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Environmental Impact Assessment for Renewable Energy Projects: Risks and Solutions in Solar, Wind, and Hydropower

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Reducing global warming and promoting natural benefits are critical objectives for the global community, spanning various sectors and initiatives. The commitment to reducing greenhouse gas emissions by 80-95 percent by 2050, along with promoting renewable energy sources, is central to this effort. Solar power development in regions with high solar radiation requires open, agricultural, or marginal areas, distinguishing it from projects that misuse valuable land. Social concerns, such as noise from wind turbines and changing landscapes, raise questions about visual impact and landscape rehabilitation. Impacts on flora and fauna, shadowing effects, and wind changes caused by turbines are important considerations. Hydropower projects also affect river dynamics through reservoirs and physical barriers, which must be addressed before implementation. The Environmental Impact Assessment (EIA) is a valuable tool for identifying these issues, as it provides a baseline for analyzing project impacts and includes predictive forecasts. Managing these environmental and social factors, including potential legal challenges, requires adopting a management system early in the project. This paper will analyze the environmental and social impacts of renewable energy projects, focusing on case studies of solar, wind, and hydropower. It will also explore how EIAs can predict and mitigate negative impacts and present strategies for effective environmental management at the early stages to balance environmental and social objectives.

Keywords: Renewable energy, environmental impact assessment, risks, solutions, solar farms, wind turbines, hydropower.

1. Introduction

The energy industry today is fast developing and expanding, requiring guidance on legal procedures focusing on preventing and controlling pollution and reducing negative effects on environmental and human health and safety. Independent assessments playing a pivotal role in this regard are the assessments of the operations of different energy facilities or installations. The most economically feasible and logical approach and the most widely used techniques are solar and wind electric power generation, geothermal power and heat production, and hydropower, as well as wind energy-related installations and solar energy systems, respectively. All those facilities are part of the modern EIA process, which is being analyzed

within this work. An appropriate agenda for EIA involves systematic studies of the alteration of the human environment because of activity. These research initiatives have contributed to mitigating or even eluding damage from refineries, chemical and food factories, energy plants, and so on. A balance needs to be struck between economic demand and cautious action. At the same time, demand for EIA specialists is steadily increasing, rising further in industrial development periods. The paper identifies the theoretical understanding and scientific minority of EIA problems related to renewable energy plants and produces solutions for them. [1].

1.1. Definition and Purpose of EIA

Environmental Impact Assessment (EIA) is a process meant to ensure that, in a systematic manner and based on the use of the best available scientific knowledge, the potential effects on the environment of certain public and private projects or policies are identified, determined, predicted, and/or evaluated, possibly including existing impacts and considering changes in relation to environmental conditions following project implementation. Projects include installations, tangible or intangible projects, plans, programs, and other legislative or administrative measures, as well as any other legislative, regulatory, or administrative requirements and national regulations. The findings of the EIA process are subsequently used in order to: (i) inform different interested parties on the potential environmental impacts of the proposed projects or initiatives, (ii) involve the public in the decision-making process and participate in environmental decision-making, (iii) promote transparency of government decision-making processes, and (iv) contribute to the capable development of projects in the light of having a positive impact, thereby providing a constructive contribution to the public and to interested parties willing to support related initiatives and to aid decision makers. The EIA process therefore includes the assessment of the likely significant environmental effects, the way in which the public is informed and participation is promoted, how consultation with the authorities and involved parties is performed, before relevant decisions are made, and the way in which the opinions expressed are taken into consideration. Thus, the EIA provides tailored and focused input to inform decision makers in making the right choices, ensuring that environmental aspects are taken into account in decision-making processes to evaluate public interest while balancing private interests [2].

1.2. Importance of EIA in Renewable Energy Projects

Renewable energy projects play a key role in reducing the effects of climate change. However, planning these projects can be challenging. A crucial part of this planning process is conducting an Environmental Impact Assessment (EIA), which helps identify and manage potential environmental, social, and health risks associated with these projects. This study focuses on the risks linked to three types of renewable energy projects—solar farms, wind farms, and hydropower—and proposes solutions to address them in each sector. Given the prominence of these industries in the media, it's essential to provide a concise overview of the solutions that EIA teams can implement. This underscores the significance of EIAs in the renewable energy sector [3].

