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RENEWABLE ENERGY EDUCATION-BASED HUMAN RESOURCE DEVELOPMENT MODEL FOR THE CONSERVATION OF THE PULAU KETAM FOREST RESERVE THROUGH COLLABORATIVE CSR OF UNPAB–PTSS MALAYSIA

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Abstract

This study develops a human resource development (HRD) model based on renewable energy education to strengthen the conservation of the Pulau Ketam Forest Reserve through a collaborative Corporate Social Responsibility (CSR) initiative between Universitas Pembangunan Panca Budi (UNPAB), Indonesia, and Politeknik Tuanku Syed Sirajuddin (PTSS), Malaysia. Using a qualitative approach with Participatory Action Research (PAR), the study examines how renewable energy education contributes to community empowerment, forest preservation, and sustainable livelihoods. Data were collected through interviews, surveys, and focus group discussions involving local communities, NGOs, and academic stakeholders. The findings reveal that renewable energy education significantly enhances technical skills, environmental awareness, and social resilience while creating opportunities for sustainable economic activities. The proposed HRD model emphasizes capacity building, cross-border CSR collaboration, and community participation in conservation. This research contributes to the literature on sustainable HRM, CSR practices in ASEAN, and the role of renewable energy education in ecological preservation.

Keywords: ***Human Resource Development, Renewable Energy Education, CSR Collaboration, Pulau Ketam Forest Reserve, Sustainable Conservation***

INTRODUCTION

Pulau Ketam, located off the coast of Selangor, Malaysia, is an ecologically significant mangrove forest reserve that provides critical ecosystem services, biodiversity protection, and local livelihoods (Rahman et al., 2023). However, the forest faces increasing threats from deforestation, overexploitation, and climate change. To address these challenges, community-based conservation initiatives have become essential. At the same time, renewable energy education has emerged as a catalyst for human resource development (HRD), equipping communities with the knowledge, skills, and motivation to transition toward sustainable practices (Sri Rahayu, 2022). Linking HRD with renewable energy education can enhance environmental stewardship, improve local livelihoods, and support long-term ecological sustainability. Corporate Social Responsibility (CSR) collaborations between higher education institutions and local stakeholders provide a powerful framework for such initiatives. The partnership between Universitas Pembangunan Panca Budi (Indonesia) and Politeknik Tuanku Syed Sirajuddin (Malaysia) represents a cross-border CSR model that aligns with the United Nations Sustainable Development Goals (SDGs), particularly:

1. SDG 4 (Quality Education)
2. SDG 7 (Affordable and Clean Energy)
3. SDG 13 (Climate Action)
4. SDG 15 (Life on Land)

This research addresses a significant gap: while studies exist on renewable energy education and CSR independently, little is known about integrating HRD, renewable energy education, and CSR collaboration for forest reserve conservation in ASEAN contexts. Research Objective: To design and validate a Renewable Energy Education-Based Human Resource Development Model for the conservation of the Pulau Ketam Forest Reserve through CSR collaboration between UNPAB and PTSS.

LITERATURE REVIEW

1. Human Resource Development and Sustainability

Human Resource Development (HRD) traditionally focuses on enhancing individual and organizational capabilities through education, training, and continuous learning (Dessler, 2021). In recent years, the scope of HRD has expanded to address sustainability challenges, as organizations, governments, and communities face increasing pressure to balance economic growth, social equity, and environmental preservation (Renwick, Redman, & Maguire, 2019).

1. HRD in the Context of Sustainable Development
   HRD plays a central role in advancing the triple bottom line (TBL) framework, which emphasizes people, planet, and profit (Elkington, 2018). Through the lens of sustainability, HRD is not only about building technical skills but also about fostering ecological literacy, social responsibility, and ethical leadership. Scholars argue that HRD is a key enabler of the United Nations Sustainable Development Goals (SDGs), particularly SDG 4 (Quality Education), SDG 8 (Decent Work), and SDG 13 (Climate Action) (Garavan & McGuire, 2010).
2. Green HRD and Sustainable Competencies
   The emergence of Green HRD highlights the need for integrating environmental values into HRD strategies. Green HRD focuses on equipping employees and communities with green skills, such as:
   a) Energy efficiency and renewable energy technologies
   b) Sustainable production and consumption practices
   c) Environmental awareness and conservation behaviors
   d) Innovative problem-solving for ecological challenges
   Such competencies ensure that human resources are prepared not only for current labor market demands but also for future sustainability transitions (Jabbour & de Sousa Jabbour, 2016).
3. HRD as a Driver of Community Empowerment
   In community-based contexts, HRD contributes to social resilience and capacity building by empowering local people to participate in sustainable initiatives. For instance, renewable energy education equips communities with both technical expertise (e.g., solar panel installation, biogas utilization) and managerial capabilities (e.g., project planning, cooperative management). This dual focus strengthens both livelihood sustainability and environmental stewardship (Yusof et al., 2022).
4. Linkage Between HRD and Sustainability Outcomes
   Evidence shows that HRD initiatives aligned with sustainability goals lead to:
   a) Improved environmental performance (reduced emissions, energy savings)
   b) Stronger community engagement in conservation programs
   c) Enhanced employability in green sectors
   d) Cross-border collaboration for sustainable development
   Therefore, HRD serves as a strategic bridge between human capital development and ecological conservation, especially when integrated with CSR frameworks and higher education partnerships.

