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Developing an Indicator System for Measuring the Social Sustainability of Offshore Wind Power Farms

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Abstract: Taiwan's government has promoted investment in an offshore wind power farm, and local fishermen have protested. A social impact assessment (SIA) has examined the impact of the proposed offshore wind power farm on all stakeholders. The main objective of the present study was to develop an indicator system for measuring the social sustainability of offshore wind power farms; this study also reports on the particular case of Taiwan's offshore wind power project. This study began by defining 35 social sustainability indicators and selecting 23 representative indicators by using rough set theory. Subsequently, 14 key indicators were constructed using the social construction of technology (SCOT) method. Finally, we developed a social impact index for evaluating the social sustainability of offshore wind power farms by using the analytic network process and Dempster-Shafer theory. Our social impact index yields a total score of 0.149 for Taiwan's pilot offshore wind power project; this result indicates that the pilot project is socially sustainable. A substantial contradiction exists between the fishermen's protest and the results of the social impact assessment. The findings can assist the government in building a coordination platform for the investors and the fishermen. Government regulation is necessary to set boundaries for fishing areas that protect both the fishermen's and investors' rights.

Keywords: social sustainability; social impact assessment; social construction of technology; offshore wind power

1. Introduction

Taiwan is facing a major energy security problem caused by the scarcity of fossil energy reserves. Offshore wind power farms provide an opportunity to replace a portion of thermal and nuclear power generation. Taiwan's capacity for offshore wind power is estimated to be 3000 MW, which equals 7.3% of the total installed capacity in 2016. Developing renewable energy, including wind power, is a long-term energy policy that may satisfy demands from the public for energy security, reduction of nuclear power, and reduction of air pollution. However, when Taiwan's government planned a 15 MW offshore wind power farm as a pilot project, fishermen protested. The pilot project is located on the Taiwan Strait, six kilometers away from Zhunan township's coastline, as shown in Figure 1. The fishermen have petitioned the committee of environmental impact assessment (EIA) for a review of the pilot project. The fishermen argued that they have fishing rights and are concerned about the environmental impacts on marine life and fishery viability. The developers explained that an offshore wind power farm has been well planned to avoid environmentally sensitive areas and areas with exclusive fishing rights. The controversies exist between fishermen and developers. The government therefore suggested a compromise that the fishermen share the stocks with the developers. Moreover, Taiwan's government demanded a social impact assessment (SIA) of the offshore wind power farm. The main objective of this study was to develop an indicator system for measuring the social sustainability of offshore wind power farms.