Investing in renewable energy infrastructure brings many benefits, such as energy independence, reduced energy costs, and job creation. However, these projects can also have notable environmental impacts, which differ depending on the type of renewable technology

used. It's vital for developers to comply with government regulations at the federal, state, and local levels, especially for solar and wind projects. These regulations often require securing necessary permits and conducting environmental studies on the proposed site. Most large-scale renewable energy projects must undergo an EIA due to their impact on land use and the environment as a whole [4].

1.3. Structure of the paper

This paper includes six sections. The introduction is the first section, providing an overview of EIA and its role in renewable energy projects. The second section discusses different renewable energy technologies like solar, wind, and hydropower. The third section highlights environmental risks and concerns associated with these projects. The fourth section explains the EIA process, including its steps and importance. The fifth section presents case studies and best practices in managing environmental risks. Finally, the conclusion summarizes the key findings and recommendations for improving the EIA process.

2. Renewable Energy Technologies

Renewable energy sources are derived from natural processes that do not reduce the level of energy available nor release undesirable by-products. Such natural resources, also called distributed energy resources or distributed power plants, are available virtually anywhere on or near the Earth's surface and include sources such as solar, wind, snow melt, geothermal, and hot water. Even though the exploitation of renewable energy sources will reduce the potential for high emissions of greenhouse gases with respect to fossil fuel cycles (at least at the point of consumption), a certain degree of pollution can still exist and must therefore be properly addressed. Moreover, renewable energy sources are associated with significant variations in both time and space, as well as differences in accessibility or accessibility costs, leading to environmental sustainability concerns, economic implications, and public acceptance problems that can be mitigated using Environmental Impact Assessment frameworks [5].

The EIA process is used today in almost all jurisdictions that require renewable energy development approvals for utility-scale commercial renewable energy projects. In member countries, an EIA Directive was signed to analyze in advance the environmental effects of a wide range of public or private projects that are likely to have significant impacts on environmental development. EIA studies are fundamental instruments for identifying, analyzing, and mitigating possible adverse impacts associated with renewable energy projects. Even though many EIA processes within member countries have become increasingly complex, unique procedures, technical guidelines, and science-based criteria are needed for specific cases of renewable energy power plants.

2.1. Solar Energy: Overview and Environmental Considerations

Solar energy is an attractive and clean renewable energy source that can reduce our reliance on fossil fuels, thereby reducing the carbon footprint. Solar plant facilities can normally be constructed in rural and suburban regions with lower electricity demand; thus, environmental, visual, and land-use effects are generally major concerns when planning these installations. Environmental conservation organizations and local residents alike tend to fight hard against the erection of solar panels or any other facility that may compromise the landscape's natural

beauty. In order to alleviate the need for space for solar energy generation, agrivoltaics—a "cooperative" land-use practice where crops are grown on a photovoltaic solar farm—is also gaining traction [6].

Besides conflicting land-use issues, the installation of solar plant facilities also affects local fauna and flora; it has been widely reported that solar panels can confuse insects and birds, increasing local mortality rates. Additionally, solar energy production increases the temperature of the solar panels themselves, a factor that must be taken into account for studying ground details and grazing/pollution. As for the social impact on local residents, solar and wind power generation have the lowest impacts in all areas. Despite these differences, solar and wind power production are probably the least impactful energy sources to develop during the construction phase. Overall, solar plants bring notable benefits to the environment by reducing global warming through increased power production; however, social concerns regarding other non-physical impacts of significant solar farms and remote communities must be carefully considered [7].

2.2. Wind Energy: Overview and Environmental Considerations

Wind energy is one of the well-known emerging sources of renewable energy throughout the world. It has been playing a significant role in generating electricity in recent decades and has attracted significant attention from governments and firms. With the decrease in installation costs of wind turbines, property owners who have areas suitable for wind energy have an opportunity for a diversified revenue stream. Not only do wind energy projects provide economic benefits, but they also reduce CO2 emissions, mitigate greenhouse effects, and contribute to sustainability. As a result, the number of wind turbine installations has increased accordingly. Although there are various economic and environmental advantages of wind energy, it also has negative and adverse impacts on the environment [8].