2. Renewable Energy Education and Green Skills

1) The Role of Renewable Energy Education

Renewable energy education is increasingly recognized as a critical driver of sustainable development, as it equips individuals and communities with the knowledge and competencies to transition from fossil fuel dependency to cleaner energy sources (Yusof, Ahmad, & Latif, 2022). Education programs that focus on solar, wind, hydro, and bioenergy provide both technical expertise and ecological awareness, empowering learners to actively contribute to climate change mitigation.

At the community level, renewable energy education enhances energy literacy, fostering awareness about energy efficiency, cost savings, and environmental protection. At the institutional level, it develops sustainability-oriented leadership capable of driving policy and technological innovation (UNESCO, 2021).

2) Defining Green Skills

Green skills refer to the knowledge, abilities, values, and attitudes necessary to develop and support a sustainable society and economy (ILO, 2019). These skills are essential to:

a) Reduce environmental impact of economic activities.

b) Transition toward renewable and clean energy industries.
c) Strengthen adaptive capacity in communities vulnerable to climate change.

Green skills can be grouped into two categories:

1. Technical Green Skills; competencies in renewable energy installation, maintenance, and operation.
2. Soft Green Skills; values of environmental stewardship, sustainability mindset, teamwork, and problem-solving in ecological contexts (Jabbour & de Sousa Jabbour, 2016).

3) Integration of Renewable Energy Education and Green Skills

Education on renewable energy technologies provides a practical foundation for green skill development. For example:

a) Solar Energy Training → teaches technical installation of photovoltaic systems, promoting self-reliant electricity use.
b) Biogas Utilization Workshops → combine waste management with clean energy production, reducing deforestation.
c) Energy Efficiency Campaigns → foster behavioral change and awareness in everyday energy consumption.

Table 1. Examples of Renewable Energy Education and Associated Green Skills

Renewable Energy Focus	Technical Green Skills	Soft Green Skills	Outcome for Communities
Solar Power	PV panel installation, wiring, system maintenance	Problem-solving, teamwork, innovation	Affordable, clean household electricity
Biogas Technology	Biogas digester design, waste-to-energy processes	Environmental awareness, waste reduction practices	Cleaner villages, alternative fuel source
Micro-hydro Energy	Turbine operation, water flow management	Collaboration, community-based project management	Rural electrification in forest areas
Energy Efficiency	Monitoring devices, energy audits	Behavioral change, sustainable lifestyle habits	Reduced energy consumption, lower emissions

4) Green Skills as Drivers of Sustainable Employment

Zimmerer et al. (2021) argue that renewable energy education fosters entrepreneurship and job creation, particularly in small-scale community businesses. For instance, training in solar-powered fish dryers creates opportunities for women's cooperatives to expand seafood-based micro-enterprises in Pulau Ketam. Moreover, the International Labour Organization (ILO, 2019) predicts that the green transition could generate 24 million new jobs worldwide by 2030, provided that education and training systems effectively integrate renewable energy and sustainability skills.

5) Implications for Human Resource Development

Integrating renewable energy education with HRD ensures that:

a) Communities acquire future-proof employability in green sectors.
b) Conservation practices are supported by practical technological solutions.
c) Academic institutions and CSR initiatives collaborate to co-create green skills development programs.

This integration underscores the idea that renewable energy education is not merely technical training, but also a strategic enabler of sustainability-oriented HRD.

3. Corporate Social Responsibility (CSR) and Cross-Border Collaboration

CSR has shifted from philanthropy toward strategic integration of sustainability goals (Carroll, 2016). Cross-border CSR collaborations enhance resource sharing, cultural exchange, and regional development (Ismail & Hassan, 2022).