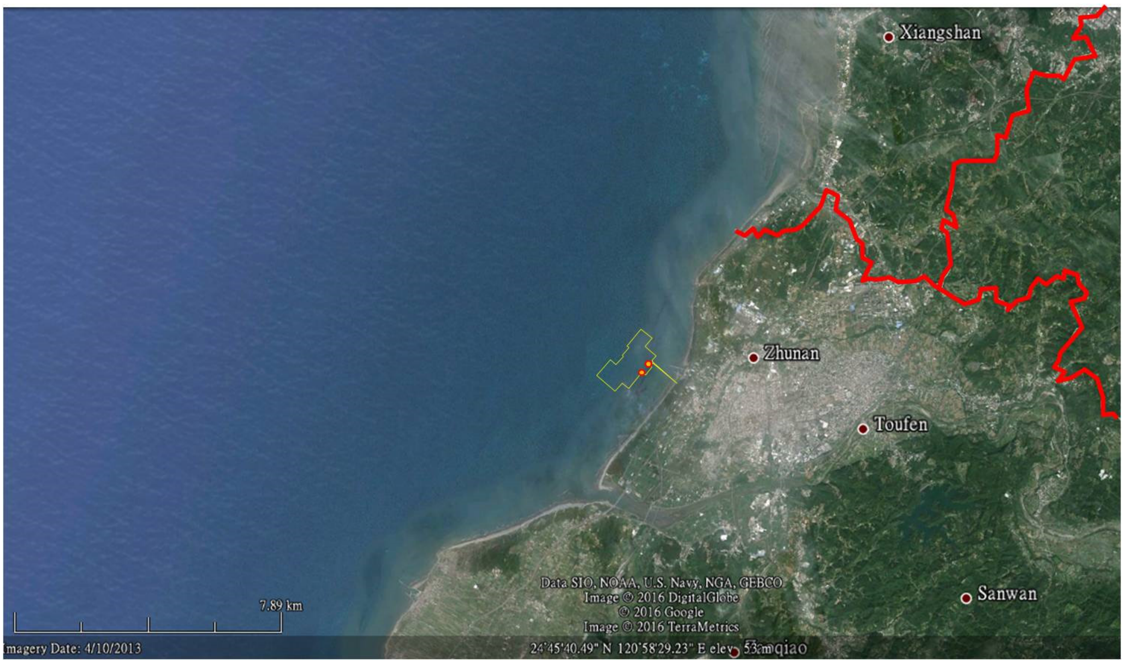

Figure 1. Location of the pilot project.

In general, public responses to offshore wind power are not as well exposed as public responses to onshore wind power [1]. Among the main positive social impacts of the development of wind power are the creation of job opportunities and promotion of regional development. Social acceptance and public attitude are the most important social criteria for wind power projects [2]. For example, an inferential result based on a sample of 226 respondents in Australia showed concern about wind turbines as the variable having the strongest correlation with social acceptance [3]. A case study of Ontario, Canada showed that the level of public support strongly influences wind power promotion [4]. Moreover, the level of public support depends on the public having experience with local wind power [5]. In Scotland, community-based wind power generation and strategic reinvestments produce significant effects on employment and income [6].

SIA is a crucial procedure for projects that introduce wind power farms. However, scholars must still explore methods for developing a complete indicator system for measuring the social sustainability of wind power farms. All concerns that directly or indirectly affect the public can be within the scope of an SIA. A checklist of social impacts on the public includes any changes or disruptions to the following: (1) way of life; (2) culture; (3) community; (4) political systems; (5) environment; (6) health and well-being; (7) personal and property rights; and (8) fears and aspirations [7]. SIA is recognized as a participatory process for managing the social issues connected with an infrastructure project. It provides a means by which affected people, investors, governments, and other stakeholders can understand the issues. Once the SIA has been completed, methods for avoiding or reducing negative impacts and increasing positive impacts could be discussed and applied [8].

Stakeholder participation is crucial for any assessment framework. The Society of Environmental Toxicology and Chemistry, United Nations Environment Programme (UNEP/SETAC) developed a framework for categorizing social impacts according to five stakeholder groups, namely the local community, value chain actors, consumers, workers, and society [9]. Dreyer *et al.* categorized social life cycle impacts into optional and obligatory sets. An obligatory set includes the minimum requirements that a company must assume for the sake of corporate social responsibility [10]. A generalized framework of social sustainability assessment was introduced and applied to South Africa [11,12]; this framework categorized social impact indicators into three aspects: internal human resources, external population, and macro-social performance. The advantages of this framework include (1) a focus on the business level; and (2) the ability to be used for both internal management and external benchmarking. Wind power farms in Taiwan require investment from private businesses. This study employed social impact factors based on the framework developed in South Africa [11,12].

2. Methods

2.1. Analytical Framework

First, initial social sustainability indicators were generated for evaluating wind power farms, based on a literature review and subsequent discussions. Rough set theory (RST) was applied to select key indicators. Because stakeholder participation is crucial in the process of social sustainability assessment, social construction of technology (SCOT) was used to construct social sustainability indicators based on key indicators. Five principles suggested by Keeney and Raiffa [13], namely completeness, nonredundancy, operationality, decomposability, and minimal size, were examined to obtain final indicators.

Based on the constructed social sustainability indicators, the SIA began by measuring individual indicators. To cope with incomplete information, Dempster-Shafer Theory (DST) was applied. Individual indicators were measured and integrated. The analytic network process (ANP) was used to elicit the preferences of the stakeholders; stakeholder preferences determined the weighting scheme. Using the performance levels of the indicators and the weighting scheme, we integrated the overall performance of the indicators. Figure 2 shows the analytical framework.

