International Journal of Environmental Sciences
ISSN: 2229-7359
Vol. 11 No. 16s,2025
https://theaspd.com/index.php

# Harnessing Solar Energy And Sustainable Water Practices In India: A Pathway To Environmental Resilience

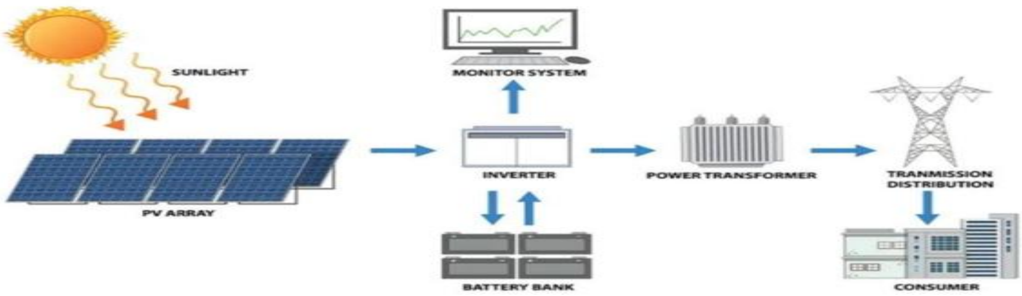
**Priyadarshini Praharaj[1], Archita Aparajita Mallick[2] Apurv Sharma[3], Tanmay Khuntia[4] Debabrata Mohanty[5]**
[1,2,3,5]School of Commerce, XIM University Plot No:12(A), Nijigada, Kurki, Harirajpur-752050, Dist.-Puri, Odisha, India, mohantydebabrata5@gmail.com
[4]School of Sustanability, XIM University Plot No:12(A), Nijigada, Kurki, Harirajpur-752050, Dist.-Puri, Odisha, India

***Abstract:***
*The global transition to sustainable energy is at a critical juncture, spurred by increasing energy needs from expanding population and industrialization. In contrast, traditional energy resources have previously powered economic growth; their degradation of the environment and limited nature point towards switching to cleaner energy options. Renewable energy, solar, wind, and hydroelectric, in particular, provide a promising alternative, although these come with drawbacks like intermittency, cost of infrastructure, and technological constraints. Governments are increasingly making renewable energy more cost-competitive and economically viable by using targeted policy tools such as carbon pricing schemes, subsidies, and tax incentives. This report looks at the larger picture of renewable energy uptake. It presents in-depth case studies of two pioneering solar projects in India: the REWA Solar Park in Madhya Pradesh and the GED- COL Solar PV Project in Odisha. REWA, India's largest 750 MW solar park, exemplifies effective public-private partnership, creative financing, and mass-scale economic and environmental benefits, such as a sizeable reduction in CO emissions and energy expenses. GEDCOL, a 10 MW solar power plant, prioritizes rural electrification, sustainable development, and community-centric planning in Odisha. Both examples illustrate how strategic planning, strong policy frameworks, and stakeholder consultations can be used to catalyze meaningful renewable energy deployment. These case studies provide replicable models for developing countries balancing economic growth with ecological sustainability.*
***KeyWords***: *Sustainable energy transition, Renewable energy, Solar energy, Wind energy, Hydroelectric power*

## INTRODUCTION

The world is at a pivotal point in its search for sustainable energy, with mounting population pressures and rapid industrialization that require increasingly higher energy use. The global economies have traditionally been fueled by finite resources such as coal, oil, and natural gas. Their finite supply and serious ecological costs—specifically greenhouse gas emissions—make them unsustainable in the long run (Ai et al., 2025; Bilgen, 2014). Conversely, using renewable sources like solar, wind, and hydropower provides cleaner options that are responsible for much less climate change and pollution. Regardless of the environmental benefits, renewable sources have disadvantages. Problems of intermittency, expensive infrastructure, and technological limitations create barriers to their scalability (Jafarizadeh et al., 2024). Conversely, the management of non-renewables today involves optimizing efficiency and reducing environmental damage, requiring more environmentally friendly extraction and using methods that are gaining momentum gradually. Across the world, governments are encouraging the uptake of renewables through policy levers such as tax credits, subsidies, Renewable Portfolio Standards (RPS), and Feed-in Tariff (FIT) programs (Behrens et al., 2007; Yi et al., 2019). These mechanisms facilitate the cost of clean energy investments. Significantly, renewable energy economics has changed; indicators such as the Levelized Cost of Energy (LCOE) show that renewables are becoming cheaper than fossil fuels, particularly when carbon prices and the costs of damage to the environment are included (Veronese et al., 2021). In addition, investment in renewable energy promotes the creation of jobs, diversification of the economy, and energy security through lower reliance on imported fossil fuels (Al Balushi & Matriano, 2024). The economic mechanisms of carbon taxes and cap-and-trade make fossil fuels even less desirable. Each renewable energy source's viability depends on geographic and socio-economic considerations; for instance, solar energy is best suited for sunny locations, while wind energy is best for coastal or high-altitude regions (Eikeland et al., 2020). The title combines the two most important renewable energy technologies. Renewable Currents assesses new hydropower plants' performance, sustainability, and innovations that produce electricity from water currents. Light Power conversion through

Photonic Harvesting systems surveys solar energy technologies that convert light into electricity with the help of advanced photonic systems, which focus on a move toward clean, efficient, and sustainable energy alternatives, which has been schematically represented in Fig 1, 2 & 3.