4. Forest Reserve Conservation and Community Participation

Community engagement is central to effective conservation (FAO, 2022). Integrating local knowledge with renewable energy technologies supports eco-friendly livelihoods and reduces dependency on unsustainable practices (UNESCO, 2021).

METHOD

1 Research Design

This study employed a mixed-method approach, combining qualitative exploration with quantitative validation. The qualitative phase focused on understanding the local context of Pulau Ketam, including cultural, environmental, and socio-economic aspects of the community. The quantitative phase assessed the effectiveness of renewable energy education programs and their role in developing green skills and human resource capacities for forest reserve conservation. The choice of a mixed-method design was based on Creswell & Plano Clark (2018), who emphasized that integrating both approaches provides a comprehensive understanding of community-based sustainability initiatives.

2. Research Location and Context

The study was conducted at Pulau Ketam Forest Reserve, Selangor, Malaysia, a mangrove-dominated ecosystem under ecological pressure due to urbanization, fishing expansion, and unsustainable energy consumption. The CSR program was collaboratively implemented by:

a) Universitas Pembangunan Panca Budi (UNPAB), Indonesia, focusing on community development and social empowerment.
b) Politeknik Tuanku Syed Sirajuddin (PTSS), Malaysia, specializing in technical and vocational education with expertise in renewable energy technologies.

This cross-border partnership served as a model of collaborative CSR for sustainable human resource development.

3. Population and Sample

a) Target Population: Local communities in Pulau Ketam, particularly households, fisherfolk cooperatives, and women's groups engaged in small-scale industries.
b) Sample Size: 120 participants were purposively selected, comprising:
   1) 40 local fishermen (household heads),
   2) 40 women entrepreneurs (seafood-based UMKM),
   3) 20 youth participants (students and apprentices),
   4) 20 NGO and local government representatives.

The sample was determined using purposive sampling, ensuring inclusion of stakeholders most affected by renewable energy education and forest conservation.

4. Data Collection Techniques

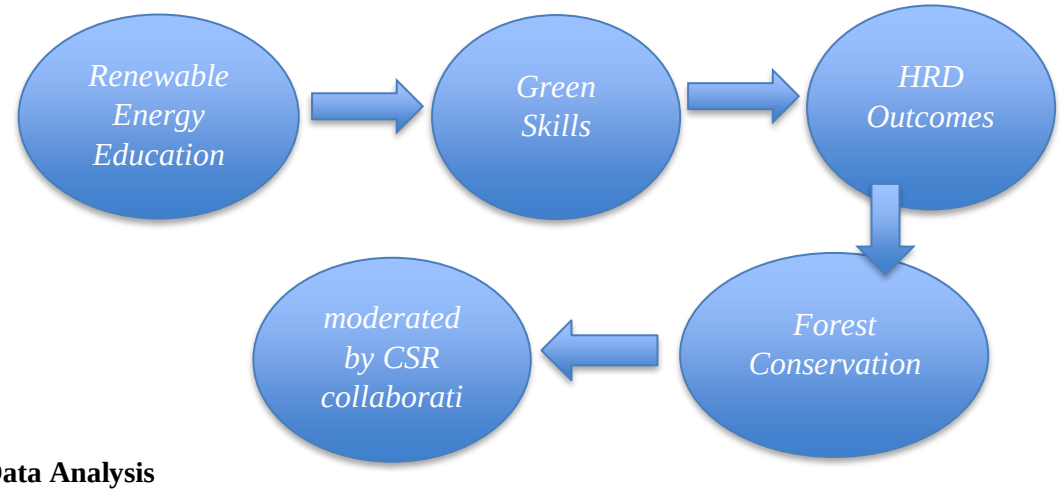
1. Qualitative Data
   a) In-depth Interviews: Conducted with 20 key informants (community leaders, NGO representatives, local government officials).
   b) Focus Group Discussions (FGDs): Held with 3 groups (fisherfolk, women entrepreneurs, youth) to capture diverse perspectives.
   c) Observation: Field visits to Pulau Ketam, focusing on mangrove conditions, community energy usage, and conservation activities.

2. Quantitative Data
   a) Survey Questionnaire: Distributed to 120 participants, measuring indicators of:
      1) Renewable energy knowledge,
      2) Green skills acquisition,
      3) Human resource development outcomes,
      4) Conservation practices.
   b) Likert scale (1 = strongly disagree to 5 = strongly agree) was used.