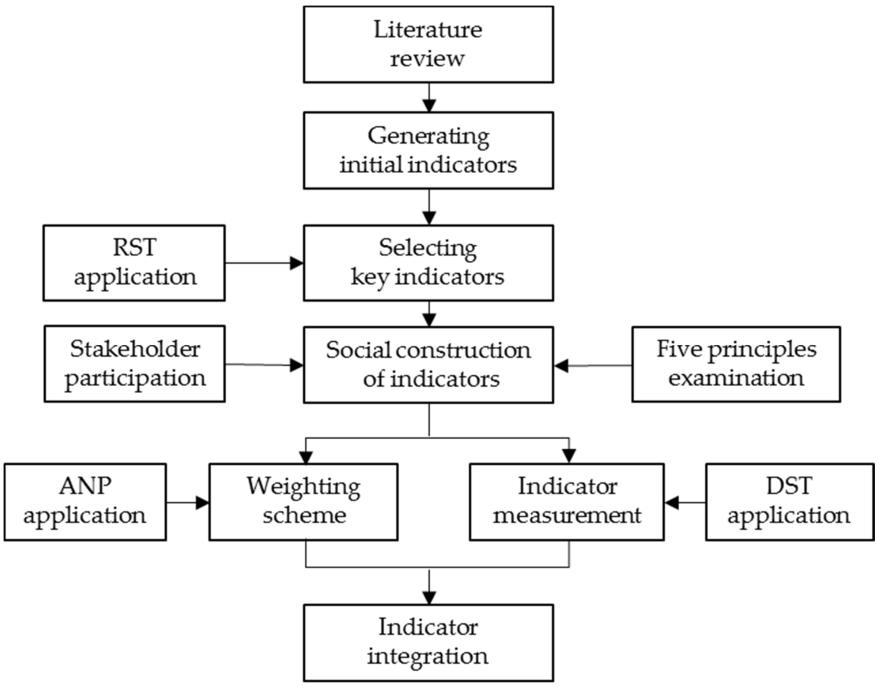

Figure 2. The analytical framework.

2.2. Rough Set Theory (RST)

RST is used to analyze vague data; it was originally proposed by Pawlak [14]. Numerous researchers have applied RST to induce decision rules. For example, 12 decision rules were induced to evaluate virtual network laboratory exercises using RST [15]. RST was applied to induce eight decision rules regarding age-friendly transportation [16]. Key transport sustainability indicators were selected using RST [17].

The core concept of RST is the calculation of indiscernibility relations by using ordinal (or category) scales. Two fundamental operations of RST are the calculations of lower and upper approximations of a set; these two basic operations address inconsistency. The difference set between an upper and a lower approximation is called a boundary. Greco *et al.* developed an application of RST for solving multiple criteria decision problems [18]. An extension procedure was applied to select key transport sustainability indicators [17].

2.3. Social Construction of Technology

Stakeholder analysis is an analytical process considering public participation. SCOT provides a methodology for formalizing stakeholder analysis. SCOT practitioners use the phrase "human action shapes technology" to replace the phrase "technology determines human action." The SCOT conceptual framework can be summarized by the following four core components [19]:

(1) Interpretive flexibility: Indicators can be constructed and interpreted flexibly. For the case of Taiwan's offshore wind power farm, the flexible construction of social sustainability indicators depends on the interactions among relevant social groups.
(2) Relevant social groups: A relevant social group is a group of individual or institutional stakeholders. For the case of Taiwan's offshore wind power farm, fishermen constitute one of the relevant social groups.
(3) Closure and stabilization: Different social groups may focus on different interests during the indicator construction process. The construction process achieves closure when the interaction among relevant social groups reaches consensus. Two varieties of closure are relevant. One variety of closure is called rhetorical closure; this denotes a declaration that no further problems exist and that the relevant social groups do not need to interact further. The second variety of closure occurs when unresolved problems are redefined as negligible [20].
(4) Wider context: The wider context involves additional considerations of when and how the relevant social groups participate in the indicator construction process. The identification of a technological frame [21] can facilitate these considerations.

SCOT has been widely applied in the natural and social sciences. For example, a set of port sustainability indicators was developed using SCOT [22]. Another application of SCOT is to facilitate the decision of siting nuclear waste facilities by analyzing different environmental conflicts [23].