One of the most significant environmental impacts is the death of birds and bats due to wind turbine blades. Huge wind turbine blades travel at very high speeds and reach many heights sought by birds. Therefore, birds frequently die when they collide with large wind turbines. The death of bats is classified as harmful to the environment, and their migration trends are also disturbed. Other expected negative environmental impacts include noise effects, visual effects, bird strike impacts, and influences on ecosystems and habitat destruction. Therefore, it is noted that wind projects require environmental safety analysis. Environmental impact assessments are necessary to plan and implement such project activities. An Environmental Impact Assessment (EIA) is a critical tool for authorities, developers, and organizations for wind energy projects. The key objectives are to evaluate the possible environmental impacts, assess risk perceptions, and find appropriate engineering solutions [7].

2.3. Hydropower: Overview and Environmental Considerations

Hydropower is another popular method for generating renewable energy. Hydroelectric dams harness the energy of moving water to turn turbines, which in turn drive the mechanisms that generate electricity. Hydropower is one of the oldest and most reliable forms of renewable energy, having provided power to people since around 500 C.E. The largest modern hydroelectric dam is the Three Gorges Dam. The first hydropower project licensed was a watermill built on the River Thames in 1066. Albania and Norway provide large proportions

of their total electricity from hydropower plants. Albania sources almost all its generated electricity from hydropower, producing around 99% of its electricity from hydropower, but the country is still entitled to produce more. When this is realized, Albania could even export generated electricity from hydropower. Similarly, Norway produces around 92% of all its electricity from hydro energy and remains a net exporter of hydro energy [9].

Like other renewable sources of energy, hydropower is cost-effective, reliable, and has minimal greenhouse emissions. In addition to these general benefits, hydropower from certain storage reservoirs in suitable locations can also generate power when there are problems with grid supply or power stations, such as during holiday periods when either wind generation or traditional power stations may be out of service. It can also therefore offer a technically valuable and beneficial service of peak load reserve capacity, and tidal and wave power can be equally valuable as they are naturally and consistently agreeable to strong winter storms, often originating in the North Atlantic. Because hydropower is diverse, it can be used in different ways to generate electricity. Depending on geographic location, direction of current water flow, and water volume, hydropower facilities can be designed to generate energy in a variety of ways, with emphasis on energy storage, storage peak regulation capacity, or in just one capacity [10][11].

3. Environmental Risks and Concerns in Renewable Energy Projects

Despite the environmental benefits of renewable energy, environmental activities and problems are not avoidable in the development process. The adverse environmental factors vary with different forms of renewable energy projects, the influencing factors, and other concomitant activities. Renewable energy projects include solar farms, wind turbine farms, and hydropower, large-scale or small, clustered or scattered distribution, short-term or long-term construction, etc. Those differences lead to various types of construction and operation patterns that need to be carefully considered. Therefore, specific problems, characteristics, and inherent laws are quite different in solar farms, wind turbine farms, and hydropower, although they share the same category of renewable energy. Then, comprehensive and deep concerns about the possible environmental impact of these projects need to be emphasized [11][10][12].

In summary, natural resources, geological conditions, and ecosystems play a significant role in solicitation, which differs from other planned impacts and creates a natural environment as a hysteresis shield to limit the forecast accuracy and objective knowledge level of the hoped-for benefits. Consequently, as empirical analysis and simulation of causal relationships are difficult to perform, and ideal technical specifications are hard to obtain, the result is whether we should focus on the risks of low satisfaction or negative development benefits of renewable energy projects. After all, the adequacy and effectiveness of the political, legal, and technical systems of environmental evaluation and mitigation are key issues influencing the sustainable development of renewable energy projects.

3.1. Land Use and Habitat Disruption

Land Use and Habitat Disruption: Renewable energy projects, especially solar farms and wind turbines, require large areas due to their low energy production per unit area. Although it is not as greenfield development as shale gas, it still poses risks due to habitat change and species movement between different natural areas and extinction. Measures should be adopted to

prevent or mitigate habitat disruption, adapt projects to the surrounding environment, and link otherwise isolated natural areas. These measures include avoiding certain locations, preserving or compensating for affected habitats, creating new habitats, and enhancing wildlife features in other locations. It is important for the relationship between a project and the surrounding ecosystem to be understood as both a spatial and functional relationship. The land use and habitat disruption component or zone of influence plan may also provide mitigation or compensation measures. Such plans will also benefit from detailed knowledge of fauna and flora. To plan well for the disposal of a site at the end of the project, planners need to be aware of the main habitats and ecological areas in the local region [13][14].