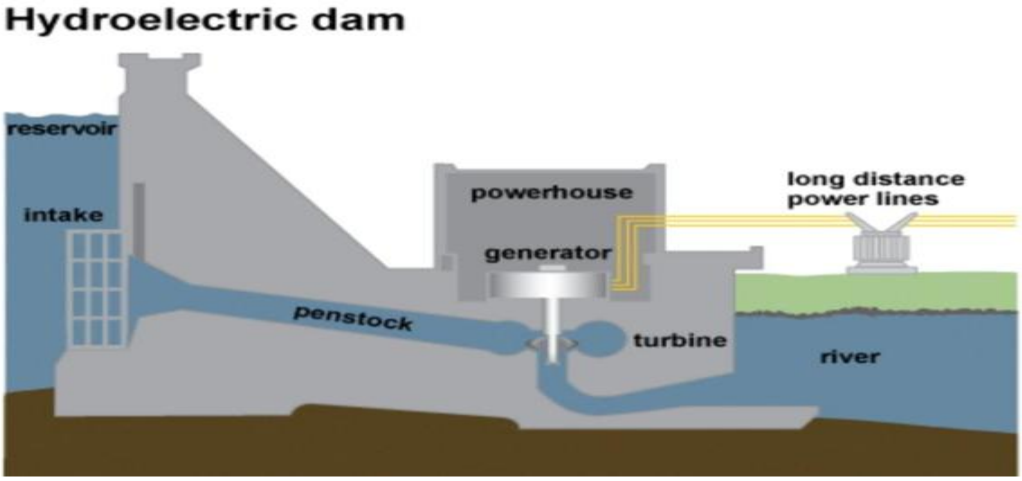




Fig: 1 Light to Power Conversion via Photonic Harvesting Systems Fig: 2 Evaluating Modern Hydropower Plants

Unleashing this potential depends on integrating strong policy support, economic analysis, and technological innovation, enabling a secure and sustainable future for global energy (Adetomi Adewnmi et al., 2023).

**Impacts of REWA and GEDCOL Solar Parks in India:**

India's REWA Solar Park in Madhya Pradesh is an exemplary model for mass deployment of renewable energy. India's Ultra Mega Solar Park, REWA, in Madhya Pradesh, is a perfect example of the country's strategic development of renewable energy (Ullah, 2021). Having an installed capacity of 750 MW across 1,500 hectares, REWA ranks among the world's largest solar parks. Organized through a public-private partnership with the Indian government, the Madhya Pradesh State Government, the Solar Energy Corporation of India (SECI), and multilateral banks, it has been a good example of coordination in mega infrastructure projects (Mohanty, 2024). Commissioned in 2020, the project parallels India's renewable energy target—175 GW by 2022 and 500 GW by 2030—and will produce 1,500 million units of electricity annually, lighting up more than 1.5 million homes. The project aims to lower carbon emissions, improve energy security, and drive economic growth has been stated in Table 1. It attained one of India's lowest tariffs (2.97/kWh) via a competitive reverse auction. The project site at Manamunda was strategically selected based on high solar irradiance and minimal environmental effect, and it was procured through compensation mechanisms and community outreach to realize equitable land use (Heynen, 2017). Regardless of such drawbacks as land acquisition, maintenance needs, and initial high investment, the project overcame these through strong planning, policy backing, and planned maintenance (Standal, 2018). It provided various socio-economic advantages, such as generating jobs during construction and enhancing the population's access to electricity (Okkonen & Lehtonen, 2016), stimulating agricultural and industrial production. A comparative analysis of the REWA and GEDCOL Solar Project has been presented in Fig 3.

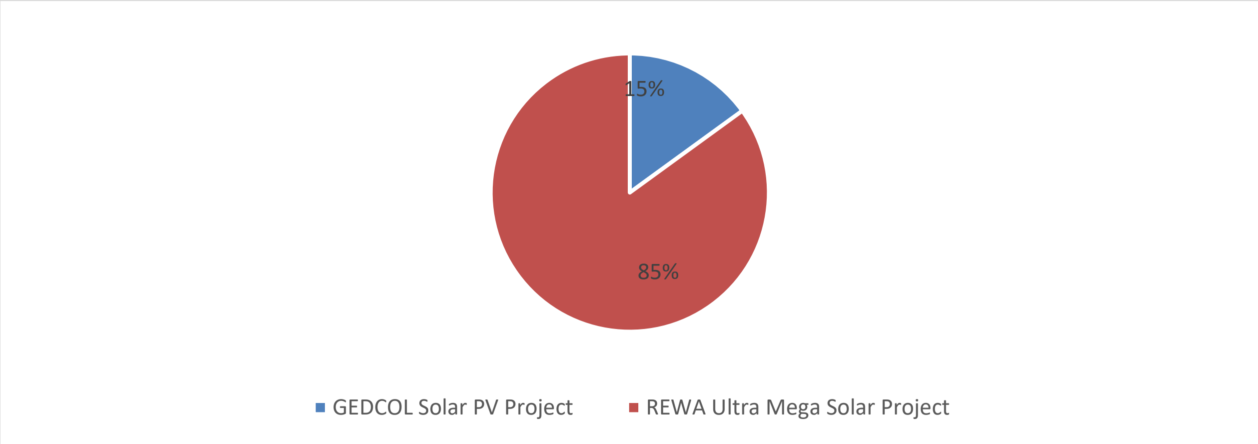



**Fig: 3 Comparative analysis of REWA and GEDCOL Solar Project**

The GEDCOL Solar PV Project is a good example of how renewable energy can help solve environmental and energy issues (Boateng, 2016). Its effective implementation provides a template for like initiatives throughout India. It demonstrates the success of policy-supported, community-friendly, and technically superior solar development in spurring clean energy transformation and rural growth.