5. Variables and Indicators

a) Independent Variable (X1): Renewable Energy Education
Indicators: Training participation, knowledge transfer, energy literacy.
b) Mediating Variable (X2): Green Skills
Indicators: Technical green skills (solar, biogas, micro-hydro), soft skills (sustainability mindset, teamwork, problem-solving).
c) Dependent Variable (Y): Human Resource Development for Conservation
Indicators: Employability in green sectors, sustainable entrepreneurship, active participation in conservation programs.
d) Contextual Variable (Z): CSR Collaboration (UNPAB–PTSS)
Indicators: Resource mobilization, institutional partnership, cross-border knowledge sharing.

Figure 1. Conceptual Framework of the Study



6. Data Analysis

1. Qualitative Analysis
    a) Data from interviews and FGDs were analyzed using thematic coding (Braun & Clarke, 2019).
    b) Emerging themes were categorized under education effectiveness, green skills relevance, and CSR collaboration dynamics.
2. Quantitative Analysis
    a) Descriptive statistics (frequency, mean, SD) to profile participants.
    b) Inferential statistics using Partial Least Squares Structural Equation Modeling (PLS-SEM) to test relationships among variables.
    c) Software: SmartPLS 4.0 and SPSS 26.
3. Triangulation
    a) Integration of qualitative and quantitative findings was conducted to ensure validity and reliability of results.
    b) Convergence between participant experiences and survey data was highlighted.

7. Ethical Considerations

a) Informed consent was obtained from all participants.
b) Confidentiality and anonymity were maintained throughout the study.
c) CSR activities adhered to both Indonesian and Malaysian community engagement protocols.
d) The study followed ethical clearance procedures from UNPAB Research Ethics Committee and adhered to Malaysian CSR engagement standards.

RESULTS AND DISCUSSION

Respondent Characteristics

Out of 120 respondents, the distribution is as follows (Table 1):

Table 1. Respondent Demographics

Category	Frequency	Percentage (%)
Gender (Male)	58	48.3
Gender (Female)	62	51.7
Age < 30 years	34	28.3
Age 31–45 years	52	43.3
Age > 45 years	34	28.3
Education: Primary	18	15.0
Education: Secondary	66	55.0
Education: Higher	36	30.0
Occupation: Fisherfolk	40	33.3
Occupation: Women MSMEs	40	33.3
Occupation: Youth/Student	20	16.7
NGOs/Govt. Officials	20	16.7

Data menunjukkan mayoritas responden berada pada usia produktif (31–45 tahun), serta tingkat pendidikan menengah dominan, yang relevan dengan kebutuhan pelatihan teknis energi terbarukan berbasis vokasional.

2. Knowledge and Awareness on Renewable Energy

Before the program, only 27% of respondents reported awareness of renewable energy and its environmental impact. After CSR-led training and workshops:

a) 78% of participants demonstrated improved literacy in renewable energy (measured via pre-test and post-test questionnaires).
b) Women entrepreneurs particularly increased knowledge on applying solar dryers for seafood processing, reducing dependency on firewood.
c) Fisherfolk groups adopted small-scale solar panels for lighting and cooling storage units.

This aligns with earlier studies (OECD, 2022) that emphasize energy literacy as a precursor to green behavioral change in community-based sustainability projects.

3. Development of Green Skills

Green skills acquisition was assessed across technical, cognitive, and soft-skill dimensions (Table 2).

Table 2. Green Skills Development Indicators

Skill Dimension	Before Training (Mean)	After Training (Mean)	Change
Technical (solar, biogas, hydro)	2.1	4.3	+2.2
Cognitive (problem-solving, energy literacy)	2.4	4.1	+1.7
Soft Skills (teamwork, sustainability mindset)	2.8	4.5	+1.7

(*Scale: 1 = very low, 5 = very high*)

The largest increase was observed in technical skills (+2.2 points), indicating that renewable energy training provided practical and applicable knowledge that could be directly linked to conservation practices.
This finding resonates with ILO (2021) on the importance of vocational green skills to prepare communities for sustainable livelihoods.

4. Human Resource Development for Conservation

The study tested the impact of renewable energy education and green skills on human resource development outcomes using PLS-SEM. Key findings:

a) Renewable Energy Education → Green Skills: Strong positive effect ($\beta = 0.62$, $p < 0.001$).
b) Green Skills → HRD Outcomes: Positive and significant ($\beta = 0.55$, $p < 0.001$).
c) HRD Outcomes → Conservation Practices: Positive ($\beta = 0.48$, $p < 0.01$).
d) CSR Collaboration (Moderating Effect): Enhanced the relationship between HRD outcomes and conservation practices ($\beta = 0.33$, $p < 0.05$).