3.2. Water Resource Impacts

Water resource impact analysis is of vital importance to satisfy the public demand for water use and preservation. A renewable energy project such as a solar farm may use parched lands and thus affect water quality and the balance of seasonal water flows. A wind farm may also occupy scattered landscapes, making the impact of water resource conflicts less significant when compared to the positive influence of the generated electric power. A hydropower station can also provide power to execute integrated major water conservancy projects. However, this may have some negative and controversial impacts on water ecology and chlorinating biota. An Environmental Impact Assessment should focus on the environmental movements after power equipment is installed, put in use, and results associated with climate changes and operation mechanisms. It can then provide a powerful method to avoid water resource impacts and guarantee the sustainable development of the water resource [15].

The following suggestions are put forward to alleviate water resource impacts. (1) The land used for renewable energy projects should be compatible with local water resource conditions. Water-saving management is necessary during the construction and operation of renewable energy projects. (2) If a landscape has some geological disasters like subsidence and deformation of cracked earth during periods with empty spaces, decision-makers should undertake to remove the destroyed natural environment or to abandon the inappropriate investment concerning the lands on which solar farms and wind turbines stand. Also, before implementing planned hydropower stations, all the trade-offs between alternative resources should be carefully discussed during the decision-making process. The plan can, for instance, be rejected in favor of other types of generation technologies. (3) Because of the characteristics of large-scale concentrated generation and distribution technology and dense transmission networks, solar and wind generation capacity may not be far from equal to that of the nearby hydropower development package. The related speed of technological change and costs of local resources constitute added reasons why the role and benefits of hydropower stations should be reevaluated. (4) In order to make the analysis and demonstration of water resource impacts more quantitative, a further specific evaluation should be completed as soon as possible [16][17].

3.3. Noise and Visual Impact

One of the challenges is the tonal nature of the swooshing or grinding sounds of their mechanical blades, which gives rise to the swaying of responders' annoyance. Insomnia (difficulty falling or staying asleep or not feeling refreshed after sleep for three nights per week for at least one month) is another issue for wind farm residents pointed out in some wind farm

noise exposure studies, particularly for light sleepers. When it comes to promoting renewable energy and the construction of renewable energy projects, galloping wind turbines and broad serene field solar harvesters usually come to mind as iconic imagery. Despite the relatively harmonious nature of solar and wind resources that offer tens of gigawatts of power growth potential at an estimated cost of zero-emission energy, the development of green and clean energy sources may face public resistance due to their environmental impact and the resulting risk in terms of economic interests and social stability. The environmental impact of renewable energy projects includes impacts on air quality, water usage and waste management, sound or noise and visual impact, impacts on cultural and natural features, emissions, greenhouse gas emissions and climate change, impacts on biological factors, and potential impacts on radiation exposure, especially for large-scale solar and wind energy farms. Companies seeking to design, finance, and construct these projects are typically required by law to conduct environmental impact assessments. These assessments can aid in understanding risks and in identifying effective environmental mitigation measures in order to protect human health, maintain ecological diversity, and support sustainability [18][16][17].

3.4. Wildlife Interactions

Wildlife interactions associated with renewable energy plants largely relate to wind farms for their impacts on bats and birds, particularly in the migratory birds' pathways. The impacts on bats largely originate from the movement of the turbines' fans, which are known to kill or maim bats due to barotrauma problems. This scenario is particularly known to happen on larger turbines and occurs in migration routes. Both bats and birds are attracted to the light mast of wind farms, which can sometimes lead to a high collision rate. Most knowledge on wildlife interactions comes from centralized North American and European experiences, although general impacts have also been noted in other countries, particularly in high bat-diverse areas in national parks. Controlling and mitigating the impacts of wind farms would require an understanding of local wildlife patterns and adaptations, particularly in avoiding migration routes and not having flying-encouraging guidance infrastructure. The use of bat deterrent technologies, such as the utilization of specific noise frequencies, is a method to manage bat interactions, and having easy and regular access to the turbine makes collecting dead or damaged bats and bringing them to a rescue center possible. All wildlife mitigation and control plans require comprehensive surveys to be effective. These measures will attract conservationists and other concerned parties, making the project more easily accepted [19].