**Table: 1 REWA Ultra Mega Solar Project Impact (Madhya Pradesh)**

| o. | ct | neter | ls | enges | gies | ct | nization | e | ence |
|---|---|---|---|---|---|---|---|---|---|
| | | hology | PV ology | cost | nced iles | energy | ISL | Reports | ct Report |
| | | t ucts | wable icity | mittent y | ration | ble power | ISL | Releases | Articles |
| | | ect ucts | and opment | gaps | ing ams | -economic ment | Govt., ractors | a rage | Reports |
| | | holder vement | & e sector | dination | parent ng | th mentation | ISL, Power | ct Docs | uncements |
| | REWA | omical oach | tment | ing enges | & cial ort | ced cial risk | cial utions | ce Docs | Reports |
| | ct | utional oach | ucratic s | latory es | support | mlined opment | E | Briefs | cations |
| | | l oach | munity ance | of eness | gement ams | acceptance | inistration | l Impact sments | y Reports |
| | | r Linkage | mal water | r scarcity | cleaning ods | ervation s | ct lopers | Reports | r Studies |
| | | nical oach | tenance iciency | nical | st O&M ices | oved ility | ISL, tenance s | nical rts | tenance elines |
| | | ssful ples | -scale plant | cation | l for projects | ration for ar projects | | ss Stories | Studies |

Table 2:GEDCOL Solar PV Project Summery (Manamunda, Odisha) Water Management Challenges and Innovations in India:

| o. | ct | neter | ls | enges | gies | ct | nization | e | ence |
|---|---|---|---|---|---|---|---|---|---|
| | COL PV ct | nology | PV ology | cost | nced les | n energy | COL | . Reports | ct Report |
| | | t Products | wable icity | mittent y | ration | ble power | COL | Releases | Articles |
| | | ect ucts | and opment | gaps | ing ams | -economic ment | Govt., ractors | a rage | Reports |
| | | holder vement | & e sector | dination s | sparent ng | oth mentation | COL, r Grid | ct Docs | ouncements |
| | | omical oach | tment | ing enges | & cial ort | ced cial risk | ncial utions | nce Docs | Reports |
| | | utional oach | ucratic s | latory es | y support | mlined opment | E | y Briefs | cations |
| | | l oach | munity ance | of eness | gement ams | acceptance | inistration | l Impact sments | y Reports |
| | | r Linkage | nal water | r scarcity | cleaning ods | ervation s | ct lopers | Reports | r Studies |
| | | nical oach | tenance iciency | nical | st O&M ices | oved ility | COL, tenance s | nical rts | tenance elines |
| | | essful nples | -scale plant | cation s | l for projects | ration for r projects | COL | ess Stories | Studies |

**Water Management Challenges and Innovations in India: a Comparative Insights from Ganges Basin and Sundarbans Ecosystem:**

India's holiest and one of its most important rivers, the Ganges River, runs more than 2,500 kilometers and is a source of water for millions. However, serious challenges are beset due to pollution, over-extraction, sedimentation, and climate change. The river is very much part of India's ecological, cultural, and economic life, so managing it is an imperative national priority(Adel, 2002; Basu Roy, 2017; Khan et al., 2014; M. Kumar, 2019; Sinha & Kannan, 2014). Pollution is the most serious concern, as nearly 80Equally, Sundarbans, the largest continuous global mangrove forest and a World Heritage Site identified by UNESCO, covers approximately 10,000 square kilometers of India and Bangladesh (Ghosh et al., 2015). It sustains about 4.6 million people and hosts a diverse variety of biodiversity, ranging from the Royal Bengal Tiger, listed as endangered. Despite its ecological and economic significance, the region suffers from severe water management issues because of its fragile coastal topography and periodic natural calamities like cyclones, storm surges, and sea-level rise. Water problems in the Sundarbans are intricate in the resources, and their significance is discussed in Table 4. Salinity intrusion is a big issue, as being near the Bay of Bengal causes seawater to contaminate freshwater aquifers (P. Kumar et al., 2020). These sacrifices drinking water, irrigation, and fisheries, lowering agricultural output and food security. The scarcity of freshwater intensifies during the dry season (November to March), with poor rainwater harvesting infrastructure making communities reliant on unsafe sources of water. Pressure on the population, with densely populated small plots of land, raises freshwater demand and overwhelms the ecosystem. In addition, deforestation and land conversion cause environmental degradation, changing the flow of water, sedimentation, and water quality (Saengsupavanich et al., 2024). A number of adaptations have been employed to address these issues. Pond re-excavation and rainwater harvesting are inexpensive yet efficient ways of raising the availability of freshwater. These ponds, when restored, are found to be used in irrigation, fish farming, and aquifer recharge. Pond designs are used to control sediment and enhance water quality.

Integrated farming systems, which integrate aquaculture, livestock, and salt-tolerant crops, enhance food security, improve climate stress resilience, and have improved farm incomes by as much as 60. These initiatives have been very successful: water security has improved, income is higher, biodiversity is preserved, and community capacity is improved. Nevertheless, challenges persist in the form of fragmented governance, inadequate funds, socio-economic disparities, and rising climate risks. Solving these problems requires strong policies, institution building, and people-oriented, innovative approaches. Finally, the Sundarbans water regime demonstrates the potential of adaptive, locally led solutions in balancing people's development and nature protection. Sustained interventions will always need to adapt to local demands and climate pressures so that both the people and the distinctive environment they rely on these, leading to remain resilient in the long-term sustenance.

