce the financial burden on investors and developers of renewable energy projects. Non-fiscal incentives such as regulatory simplification and the provision of free or low-cost land can also encourage investment interest. According to Hutchinson et al. (2021), financial incentives can increase the attractiveness of private-sector investment in renewable energy projects. The study shows that incentive policies implemented in several countries have significantly increased renewable energy capacity. Implementing similar incentives in Raja Ampat could attract more investment, accelerate the development of renewable energy infrastructure, and reduce dependence on fossil fuels.

2. Capacity Building: Training and education for local communities on renewable energy technologies is essential to ensure sustainable maintenance and operation. These training programs can include technical skills in installing, maintaining, and managing renewable energy systems and education regarding the economic and environmental benefits of clean energy. Liu and Chu (2018) state that local capacity building is critical to the success of renewable energy projects in remote areas. Engaging local communities through training and education improves skills and knowledge and promotes a sense of ownership and responsibility for the project. In Raja Ampat, training programs can help local communities manage renewable energy projects effectively, create jobs, and improve economic welfare.

3. Environmental Policy: Protecting marine and terrestrial ecosystems should be a priority in any renewable energy project development. Strict environmental policies can ensure that renewable energy projects do not damage the natural habitats and biodiversity present in Raja Ampat. Bhattarai (2024) highlights the importance of environmental policies in maintaining a balance between renewable energy development and ecosystem preservation. Implementing policies that protect the environment can include strict environmental impact assessments, restrictions on using hazardous chemicals, and ongoing oversight of energy projects. In Raja Ampat, solid environmental policies can prevent damage to species-rich marine ecosystems, ensuring that renewable energy development goes hand-in-hand with nature conservation.

Developing renewable energy in Raja Ampat requires policies that support investment, empower local communities, and protect the environment. Financial incentives can attract

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private sector investment, while training and education programs can ensure sustainable maintenance and operations. In addition, strict environmental policies can protect sensitive ecosystems in the region, ensuring that renewable energy development does not harm the natural environment. Raja Ampat can achieve sustainable and balanced renewable energy development with this comprehensive policy approach.

5.4.5. Case Studies and Best Practices

Several case studies from other regions that have successfully implemented renewable energy in remote areas can provide insight and guidance for Raja Ampat. For example, solar energy projects on small islands in the South Pacific show how local communities can adapt and utilize new technologies. Looking at successful case studies from other regions can provide insights and guidance for Raja Ampat in implementing renewable energy in remote areas. One example is a study conducted by (Dornan, 2015), who studied the development of renewable energy resources in the Pacific Islands through the lens of public policy. This study can provide valuable lessons regarding policy frameworks and strategies that have facilitated renewable energy projects in small island developing states, which can be adapted to the Raja Ampat context.

Schelly et al. (2020) highlighted community perspectives and support for solar development projects, mainly focusing on conflict reduction and garnering local support. Understanding the dynamics of community engagement and acceptance is critical to successfully implementing renewable energy initiatives in remote areas such as Raja Ampat. Raja Ampat can tailor its approach to ensure local community support and participation by learning from models that have effectively addressed community concerns. Also, a study conducted by Price (2022) explores private sector investment in the clean energy sector in the Pacific Islands, highlighting the drivers, barriers, and opportunities for mobilizing private capital. This research can provide valuable insights into the financing mechanisms and partnerships that have facilitated renewable energy projects in island contexts. By understanding how private sector engagement has contributed to successful clean energy transitions in similar regions, Raja Ampat can explore avenues to attract investment and drive sustainable energy development.

In addition, the work of Dimou, A., & Vakalis, S. (2022) on utilizing fuel cells for energy storage and valorization of excess energy in isolated power grids presents an innovative approach to improving renewable energy integration. By exploring advanced technologies such as electrolysis and fuel cells for energy storage, Raja Ampat can explore efficient methods to manage fluctuations in renewable energy generation and ensure reliable electricity supply in remote areas. This is particularly relevant for overcoming the intermittency of solar or wind power in island regions. Popp et al. (2017), on the dietary habits of the prehistoric inhabitants of Rapa Nui (Easter Island), show how environmental adaptation and resilience are essential for survival in challenging island environments. Drawing parallels between historical adaptations to environmental constraints and modern efforts to transition to renewable energy in remote areas like Raja Ampat can provide valuable lessons in building resilience and sustainable resource management.