The figure below provides a clear comparison of the environmental impacts of solar, wind, and hydropower projects, summarizing the key differences in their effects on land use, wildlife, and water resources.

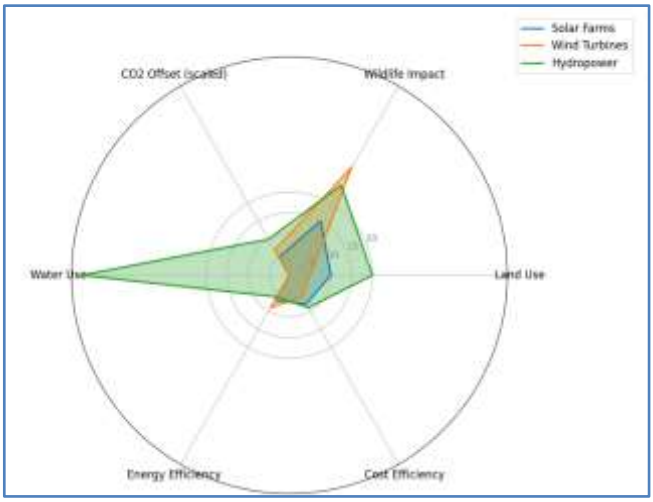

Figure 1. Clear environment impact comparison: solar, wind and hydropower

4. EIA Process for Renewable Energy Projects

The EIA process to evaluate the potential environmental impacts of solar power plants is generally similar from one country to another. The differences generally become more apparent in the details, local and domestic agency organization, and the degree of enforcement. Projects with potential environmental and legal impacts typically face an EIA process, compliance with respective alternatives to avoid residual impacts or indicate mitigation measures, stakeholder involvement, and maintaining transparency throughout the process. Renewable energy sources, including solar power plants, account for the fastest-growing sector of the energy market. Building energy electricity generation systems represent an effective alternative to offset the demand for energy sources based on carbon burning. Sunlight is a free primary energy source, and its exploitation using photovoltaic technology is an efficient, mature, traceable, sustainable, and less polluting process [19].

The construction of a solar farm facility usually leads to the clearing of ecosystems, and thus the visual landscapes and geographic biodiversity are modified. In addition, the deployment of equipment, such as solar tracking components, slightly varies in terms of their impact on relief and water resources. A solar field involves engineering solutions to maximize efficiency and reduce environmental impacts. The construction of a solar power station usually requires space, and environmental and ecosystem impacts can occur due to water usage. Boring, forest clearing, grading of the land, and landscaping can lead to the loss of vegetation from the impacted area. Dust, noise, and traffic generated during construction, as well as the capture of water in a dry and high solar insolation region, are also constraints on the environment. Moreover, despite emissions of greenhouse gases during the construction and maintenance of the facility, a solar field presents very low emissions during the exploitation phase, is biologically benign, and is socially responsible [18][20].

4.1. Scoping and Baseline Data Collection

The first phase of the process is the identification and scoping stage. This is done with those who have a 'stake in the game.' If we use the example of a wind energy project, those who would be involved would be the local residents, who can suffer from visual and noise pollution, and the local animal and bird populations, which can be affected by shadow flicker. A group of relevant stakeholders is invited to a meeting at the beginning of the project to address their comments and concerns about the proposed projects. These comments are then used to inform the scoping process to determine the content of the Environmental Impact Assessment. Suitable points of contact would be local councils, population groups, local business people, and those with a professional standpoint on all questions that arise [21].

Following the scoping meeting, discussion of the proposals or submissions has to be resolved, and decisions on the key and relevant 'terms of reference' which guide the production of the EIA document are agreed upon. This imparts a level of predictability to the EIA; it has been used successfully to improve the process and lessen conflict and confrontation. Performance-based regulation is mainly spoken colloquially to all involved, but alternatives include backcasting, adaptive management, and plan back-planning. Once the terms of reference are agreed upon, it is conventional to prepare a Project Brief for submission to the planning or permitting authority, but not all projects are EIA projects, such as exploratory sea searches, or to other stakeholders, who may also be asked to agree to the proposal [22][18].