**Table 3: Water Resource Management in the Ganges River Basin**

| o. | ct | neter | ls | enges | ions | ct | nization | ce | ence |
|---|---|---|---|---|---|---|---|---|---|
| | | nology | s, canals, toring, asting | ated structure | ernization, ime ns | ent tion, control | ral Water mission | rchGate | r Energy Case es |
| | | t ucts | r quality, tion, opower | costs | ing, erships | ble bution, y | onal oelectric r Corp | Reports | opower cts Report |
| | | ect ucts | ulture, hoods, ence | nunity ort | eness, ity ing | oved ipation, hoods | stry of r urces | Surveys | munity ipation rt |
| | | holder vement | nunities, Os | nented nance | dination s | nced boration | r urces dination | l Impact es | -Stakeholder gement |
| | Ganga | omic oach | costs, ed funding | of tment | y reforms | ted tment | ning mission | ncial rts | tment egies Report |
| | ct | nical oach | tenance, ated ns | gaps | ing ams | r ency | nical tenance s | nical uals | ing elines |
| | | l oach | awareness, ance to ge | munity tance | ation tives | lict tion | munity nizations | l Impact es | eness paigns |
| | | utional oach | y nentation | k cement | y ration | ger nance | r urces dination | y Papers | rated Water y |
| | | r Linkage | n water, rge, flood ction | tion from ff | tion ol | hier stems | Health rtments | onmental rts | tion Control ures |
| | | essful ples | Dam, ka Barrage | tenance s | oing ng | ined gement | munity-d nizations | Studies | tenance ams |

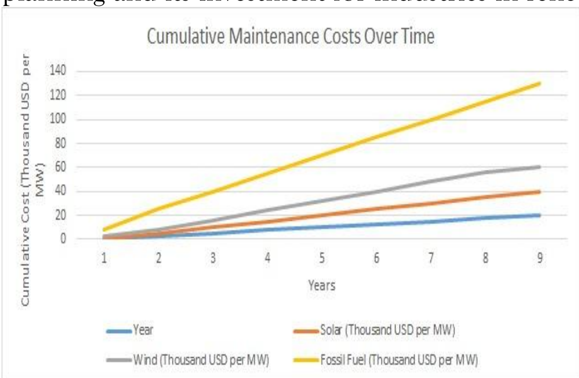
**Table: 4 Climate Resilient Water Management Strategies in the Sundarbans Region**

| o. | ct | neter | ls | enges | egies | ct | nization | ce | ence |
|---|---|---|---|---|---|---|---|---|---|
| | arbans-r ct | nology | energy, nes | costs | funding, nunity gement | inable y | ral Water mission | reports | rchGate - r Energy Studies |
| | | t ucts | gy, water gement | of data | bility es | oved y, flood ol | onal oelectric r Corp | ct data | rchGate - r Energy Studies |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | ect ucts | hoods, tion | tenance ; | ing, ity ing | ced time | stry of r urces | surveys | rchGate - r Energy Studies |
| | | holder vement | , NGOs, nunities | awareness | gement aigns | munity ort | Water orities | l ments | rchGate - r Energy Studies |
| | | omic oach | tment, ng | it access | ofinance, cial ort | r tment | ing mission | cial ts | rchGate - r Energy Studies |
| | | nical oach | tenance, gaps | ly chain ; | hubs, ng | r tions | nical tenance ; | nical ials | rchGate - r Energy Studies |
| | | l oach | ness, uality | l ance | each, sive ng | munity owerment | munity nizations | l impact es | rchGate - r Energy Studies |
| | | utional oach | y gaps, support | of works | y advocacy | ger nance | r urces dination | y papers | rchGate - r Energy Studies |
| | | r Linkage | n water, tion | tional ices | n water ons | h benefits | Health rtments | munity ts | rchGate - r Energy Studies |
| | | ssful ples | and -hydro cts | cation nges | omization, nunity vement | ble ls | munity- l nizations | studies | rchGate - r Energy Studies |

**Economics, Policy, and Environmental Impact of Energy Resources**

The geo-improvement section broadly compares renewable and non-renewable fossil energy, focusing on their economic implications. It highlights key areas such as policy analysis, technological assessments, environmental benefits, data collection, cost analysis, and economic impact evaluations. These components are essential for making informed, rational decisions about the feasibility and superiority of renewable energy sources. By examining these factors, the section emphasizes the practicality of adopting renewables over fossil fuels, showcasing how advancements in policy and technology contribute to sustainable development while supporting economic growth and environmental protection. Data collection involves systematically gathering information to analyze and evaluate the performance, impact, and feasibility of energy sources as both renewable and non-renewable. However, the total cost over time to maintain a system, facility, or equipment, assisting in determining long-term operating efficiency, budgeting, and cost-effectiveness for project planning and its investment for industries in renewable energy, is represented in (Fig 4 & 5).



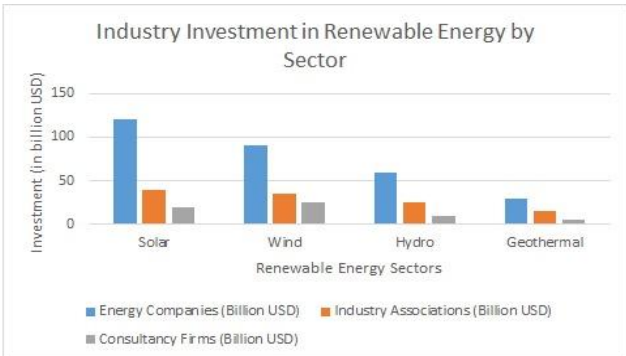
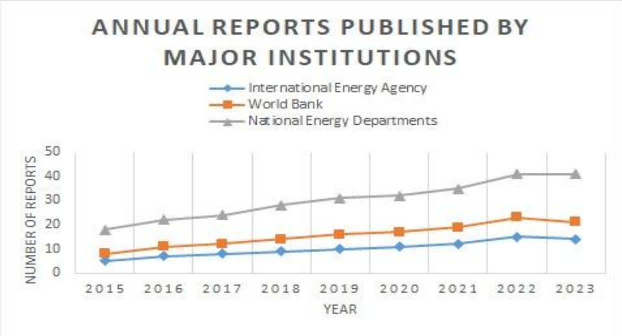




Fig 4: Cumulative maintenance cost

Fig 5: Industry investment in renewable energy

In the context of geo-improvement, it includes monitoring energy production, consumption patterns, environmental emissions, resource availability, and economic costs. Reliable data supports evidence-based decision-making, policy formulation, and technological innovation. Data collection may track solar radiation, wind speeds, and hydrological flows for renewables, while fossil energy data includes fuel extraction rates and emission levels. Accurate and consistent data is essential to compare energy systems, assess long-term sustainability, and guide investments toward more efficient and environmentally friendly energy solutions. This analysis emphasizes validity and precision through consideration of reputable sources of data, including academic Journals and reports published by well-recognized institutions such as the IEA, World Bank, and National Energy Department serve as reliable estimates of energy output, consumption and energy policy impact. Annual reports published by some of the major institutions, such as the UN, World Bank, or IEA, consolidating finances, progress, and strategies, are listed in Fig 6.