These results confirm that renewable energy education improves HRD through green skills, and CSR collaboration strengthens the pathway toward sustainable conservation.

5. Qualitative Insights from Community Voices

Interviews and FGDs revealed three main themes:

1. Empowerment through Education
   a) "Now I can teach my children about solar energy and why we must protect the mangrove," (Female MSME entrepreneur, age 39).
   b) Education acted as both knowledge transfer and intergenerational awareness building.
2. CSR as Collaborative Enabler
   a) Local leaders acknowledged that without UNPAB–PTSS collaboration, the program would lack technical expertise and funding.
   b) CSR was perceived not merely as corporate obligation, but as mutual partnership for local sustainability.
3. Linkage between Energy and Conservation
   Fisherfolk realized that using renewable energy reduced their reliance on mangrove wood for fuel, indirectly supporting forest conservation.

6. Discussion

The findings demonstrate a clear link between renewable energy education, green skills development, and conservation-oriented human resource development.

1. Renewable Energy Education as a Driver of Sustainability
   Education raised awareness and reshaped community attitudes, consistent with UNESCO (2021) that sustainability education equips communities with long-term adaptive capacities.
2. Green Skills as Critical Mediator
   Skills act as the bridge between knowledge and practice. This echoes OECD (2023) that emphasized green vocational training is key to ecological transition.
3. CSR Collaboration as Catalyst
   a) The UNPAB–PTSS model illustrates how cross-border CSR can mobilize resources, integrate technical knowledge, and ensure long-term program sustainability.
   b) Similar to Wang et al. (2020), CSR in education-driven sustainability projects tends to have higher community acceptance compared to infrastructure-only projects.
4. Impact on Conservation Practices
   By adopting renewable energy, the community reduced pressure on the forest reserve. This finding supports Ostrom's (2015) argument that community empowerment is essential in common-pool resource management.

7. Theoretical and Practical Implications

a) Theoretical: The study contributes to HRD literature by integrating green skills and CSR collaboration as mediators and moderators in the HRD–conservation nexus.
b) Practical: The model can be replicated in other island and coastal ecosystems facing environmental degradation due to unsustainable energy practices.

SUGGESTION

Based on the findings and discussion, several suggestions are offered for stakeholders, policymakers, and future researchers:

1. For Local Communities of Pulau Ketam

1. Strengthening Community Participation

a) Local residents, especially fisherfolk and women entrepreneurs, are encouraged to actively participate in renewable energy education and training to enhance their green skills and self-reliance.
b) Youth involvement should be prioritized to ensure sustainability of conservation efforts through intergenerational knowledge transfer.

2. Adopting Renewable Energy Practices
Communities are advised to integrate renewable energy solutions such as solar power, biogas, and micro-hydro into their daily activities, reducing dependence on fossil fuels and supporting forest conservation.

2. For UNPAB–PTSS Collaborative CSR Program

1. Sustainability of CSR Initiatives
   a) The CSR partnership should not only focus on short-term training but also develop a long-term institutionalized program, including mentoring, monitoring, and certification of green skills.
   b) Cross-border collaboration between Indonesia and Malaysia should be expanded into joint research, student exchange, and green technology incubation hubs.
2. **Integration with Local Policy and SDGs**
   CSR activities should be aligned with Malaysia's Renewable Energy Roadmap (MyRER 2035) and Indonesia's Green Economy Framework, as well as contributing directly to UN SDG 7 (Affordable and Clean Energy) and SDG 13 (Climate Action).

3. For Government and Policymakers

1. **Policy Support**
   a) Local governments should create regulatory frameworks and incentives that encourage the adoption of renewable energy at the community level, such as subsidies, tax relief, or microcredit schemes for green businesses.
   b) Integration of renewable energy education into technical and vocational curricula (TVET) at national level is strongly recommended.
2. **Forest Reserve Protection**
   a) Stronger legal enforcement is needed to prevent illegal logging and overfishing in Pulau Ketam.
   b) Renewable energy projects should be integrated into conservation management plans as part of nature-based solutions.

4. For Future Research

1. Comparative Studies
   Future studies should conduct comparative analysis between Pulau Ketam and other mangrove forest reserves in Southeast Asia to identify replicable models of CSR-based human resource development.
2. Longitudinal Impact Measurement
   Research should move beyond short-term outcomes to longitudinal studies that assess the long-term effects of renewable energy education on employment, income growth, and forest sustainability.
3. Interdisciplinary Approach
   Collaboration between environmental sciences, engineering, and human resource management is needed to refine the model of Renewable Energy Education-Based HRD for conservation.

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