4.2. Impact Prediction and Mitigation Measures

In an EIA for renewable energy projects, a risk assessment is usually carried out, which includes the prediction of impacts if a certain event takes place and hazards are present, in addition to the prediction of the magnitude and probability of occurrence of undesirable environmental effects intrinsically associated with the hazards. Also, possibilities involving alternative scenarios are investigated. These will culminate in the adoption of measures and, therefore, provide a facility that offers appropriate security against the possible negative consequences of alternative technological paradigms. Risk prediction in renewable energy projects needs to be different because that risk is associated with capturing the energy of the natural resource. Linking such facilities in or around protected areas can lead to diverse ecosystem impacts that are directly predictable. Therefore, EIAs conducted for such facilities are expected to be integral and wide-ranging in nature to capture potential indirect impacts relating to forest or soil use by local populations surrounding the protected areas [18][16].

Impact prediction has one of two purposes within EIA for hydropower projects. Where a prediction produces an effect that is deviant from the norm, which may impact the environmental resource and does not have well-defined, proven, and practical solutions, then the prediction's purpose is to find leads on how to mitigate the problem underlying the effect. In the case of predicting a positive impact as a result of proposed mitigation, the prediction assists in estimating benefits for public relations purposes and for investment decisions by the project owner because mitigation often involves long-term financing. This type of impact prediction does not provide leads on underlying trust problems but may assist in deciding whether or not to continue to the investment stage. In most cases, both types of prediction problems are found in hydropower projects. The main ramification of this finding is that environmental risk assessment in this case requires both independent review of the impacts by the statutory agencies responsible for the relevant services and the establishment of a

substantial buffer for the environment's role against optimisms or pessimisms inherent in the respective prediction task [21].

The figure below illustrates the correlation between various environmental factors that need to be considered during the EIA process for renewable energy projects, helping in the assessment of risks and the development of mitigation strategies.

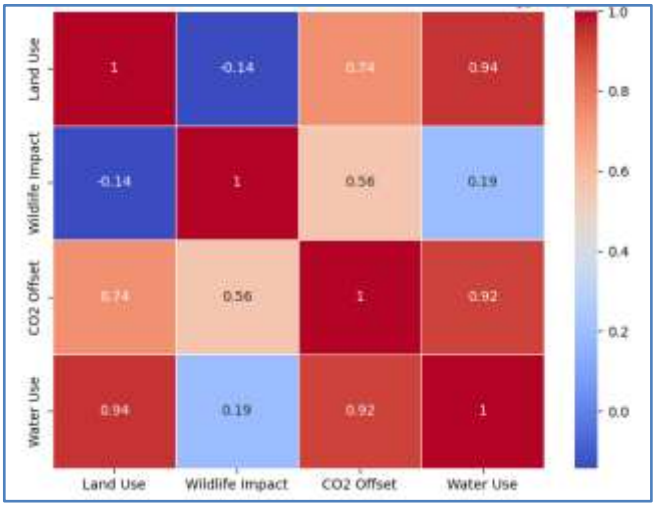

Figure 2. correlation between environment factors for renewable energy projects

4.3. Public Consultation and Stakeholder Engagement

Engagement of stakeholders and the public, and transparency in decision-making, are central to the evaluation process in most decision-making, EIA or otherwise. In many countries, these are considered the most important stages in the EIA process. Early public participation can facilitate communication between stakeholders, the public, and the development team, and can also help to identify and address social and environmental concerns. Projects that face potential opposition from local residents or environmental activist groups can benefit from early public participation, which helps project developers identify the impacts and issues that are important to the public, and so take them into account during the project development process. Some local residents and environmental NGOs can even become powerful allies in promoting these projects. On some occasions, it would be necessary to work with just a few groups to promote a positive local environment for the project [23].

The public participation process can take a variety of forms. It can involve focus group discussions, questionnaires, workshops, participatory planning, visual presentations, displays and exhibitions, community sessions, and public meetings. The intensity of public participation should be tailored to reflect the importance of the issues at stake and the potential needs and interests of relevant stakeholders. The public participation process should help refine the key issues and the scope of the proposal for a more detailed environmental assessment later. For renewable energy projects, public participation could focus on the potential environmental and social impacts of the resources, construction traffic and access routes to the site, and landscape issues. If the public can choose the type of renewable energy technology, participation should include the design and visual aspects of the projects. The

participation process and methodology to be used should be approved by the responsible ministry or agency, and the public and stakeholders should have full access to publicly available project information and documents on the project proposal to understand them and be able to comment on them [24].