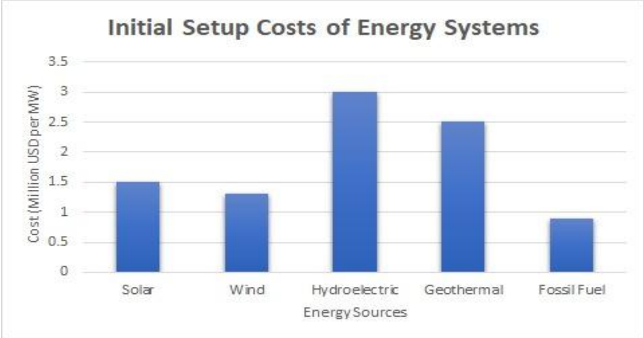
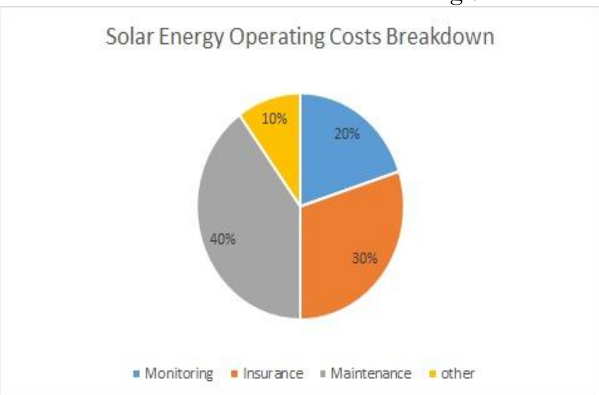
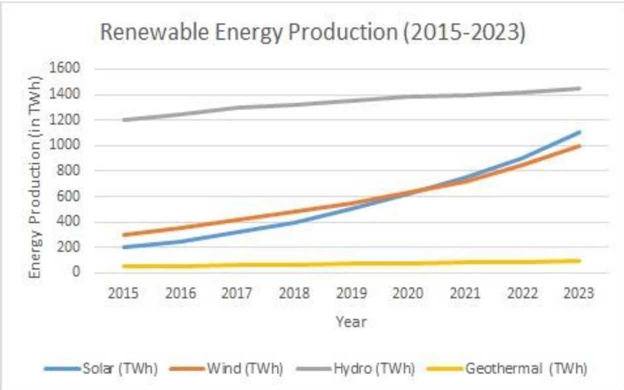




Fig 6: Annual reports published by major organization Fig 7: Initial setup cost for renewable energy system

Similarly, reports from energy companies, industry associations, and consultancy firms provide organizational details and practical examples related to renewable energy installations. The Quantitative data is collected from organizations like IRENA, focusing on energy costs, production, and market trends. Initial Investment Renewable systems (solar, wind, hydro, geothermal) have high setup costs, but these are compared to fossil fuel infrastructure costs Fig 7. Operating Costs of solar energy facilities incurs minimal operational costs since sunlight is free, reducing long-term expenses significantly (Renewable Power Generation Costs in 2022, 2022; World Energy Outlook 2023, 2023; World Bank, 2022) mentioned in Fig 8 whereas the fuel costs. Renewables save heavily by eliminating fuel purchase expenses, enhancing return on investment, and producing renewable energy from 2015 to 2023 has been reviewed and mentioned in Fig 9.



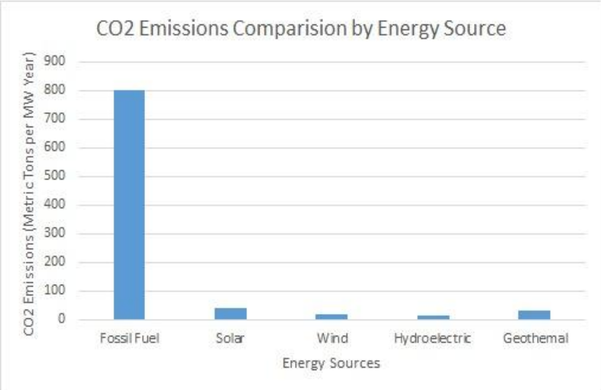

Renewable energy maintenance costs are necessary to maintain solar panels, wind turbines, and hydro power plants in working order efficiently by inspecting, repairing, cleaning, and replacing parts.

**Economic impact analysis:**

The economic impact analysis on the adoption of a renewable energy system goes beyond the realm of economy and includes the following aspects: Job creation in renewable energy adoption stimulates employment across multiple sectors, from manufacturing components to installation, maintenance, and operation (Bali Swain et al., 2022). Compared to fossil fuels, renewables support a broader range of skill-based and labor-intensive opportunities. GDP Growth: Investment in renewable energy infrastructure boosts economic activity by driving construction, innovation, and technology advancement, thereby contributing significantly to national GDP (Yu et al., 2023). Energy Security: Utilizing domestic renewable resources reduces dependence on imported fossil fuels. This enhances national energy security by minimizing exposure to geopolitical risks and supply chain disruptions.