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Rokocakau et al. (2019), on implementing a Flywheel Energy Storage System (FESS) in microgrids for remote island villages in the South Pacific, offers a practical case study for improving energy storage capabilities in remote areas. By exploring innovative storage solutions such as FESS, Raja Ampat can address energy reliability challenges and optimize the utilization of renewable resources, thus paving the way for a more sustainable and resilient energy infrastructure. In addition, a study by Vincent et al. (2009) on the interannual variability of the South Pacific Convergence Zone (SPCZ) and its implications for tropical cyclone occurrence underscores the importance of understanding climate patterns and extreme weather events in island regions. Considering the vulnerability of remote areas such as Raja Ampat to climate risks, integrating climate data and projections into renewable energy planning can improve resilience and preparedness for potential climate change impacts.

By synthesizing lessons learned from these different case studies on renewable energy implementation, community engagement, involvement of the private sector, new technologies, historical adaptation, energy storage solutions, and climate considerations, Raja Ampat could have a holistic approach tailored to achieve a shift in its remote areas to sustainable energy use. Experiences from other regions offer learning that can guide best practices to decide upon and provoke the effective execution of renewable energy solutions in Raja Ampat.

6. Conclusion

Therefore, Raja Ampat has huge potential for developing renewable energy to support sustainable tourism and improve standards of living by consolidating ecosystems. It provides opportunities for the development of different renewable energies—solar, wind, and sea energy—through its background of abundant natural resources and exceptional natural beauty. New challenges of limited access and infrastructure and limited human resources can be limited with proper policies that reward both financial and non-financial incentives, strategic partnerships between the government and private sector, and local communities. Investment in infrastructure and training programs for the local community enables them to have more capacity to ensure they manage and maintain renewable energy systems on their own. A holistic, sustainable approach will make Raja Ampat the trendsetter in how other locations could fit isolated spots with renewable energy solutions to show the entire world that clean energies and green technology prepare better economic and environmental fates while at the same time preserving this wonderful natural beauty of the main point of interest.

The SLR identifies the critical research trends in renewable energy developments in conservation areas with a focus on Raja Ampat. Some of the essential findings and contributions of this systematic literature review are:

1. Crucial Research Trends:

Renewable Energy Focus: Much of this research focuses on several renewable energy technologies—solar, wind, and marine energies—feasible for remote areas and especially conservation areas.DataBindings and Investment: Almost all of the studies emphasize the need for partnerships among the government, private, and local communities in the development of

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renewable energy. Environmental Policy: A stringent environmental policy for the preservation of sensitive ecosystems while developing renewable energy infrastructure is emphasized.

2. Challenges Encountered:

Limitations of Access and Infrastructure: The most critical challenge is access to very remote sites and the lack of basic infrastructure necessary for the planning and execution of renewable energy projects. Financial: It generally involves high initial costs for its installation and development, especially in areas that are remote, which are normally a significant constraint to renewable energy technologies. Human Resource Capacity: A limited number of local expertise and skills in renewable energies result in a continuum problem of maintenance and operation of the project.

3. Solution Proposed:

Financial Incentives: Fiscal and non-fiscal incentives can be offered by the government to attract more investment in renewable energy, including tax breaks and regulatory simplification. Capacity Building: Much is needed in terms of the training and education of local communities to see that renewable energy projects can be maintained sustainably. Environmental Policy: Any form of renewable energy project development shall consider the protection of marine and terrestrial ecosystems to seek a balance between conservation and development.

The SLR also offers reviews on renewable energy development:

• Basis for further research: Results that can be used to base further research on such will be presented in this review. This puts the effort on the particular challenge faced in renewable energy development in the conservation zone and allows the realization of the less investigated areas.

• Renewable Energy Policy Development: The results can feed into the policy maker's strategy formulation of a more feasible and sustainable strategy and policy for renewable energies, including fiscal incentives, institution building, training programs related to renewable energies, and rigid environmental policies.

• Project Implementation Guidance: This review is aimed at the project developers and gives hands-on guidance in the planning phase and implementation of renewable energy projects, by suggesting key challenges to be encountered and proposed solutions in conversation areas such as Raja Ampat.

This SLR identifies trends, challenges, and solutions for the development of renewable energy in Conservation Areas; it lays a very strong base for further research towards supporting sustainable energy across Conservation Areas.

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