5. Case Studies and Best Practices

Due to regulatory and technical requirements, the practices for EIA methods are well developed for renewable energy projects. This section constructs best practice case studies for solar, wind, and hydropower energy projects to guide developers and planners in both avoiding and managing the potential risks associated with EIAs. Each subsection begins with the specific challenges generated from EIA practices in that renewable energy project and is followed by best practices based on real projects and case experiences. Finally, case studies for EIA of renewable energy projects will be recognized and discussed in the conclusion.

Solar Photovoltaic Projects Solar farms have experienced substantial growth as a source of renewable energy worldwide. Since the location of solar farms is effectively only constrained to abundant solar radiation in theory, developers prefer to use arable lands as the construction site for proximity to where electricity is used. Due to the use of arable lands, solar farms evoke opposition in public and governmental sectors and often encounter prolonged and negative discussions. Deployment of photovoltaic systems also changes rural land use patterns, which brings different challenges for social acceptance. Therefore, this shift should attract attention from the related parties during the site selection phase. Previous studies have addressed possible effects of different approaches in the implementation of solar energy on the environment and cultural or social aspects within life cycle assessment or other environmental and social assessment methodologies [18][24].

5.1. Solar Farm Case Study: Lessons Learned

The findings from a considerably large solar farm located in Zimbabwe were studied with regard to the environmental impact assessment and associated regulations likely to affect other solar farms in Southern Africa. The majority of studies focus on EIA across a broadly defined region or specific EIAs on small-scale or informal sector projects, with very scarce user-specific and in-depth literature for shareholder review. Other research conclusions have similar findings to the ones we have reached in this study; therefore, our findings could be more widely applicable across the development and growth of different kinds of renewable projects across Southern Africa. The project achieved a Category B2 (minimal impact analysis), and the establishment of this project presents valuable lessons to be learned for future projects and support systems. Islands usually do account for these collaterals; therefore, neither regional cooperation nor power pool transmission systems and marketing are available. Although promoting PV plant development by providing cost recovery with premium prices that cover investment costs and incentives, or mechanisms to reflect the real value has concluded that PV makes a positive contribution under typical project conditions, it has been observed that no such comprehensive guidelines are available for environmental impact assessment needed for large-scale solar farms. Built environment tasks to be considered are the visual appearance and the impact on the recognized land use and planning schemes within Zimbabwe. Considering the construction and operation of solar PV power stations, the impact on biodiversity in the selected site is ultimately the innovation and better implementation of a transparent public

engagement process. The project has promoted electricity generation for general power supply via the solar systems, and a solar farm is erected wherein flora or fauna structures are not disturbed in a conservation area [25].

5.2. Wind Turbine Project: Community Engagement Strategies

Community engagement strategies can be used to ensure the removal, consideration, and mitigation of risks that may emerge during the implementation of a wind turbine project. Furthermore, these strategies can be useful as a professional learning experience derived from the consultation process. There are different benefits obtained from effective community engagement strategies. These include informing, complementing, and avoiding a negative perception of the project, its impacts, a sense of proximity, and undesired consequences related to having wind turbines. There is a permanent risk that a dialogue becomes a monologue. Therefore, a permanent, gradual process of community engagement is needed. An intense start followed by a deterioration of interest or commitment is not acceptable. Also, there is the risk that a good dialogue does not reveal the real interests or needs of the communities involved. So, anonymity, fear, and poor representations may prevail within society.

The construction, installation, and follow-up processes of a wind turbine project share common risks. The community should be informed and engaged to address potential risks and experiences related to the project. Unauthorized access to construction sites or facilities, and leniency and self-confidence derived from interacting closely with a wind turbine represent a safety risk. A serious preventive action program must be developed. These actions should integrate signs, warnings, adequate fences, the monitoring of nearby towns, and suitable control of visitors and unauthorized individuals or organizations. Awareness, explanation of expected benefits, and potential delays originated from similar actions derived from accidents, and relatively simple and inexpensive solutions are the main resources to address the injury of workers. Furthermore, the establishment of a local accident mortality increasing impact index, considering the increased score of a wind turbine as the number of victims, would be a valuable complement to determine monetary fines per incident. With respect to public health, risk factors may materialize in acoustic levels, light disorientation, and mental and noise annoyance. Dialogue, informing about potential impacts, studies, and the implementation of necessary acoustic or physical mitigation measures, if recommended, are a useful approach [18].