**Environmental impact assessment:**

As with economic impact, renewable resources have various environmental impacts. Greenhouse gas emissions from fossil fuels emit significant greenhouse gases (GHGs), contributing to climate change, which is clearly mentioned in Fig 10. Renewable sources, in contrast, produce minimal or no GHGs. Studies show that replacing fossil fuels with renewables significantly reduces emissions, aiding climate mitigation efforts (Li et al., 2024). The quality of air during the combustion of fossil fuels releases harmful pollutants such as sulfur dioxide and nitrogen oxides, which cause smog and health issues, as mentioned in Fig 11.



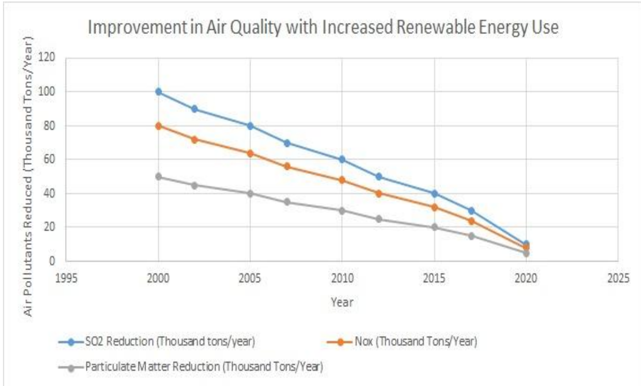




Fig 10: CO2 Emissions Comparison Fig 11: Improvement Of Air Quality

Renewable energy adoption reduces these emissions, resulting in cleaner air and improved public health, and is naturally replenishing and sustainable. Their long-term use supports environmental protection and promotes steady economic growth without depleting finite resources (Garba & Abdulrahman, 2024).

**India's Strategic Policy Framework for Solar and Hydro Energy Growth:**

India has implemented several policies to promote renewable energy, particularly in the solar and hydro sectors. Here is an overview of key policies, each supported by research paper references:

**Solar Energy Policies in India**:

Jawaharlal Nehru National Solar Mission (JNNSM) – 2010 Launched as part of the National Action Plan on Climate Change (NAPCC). Aimed to install 100 GW of solar capacity by 2022. Supported through capital subsidies, feed-in tariffs, and Renewable Energy Certificates (RECs). Focused on large-scale solar parks and rooftop solar projects (Chaudhary et al., 2015; KhareSaxena et al., 2024).

Solar Park Scheme – 2014- Encourages states to develop large-scale solar parks. Provides financial assistance of up to 20 lakh per MW for infrastructure development. Implemented in multiple states such as Gujarat, Rajasthan, and Madhya Pradesh (Kar et al., 2016).

Rooftop Solar Programme Phase II – 2019 Provides up to 40% subsidies for residential rooftop solar installations. Targets 40 GW of rooftop solar by 2022. Implemented through distribution companies (DISCOMs) (A. Kumar et al., 2023).

Production-Linked Incentive (PLI) It's a scheme for Solar PV Manufacturing – 2021- Aims to promote domestic manufacturing of solar photovoltaic (PV) modules. 4,500 crore allocated to support high-efficiency solar modules. Reduces dependency on imports, particularly from China (Wandhe, 2024).

**Hydropower Policies in India:**

National Hydroelectric Power Policy – 2008- Provides financial support for hydro projects, especially small hydropower (SHP). Encourages private sector participation and fast-tracks project approvals (Mishra et al., 2015).

Hydro Power Policy – 2018- Declared hydropower (25 MW) as a renewable energy source. Introduced Hydropower Purchase Obligations (HPOs) to increase hydro energy adoption. Provided budgetary support for flood moderation and enabling infrastructure.

Small Hydro Power (SHP) Programme-Targets hydro projects below 25 MW capacity. Provides financial assistance for micro, mini, and small hydro projects. Supports rural electrification in remote and hilly regions.

National Adaptation Fund for Climate Change (NAFCC)- Offers financial assistance for climate-resilient hydro projects. Focuses on sustainable water management and dam safety improvements.

**Overcoming Challenges in Renewable Energy Integration for a Sustainable Future**

Efficient management of renewable and non-renewable energy resources requires a coordinated, multi-sectoral approach involving government, industry, and communities. Renewable energy offers a sustainable solution but faces challenges like intermittency and infrastructure demands (Amin, n.d.; Rountree & Baldwin, 2018). Despite ongoing reliance on fossil fuels, these non-renewable sources pose significant environmental and economic risks that could hinder long-term global development. India's solar parks and renewable water management projects demonstrate how renewables can succeed in both developed and developing economies, highlighting the importance of policy support, international cooperation, and technological innovation. The economics of renewable energy focuses on comparing the costs and benefits of various energy technologies (ESMAP, 2024). Although renewables have high initial investment costs, they benefit from low fuel expenses and reduced environmental harm over time. They also generate employment and boost local economies. Government incentives and falling technology prices are helping renewables compete despite challenges like grid integration. Assessing renewables' viability involves considering resource availability, technology readiness, and social acceptance. Energy grids must adapt to handle variable renewable inputs through resilient strategies. Long-term data from multiple countries show that renewable adoption offers greater benefits than costs. Overall, transitioning to renewable energy is both an economic and environmental imperative that, with proper management and investment, can build sustainable, resilient energy systems while minimizing the drawbacks of fossil fuel dependence.