2.4. Dempster-Shafer Theory

DST is a data fusion method that can formalize subjective beliefs [24,25]. When this method is applied to decision problems, performance evaluations are transformed into abstract utility values by using basic probability assignment (BPA). BPA connects the transformation and its uncertainty. DST is a decision analysis method for managing incomplete information. The Taipei City Government used DST to evaluate sustainable transport strategies [26]. Another application of DST measured the performance levels of transport improvement strategies [27].

2.5. Analytic Network Process (ANP)

The ANP, proposed by Saaty [28], is a generalization of the analytic hierarchy process. The ANP can solve decision problems with mutually independent criteria (or indicators). Pairwise comparisons between criteria (or indicators) are performed and a supermatrix is calculated. The ANP has been applied to many fields. The ANP and goal programming were used to select candidate projects [29]. The ANP and grey relational analysis were applied to a green supplier selection problem [30].

Different social sustainability indicators can be interdependent. This study used the ANP to elicit a weighting scheme for the indicators identified by the stakeholders.

3. Results

The policy of developing renewable energy has broad consensus support from Taiwan's society. A survey of 3618 samples reveals a high degree of support from the general public (83.7%) in developing renewable energy [31]. An offshore wind power farm is estimated to have a 3000 MW potential capacity, which is larger than the capacity of Taiwan's fourth nuclear power plant (2700 MW), which has been mothballed. The present study demonstrates the process of social sustainability assessment by using the case of Taiwan's proposed offshore wind power farm.

3.1. Social Construction of Social Sustainability Indicators

This study generated initial social sustainability indicators by referring to the related literature. The process analysis method considers environmental, economic, and social aspects in generating sustainability indicators. The framework can be related to efficiency and equity considerations [32]. Another framework based on generalized efficiency and social equity was applied to assess transport sustainability [17]. Social aspect is our focus in developing social sustainability indicators. The indicators were further classified according to the three aspects of the framework applied to South Africa: internal human resources, external population, and macro-social performance [11,12]. We referred to the Global Reporting Initiative, which provides a detailed document regarding sustainability reporting guidelines [33]. A customized framework for developing offshore wind power farms [34] provided references regarding indicators.

Table 1 shows 35 generated initial social sustainability indicators, namely 19 indicators that were categorized into the aspect of internal human resources, 11 to external population, and five indicators to macro-social performance.

Table 1. Initial social sustainability indicators.

Aspect	Indicator	Definition	Measurement	Reference
Internal human resources	Employment	Employee composition	Rate of new employee hires by age, gender, and region	[33]
	Labor/ management relations	Employees' rights are guaranteed by collective agreements	Proportion of employees with rights guaranteed by collective agreements	[33]
	Occupational health	Health condition of employees	Health condition evaluated through health examination	[33]
	Occupational safety	Safety condition of employees	Rates of employee injury, disease, and fatality	[33]
	Training and education	Training and education for employees	Average hours of employee training and education per year	[33]
	Investment and procurement practices	Selecting suppliers (contractors) that were screened by the standards of an authorized economic operator (AEO)	Percentage of suppliers (contractors) that were screened by the standards of an AEO	[33]
	Nondiscrimination	Nondiscrimination for employees	Total number of incidents of discrimination	[33]
	Child labor	Operations having significant risk for child labor	Percentage of employees who are children	[33]
	Forced and compulsory labor	Operations having significant risk for forced and compulsory labor	Measures for contributing to the elimination of all forms of forced and compulsory labor	[33]
	Community impacts	Operations with negative impacts on the community	Prevention and mitigation measures for operations with negative impacts on the community	[33]