5.3. Hydropower Development: Balancing Energy Needs with Environmental Conservation

Over 100,000 dams in the US and billions of dams used in hydroelectric plants pose a risk to the aquatic, terrestrial, and human environment. These dams block critical fish migration paths and lead to dam mortality, which affects the ecosystem. It can also significantly contribute to a decrease in consumer biomass in the area. The listed endangered species, Chinook salmon and steelhead, have significantly decreased due to the presence of a large number of dams. Freshwater fish spend all or part of their lives in rivers or lakes, and blockage by dams interrupts their lives and poses a serious risk to them. With increased heat due to climate change, the water temperature will rise, and the sex ratio of aquatic species will increase and eventually decrease the population. Secondly, climate variability has steadily increased due to anthropogenic influence, but temperature increases reduce the snow and ice in the area, making it difficult to control and convert the climate variability into water. Many species rely on snow

and ice cover to survive and reproduce, and this change in water content introduces significant risks to species in the area.

This text discusses the implications of hydropower projects in place of traditional water pipes in California, USA, from different perspectives. At the national level, climate change depends on the infrastructure and rehabilitation of the aging dam, but it also poses a significant risk to aquatic species, especially endangered species. Therefore, renovation efforts must consider the competition between dam safety and the need to protect species. Nations face significant regulatory and legislative considerations that are necessary. Clean water is provided in the form of energy production and construction work, ranging from federal policies to acts concerning endangered species. Efforts to reduce dam mortality, reduce population loss, and prevent the loss of natural spawning areas are essential and also stimulate the need for investment in infrastructure development. In the face of structural public protection for species, the production of clean and affordable electricity by dams exceeding 4 megawatts has become intensely balanced under the current jurisdiction. The approval of dam projects is regulated, but difficulties exist in claiming compensation from the owners of the dam who have paid for the effort to preserve the species.

A deformed dam may not be a dead dam, so this situation focuses on some ways to mitigate the impact of developing energy supplies and expand the "reinvented" dam. Finally, previously developed fish passages identified as priority improvement areas may have been built for multiple storage areas by states to establish and complete priority projects. Therefore, the main conclusion is to point out the urgency of cost and regulatory conflicts between the dominance of the government, which produces hydroelectric facilities. Independent energy. First, the restoration of the dams must comply with climate conditions and species protection. To do otherwise would destroy the energy production and environmental benefits created by the use of hydroelectric facilities. Consequently, the resettlement of the dam is influenced by the conflict between the economic interests of public energy ventures, the objectives of the species, and the reduction of the risks of the dam, which must be based on an intelligent and strategic approach [25].

6 Conclusion

The paper sought to contribute to the existing literature on Environmental Impact Assessment (EIA) in the field of renewable energy (RE) projects and the challenges that these projects face in that matter. It also offered a detailed review of the state of the art, including the application of multicriteria analysis methods like Analytic Hierarchy Process and its combination with Principal Component Analysis in EIA for renewable energy projects, by focusing on the specific case of Kosovo. In this effort, the renewable energy projects considered were solar farms, wind turbines, and hydropower. This study discusses and analyzes the role of ecological impact assessment, air pollution, and CO2 emission effects brought on by the technologies involved, while also discussing how air modeling can improve EIA studies.

The study has answered the main goal of the paper and has provided recommendations and conclusions that may help in the evaluation process of renewable energy projects such as wind turbines, solar power, and hydropower projects. The results show that the most significant positive effects are related to the substitution of fossil fuel power plants. All the renewable energy options presented reduce the environmental impact and do not bring about cumulative

effects, and the photovoltaic solar power plant has an impact on air pollution even in winter. The most negative effect from all the options is caused by the disturbing view, wildlife, and bird mortality only for wind turbines, and this is the only negative effect that necessitates measures for its mitigation. In summary, this study has shown that the increasing use of and prospects for renewable energy technologies justify a deep debate on their implementation and, if possible, avoid potential negative environmental impacts by promoting a preventive and corrective mitigation approach or formulation that ensures the ecological, economic, and social sustainability goals of renewable energy-related projects.

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