## DISCUSSION:

The REWA Ultra Mega Solar Project in Madhya Pradesh is far more impactful than the GEDCOL Solar PV Project in Odisha. With a capacity of 750 MW, REWA is among Asia's largest solar plants, supplying power to major consumers like Delhi Metro and significantly reducing CO emissions by over 1.5 million tons annually. It sets a benchmark in cost efficiency and supports India's national renewable targets. In contrast, the 50 MW GEDCOL project has a limited local impact. While beneficial for Odisha's energy goals, it lacks REWA's national significance. Thus, REWA contributes approximately 85% of the overall impact compared to GEDCOL's 15%. Like solar, the Ganga and Sundarbans water Management Systems address different but vital objectives in water resources. The Ganga system targets pollution control and water-quality improvement for agriculture, drinking, and industry. Programs like Namami Gange, sewage-treatment plants, and industrial effluent monitoring work to rejuvenate the river, yet challenges persistent contamination, encroachment, and seasonal shortages hinder full restoration (Sarkar et al., 2007; Trivedi, 2010). Conversely, the Sundarbans system is designed to protect the world's largest mangrove forest from climate-change impacts, including sea-level rise, salinity intrusion, and cyclones. Measures such as embankment construction, tidal-river management, and large-scale afforestation bolster climate resilience and conserve biodiversity. While embankment breaches and freshwater scarcity remain concerns, this system excels in disaster risk reduction and habitat preservation. Ultimately, the preferable system depends on priorities: for ecological protection and climate adaptation, the Sundarbans approach is superior; for broad-scale human water needs and pollution mitigation, the Ganga framework is essential. Both are indispensable components of India's integrated renewable energy management strategy. However, in conclusion, the REWA Solar Project and Sundarbans Water Management System demonstrate national leadership in renewable energy and climate resilience. While GEDCOL and Ganga systems serve regional needs, REWA and Sundarbans offer broader environmental and socio-economic benefits. All four represent complementary pillars in India’s sustainable energy and water resource management strategy.

## REFERENCE:

1. Adel, M. M. (2002). Man-made climatic changes in the Ganges basin. International Journal of Climatology, 22(8), 993–1016. https://doi.org/10.1002/joc.732
2. Adetomi Adewnmi, Kehinde Andrew Olu-lawal, Chinelo Emilia Okoli, Favour Oluwadamilare Usman, & Gloria Siwe Usiagu. (2023). Sustainable energy solutions and climate change: A policy review of emerging trends and global responses. World Journal of Advanced Research and Reviews, 21(2), 408–420. https://doi.org/10.30574/wjarr.2024.21.2.0474
3. Ai, H., Tan, X., Mangla, S. K., Emrouznejad, A., Liu, F., & Song, M. (2025). Renewable energy transition and sustainable development: Evidence from China. Energy Economics, 108232.