Table 1. *Cont.*

Aspect	Indicator	Definition	Measurement	Reference
Internal human resources	Bribery	Operations with bribery behavior	Percentage of employees trained in antibribery policy	[33]
	Level of policy support	Business supporting public policy	Business expresses its cooperation with public policy	[33]
	Compliance	Compliance with laws and regulations	Monetary value of fines for noncompliance with laws and regulations	[33]
	Customer health and safety	Health and safety impacts of products and services on customer during all life cycle stages	Total number of incidents of noncompliance that produced health and safety impacts on customers from products and services	[33]
	Customer privacy	Guarantee customer privacy	Total number of customer complaints regarding customer privacy	[33]
	Employment stability	Enhance employment stability to improve sustainable development	Employee turnover rate	[11,12]
	Employment practices	Business engages in stable relationships with employees	Total number of incidents of violating laws, international human rights declarations	[11,12,33]
	Health and safety	Implementing precautionary procedures to prepare for employees' health and safety incidents	Evaluations of preventive measures	[11,12]
	Research and development (R&D)	R&D activities for enhancing sustainable business development	Percentage of budget allocated to R&D	[11,12]
External population	Human resources	Human resources provided by the local community	Local employment and industry development	[11,12]
	Production resources	Infrastructure provided in the local community to support a business's production	Public utilities and housing provided in the local community	[11,12]
	Community resources	Atmosphere created in the local community, including culture, security, and social cohesion	Employees' perceptions about their surroundings and way of life	[11,12]
	Marine landscape	Aesthetics of the ocean view	Evaluated by the public	[34]
	Community acceptance	Degree to which the business is accepted by the local community	Evaluated by the public of the local community	[11,12,34]
	Fishery impacts	Fishery impacts of the offshore wind farm	Level of support evaluated by fishermen	[34]
	Marine life	Marine life impacts of the offshore wind farm	Level of support evaluated by fishermen	[34]
	Marine sightseeing	Marine sightseeing impacts of the offshore wind farm	Level of support evaluated by marine sightseeing businesses	[34]
	Bird life	Bird life impacts of the offshore wind farm	Level of support evaluated by avian biology experts	[34]
	Tourism and related business	Tourism and related business impacts of the offshore wind farm	Level of support evaluated by tourism businesses	[34]
	Air quality	Contribution to air quality from alternative energy	Reduction in air pollutants caused by alternative energy effects	[34]

Table 1. *Cont.*

Aspect	Indicator	Definition	Measurement	Reference
Macro-social performance	Electricity price	Adjustment of electricity price caused by alternative energy	Adjustment of electricity price caused by alternative energy	[34]
	Job creation	Job creation caused by introducing the offshore wind farm	Parameter calculated using an input-output model	[34]
	Alternative energy	Alternative energy effect caused by introducing the offshore wind farm	Percentage of electricity generated by offshore wind power	[34]
	Socioeconomic performance	External economic impacts caused by introducing the offshore wind farm	Contribution to GDP and taxes	[33]
	Socioenvironmental performance	Contribution to improving the environment	Company's initiatives to improve society's environmental monitoring ability, and enforcement of laws	[33]

On the basis of these 35 initial social sustainability indicators, RST was used to select key indicators by referring to the application of transport sustainability indicators [17]. Condition attributes were defined as significance, causality, and measurability. Moreover, representative was defined as a decision attribute. Both condition and decision attributes were classified into good, medium, and bad categories. Ten indicators of the set of lower approximation were selected as core indicators, and 13 indicators of the boundary set were selected as subcore indicators, as shown in Table 2.

Table 2. The core and subcore indicators.

Core Indicators	Subcore Indicators
Employment	Labor/management relations
Investment and procurement practices	Occupational health
Health and safety	Occupational safety
Marine landscape	Training and education
Community acceptance	Employment stability
Fishery impacts	Research and development
Marine sightseeing	Community impacts
Job creation	Level of policy support
Alternative energy	Human resources
Socioenvironmental performance	Community resources
	Marine life
	Electricity prices
	Socioeconomic performance

Social construction of social sustainability indicators was conducted on the basis of the 23 key indicators. Four technological frames were defined, namely scientific, operational and public relations, regulatory, and nonprofessional frames. The relevant goals, views, focuses, and requirements are detailed in Table 3. For example, the fishermen are classified into the nonprofessional frame; their goal is to ensure free access to the wind power farm, and they view social sustainability indicators as a guarantee. Their focus is catching fish; and they prefer simple and useful social sustainability indicators.

Representatives of the relevant social groups were invited to participate in the indicator construction process. The representatives included two from the wind power generation industry, nine from government, five from academia, and three from the fishing industry and the public. A questionnaire was designed to elicit their opinions. They were asked a series of questions regarding the suitability of the 23 key indicators. Majority rule was applied first. Subsequently, five principles suggested by Keeney and Raiffa were examined, namely completeness, nonredundancy, operationality, decomposability, and minimal size [13]. Finally, 14 indicators were selected using SCOT and the five principles. Figure 3 shows the hierarchical structure of the indicators: seven indicators were categorized into the aspect of internal human resources; four indicators were categorized into the aspect of external population; and three indicators into the aspect of macro-social performance.

Table 3. Four technological frames defined in constructing social sustainability indicators (SSIs).

Technological Frames	Scientific Frame	Operational and Public Relations Frame	Regulatory Frame	Nonprofessional Frame
Actors	Academic researchers	Investors	Bureau of Energy, Ministry of Economic Affairs	Fishermen and the public
Goals	To improve social sustainability scientifically and systematically	To establish a positive public image and assuage the protest from fishermen and the public	To develop objective SSIs	To ensure free access to the wind power farm (fishermen). To reduce negative impacts on the marine environment (public)
Views of social sustainability indicators	Prefer quantitative monitoring tools	As a statement for convincing fishermen and the public	As a means of fulfilling its commitment to relevant social groups	As a guarantee to fishermen and the public
Focuses	Completeness and nonredundancy	No clearly defined notions of social sustainability	Balanced score	Fish catches (fishermen). Marine environment impacts (public)
Requirements	Hierarchical, quantitative, and justifiable SSIs	Simple and impressive SSIs	Checklist-based design	Simple and useful SSIs

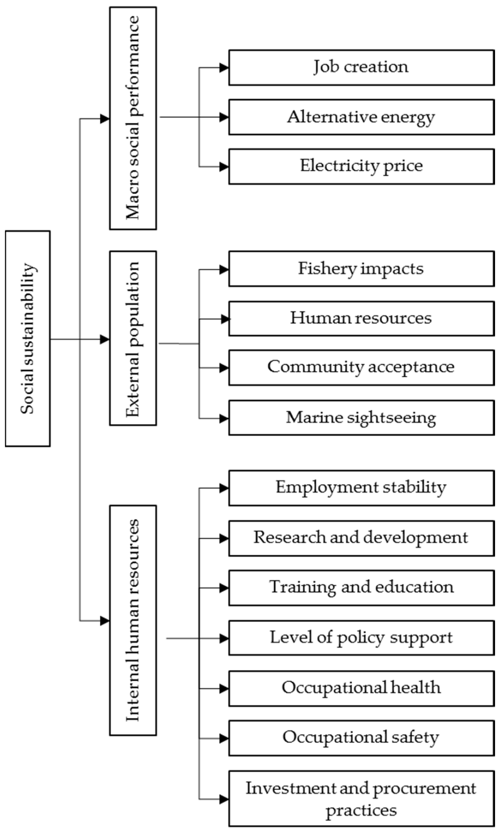

Figure 3. The hierarchical structure of social sustainability indicators

3.2. Measurement and Integration of Social Sustainability Indicators

Table 4 shows performance measurements for the social sustainability indicators. DST was applied to transform the performance levels into utility values. The representatives of the relevant social groups, including industry, government, and academia, were invited to participate in the process of social sustainability measurement. Nonprofessional, fishermen and the public frames were excluded at this stage because of their limited professional competence. The assessments of utility and weight require professional judgment. Five representatives of industry, two representatives of government, and nine representatives of academia were invited to participate in the assessment process. Five-point Likert scales were used to evaluate utility; very good performance was coded as 1.0; good performance was coded as 0.5; average performance was coded as 0.0; bad performance was coded as −0.5; and very bad performance was coded as −1.0.

Table 4. Indicator measurement and integration.

Indicator	Performance	Utility	Weight	Social Impact Index
Investment and procurement practices	30% of wind power suppliers that were screened by the standard of an AEO compared with 2.35% of the total manufacturing industry	0.116	0.053	0.003
Occupational safety	1.56 composite disabling index of wind power operation compared with 0.55 in total	0.142	0.051	0.009
Occupational health	91.85% of employees passed health exams	0.248	0.034	0.008
Level of policy support	35% of companies expressed cooperation with public policy	−0.011	0.043	0.000
Training and education	42.50 h per year in the wind power industry compared with 23.20 h per year in total	0.225	0.028	0.006
Research and development	4% research and development budget in the wind power industry compared with 1.2% in total	0.280	0.027	0.006
Employment stability	0.27 employee turnover rate in the wind power industry compared with 1.2% in total	0.308	0.038	0.012
Marine sightseeing	38% support evaluated by marine sightseeing businesses	0.073	0.041	0.007
Community acceptance	85% acceptance evaluated by the public of the local community	0.202	0.063	0.014
Human resources	46% of local employment belongs to the manufacturing industry	0.209	0.047	0.012
Fishery impacts	9% support evaluated by fishermen	−0.028	0.077	−0.005
Electricity price	3.37% adjustment of electricity price attributable to alternative energy effect	−0.028	0.164	−0.006
Alternative energy	2.65% of electricity generated by offshore wind power	0.256	0.123	0.033
Job creation	16,628 opportunities	0.270	0.211	0.050