4. Al Balushi, A. K., & Matriano, M. T. (2024). Renewable Energy Investments Impact on Economic Diversification and Strategic Growth: A Review of Literature in the Context of Oman Vision 2040. https://pdfs.semanticscholar.org/c987/f6cc3095eedba8956d48a27abf5f05a2c387.pdf
5. Amin, A. Z. (n.d.). Renewable Energy Benefits: Measuring the Economics.
6. Bali Swain, R., Karimu, A., & Gråd, E. (2022). Sustainable development, renewable energy transformation and employment impact in the EU. International Journal of Sustainable Development & World Ecology, 29(8), 695–708. https://doi.org/10.1080/13504509.2022.2078902
7. Basu Roy, S. (2017). Ganga Action Plan (GAP): The Challenge of 'Regulatory Quality.' https://mpra.ub.uni-muenchen.de/id/eprint/81148
8. Behrens, A., Giljum, S., Kovanda, J., & Niza, S. (2007). The material basis of the global economy. Ecological Economics, 64(2), 444–453. https://doi.org/10.1016/j.ecolecon.2007.02.034
9. Bilgen, S. (2014). Structure and environmental impact of global energy consumption. Renewable and Sustainable Energy Reviews, 38, 890–902.
10. Boateng, E. (2016). The potential socio-economic and environmental impacts of solar PV mini-grid deployment on local communities: A case study of rural island communities on the Volta Lake, Ghana [Master's Thesis]. https://www.academia.edu/download/79286895/URN_NBN_fi_jyu-201604182231.pdf
11. Chaudhary, A., Krishna ,Chetan, & and Sagar, A. (2015). Policy making for renewable energy in India: Lessons from wind and solar power sectors. Climate Policy, 15(1), 58–87. https://doi.org/10.1080/14693062.2014.941318
12. Eikeland, O. F., Apostoleris, H., Santos, S., Ingebrigtsen, K., Boström, T., & Chiesa, M. (2020). Rethinking the role of solar energy under location specific constraints. Energy, 211, 118838. https://doi.org/10.1016/j.energy.2020.118838
13. ESMAP. (2024). Empowering Small Island Developing States: Scaling Up Renewable Energy for Resilient Economic Growth. Washington, DC: World Bank. https://doi.org/10.1596/41678
14. Garba, N., & Abdulrahman, B. (2024). Renewable Energy Sources, Sustainability and Environmental Protection: A Review. European Journal of Theoretical and Applied Sciences, 2(2), 449–462. https://doi.org/10.59324/ejtas.2024.2(2).39
15. Ghosh, A., Schmidt, S., Fickert, T., & Nüsser, M. (2015). The Indian Sundarban Mangrove Forests: History, Utilization, Conservation Strategies and Local Perception. Diversity, 7(2), Article 2. https://doi.org/10.3390/d7020149
16. Heynen, A. (2017). Private sector electrification in Base of the Pyramid marketplaces in India: Opportunities for energy and business to create Shared Value [PhD Thesis, The University of Queensland]. https://doi.org/10.14264/uql.2018.12
17. Jafarizadeh, H., Yamini, E., Zolfaghari, S. M., Esmaeilion, F., Assad, M. E. H., & Soltani, M. (2024). Navigating challenges in large-scale renewable energy storage: Barriers, solutions, and innovations. Energy Reports, 12, 2179–2192. https://doi.org/10.1016/j.egyr.2024.08.019
18. Kar, S. K., Sharma, A., & Roy, B. (2016). Solar energy market developments in India. Renewable and Sustainable Energy Reviews, 62, 121–133. https://doi.org/10.1016/j.rser.2016.04.043
19. Khan, M. R., Voss, C. I., Yu, W., & Michael, H. A. (2014). Water Resources Management in the Ganges Basin: A Comparison of Three Strategies for Conjunctive Use of Groundwater and Surface Water. Water Resources Management, 28(5), 1235–1250. https://doi.org/10.1007/s11269-014-0537-y
20. KhareSaxena, A., Saxena, S., & Sudhakar, K. (2024). Solar Energy Policy for India: An Overview. CSEE Journal of Power and Energy Systems, 10(6), 2308–2320. https://doi.org/10.17775/CSEEJPES.2020.03080
21. Kumar, A., R, S. M., Mohan, V., Viswanathan, R., & S, A. V. (2023). An Adaptive Staggered Investment Strategy for promotion of residential rooftop solar PV installations in India. International Journal of Sustainable Energy Planning and Management, 37, 75–94. https://doi.org/10.54337/ijsepm.7477
22. Kumar, M. (2019). The Ganga Pollution is the Big Problem. 09(01).
23. Kumar, P., Tiwari, P., Biswas, A., & Acharya, T. (2020). Geophysical and hydrogeological investigation for the saline water invasion in the coastal aquifers of West Bengal, India: A critical insight in the coastal saline clay–sand sediment system. Environmental Monitoring and Assessment, 192(9), 562. https://doi.org/10.1007/s10661-020-08520-x
24. Li, Y., Ravi, V., Heath, G., Zhang, J., Vahmani, P., Lee, S.-M., Zhang, X., Sanders, K. T., & Ban-Weiss, G. A. (2024). Air quality and public health co-benefits of 100% renewable electricity adoption and electrification pathways in Los Angeles. Environmental Research Letters, 19(3), 034015. https://doi.org/10.1088/1748-9326/ad24cc
25. Mishra, M. K., Khare, N., & Agrawal, A. B. (2015). Small hydro power in India: Current status and future perspectives. Renewable and Sustainable Energy Reviews, 51, 101–115. https://doi.org/10.1016/j.rser.2015.05.075
26. Mohanty, D. (2024). Green Transit: Harnessing Renewable Energy For Sustainable Integration. Educational Administration: Theory and Practice, 30(4), 7242–7254.
27. Okkonen, L., & Lehtonen, O. (2016). Socio-economic impacts of community wind power projects in Northern Scotland. Renewable Energy, 85, 826–833. https://doi.org/10.1016/j.renene.2015.07.047
28. Renewable power generation costs in 2022. (2022).
29. Rountree, V., & Baldwin, E. (2018). State-Level Renewable Energy Policy Implementation: How and Why Do Stakeholders Participate? Frontiers in Communication, 3. https://doi.org/10.3389/fcomm.2018.00006
30. Saengsupavanich, C., Agarwala, N., Magdalena, I., Ratnayake, A. S., & Ferren, V. (2024). Impacts of a growing population on the coastal environment of the Bay of Bengal. Anthropocene Coasts, 7(1), 24. https://doi.org/10.1007/s44218-024-00055-9
31. Sarkar, S. K., Saha, M., Takada, H., Bhattacharya, A., Mishra, P., & Bhattacharya, B. (2007). Water quality management in the lower stretch of the river Ganges, east coast of India: An approach through environmental education. Journal of Cleaner Production, 15(16), 1559–1567.
32. Sinha, R. K., & Kannan, K. (2014). Ganges River Dolphin: An Overview of Biology, Ecology, and Conservation Status in India. AMBIO, 43(8), 1029–1046. https://doi.org/10.1007/s13280-014-0534-7

33. Standal, K. (2018). Challenges of Gender, Power and Change in Solar Energy Interventions in Rural India. Imagined Beneficiaries and the Makings of Women's Empowerment in the Village Electrification Project. https://www.duo.uio.no/handle/10852/65440
34. Trivedi, R. C. (2010). Water quality of the Ganga River – An overview. Aquatic Ecosystem Health & Management, 13(4), 347–351. https://doi.org/10.1080/14634988.2010.528740
35. Ullah, A. (2021). Public private partnership in solar energy development of India. Amirullah, Public Private Partnership in Solar Energy Development of India, International Journal of Multidisciplinary Educational Research (ISSN: 2277-7881), 10(12), 2.
36. Veronese, E., Manzolini, G., & Moser, D. (2021). Improving the traditional levelized cost of electricity approach by including the integration costs in the TECHNO-ECONOMIC evaluation of future photovoltaic plants. International Journal of Energy Research, 45(6), 9252–9269. https://doi.org/10.1002/er.6456
37. Wandhe, D. P. (2024). An Overview on Production Linked Incentive (PLI) Scheme by The Government of India (SSRN Scholarly Paper 4693578). Social Science Research Network. https://doi.org/10.2139/ssrn.4693578
38. World Bank. (2022). State and Trends of Carbon Pricing 2022. Washington, DC: World Bank. https://doi.org/10.1596/978-1-4648-1895-0
39. World Energy Outlook 2023. (2023).
40. Yi, Z., Xin-gang, Z., Yu-zhuo, Z., & Ying, Z. (2019). From feed-in tariff to renewable portfolio standards: An evolutionary game theory perspective. Journal of Cleaner Production, 213, 1274–1289. https://doi.org/10.1016/j.jclepro.2018.12.170
41. Yu, Z., Ridwan, I. L., Tanveer, M., & Khan, S. A. R. (2023). Investigating the nexuses between transportation Infrastructure, renewable energy Sources, and economic Growth: Striving towards sustainable development. Ain Shams Engineering Journal, 14(2), 101843.