Table 4 shows that the three indicators with the highest utility are (1) employment stability; (2) research and development; and (3) job creation. The three indicators with the lowest utility are (1) fishery impacts; (2) electricity impacts; and (3) level of policy support. Moreover, the three lowest-utility indicators were evaluated as having negative impacts, and all others were evaluated as having positive impacts.

The ANP was used to elicit the weighting scheme of the indicators. That the numbers of representatives in each relevant social group were unequal was considered. We first calculated the averages of utility and weight with respect to each social group. Subsequently, the averages of each social group were averaged again to obtain the final results. This process provided balanced representation.

Table 4 shows that the three most important indicators are (1) job creation; (2) electricity price; and (3) alternative energy.

Using a simple additive weighting method [35] to integrate utility and weight, the social impact index can be calculated. Table 4 shows that the three indicators with the highest social impact index are (1) job creation; (2) alternative energy; and (3) community acceptance. The three indicators with the lowest social impact indices are (1) electricity price; (2) fishery impacts; and (3) level of policy support. The overall social impact index, an aggregate of the social impact indices of all 14 indicators, yields a score of 0.149. The results justify the pilot project from the perspective of social sustainability.

4. Discussion

The ANP can elicit a weighting scheme for the indicators and consider the interrelationships between the indicators. Figure 4 shows that four pairs of indicators are highly interrelated (red lines), namely occupational health *versus* occupational safety, training and education *versus* occupational health, training and education *versus* employment stability, and electricity price *versus* alternative energy. Moreover, blue lines indicate pairs of indicators with moderate interrelationships. The results indicate that any measures to improve the social sustainability of the wind power farm should consider the indicator interrelationships. Application of fuzzy cognitive maps in evaluating transport sustainability strategies illustrated a practical consideration of such interrelationships [36].

The evaluations of relevant social groups yielded results regarding utility, weight, and the social impact index. Table 5 shows that the representatives of industry and government assessed the utility and social impact indices of all indicators as positive. These results can be explained by their supportive attitudes toward this offshore wind power farm. By contrast, the representatives of academia assessed the utility and social impact indices of the indicators of occupational safety, level of policy support, marine sightseeing, and fishery impacts as negative. These results can be explained by their concerns about these four indicators.

The various weightings from the relevant social groups yield another valuable observation. The three most important indicators from industry's viewpoint are (1) electricity price; (2) fishery impacts; and (3) investment and procurement practices. The three most important indicators from government's viewpoint are (1) alternative energy; (2) job creation; and (3) electricity price. The three most important indicators from academia's viewpoint are (1) job creation; (2) electricity price; and (3) alternative energy. The results show that the representatives of government and academia focus on similar indicators, and differ from the representatives of industry. The only consensus is on the electricity price.

The assessment of fishery impacts reveals contrasting opinions from the relevant social groups, even though the representatives of fishermen were excluded from the evaluation process of social sustainability. The indicator of fishery impacts was measured according to the level of support evaluated by fishermen. Only 9% of fishermen supported the development of the wind power farm, as shown in Table 4. They expressed concerns regarding the reduction of fishing grounds, electromagnetic waves, and noise from the spread of transmission lines under the seabed. The representatives of academia evaluated the utility of fishery impacts as negative because of their concerns regarding protests from fishermen. However, the representatives of industry and government asserted that the offshore wind power farm would produce an artificial fish reef and fish aggregation effects. Therefore, they asserted positive utility regarding fishery impacts. The conflicts between the investors and the fishermen are difficult to resolve. Singular and cumulative effects of the offshore wind power farm should be adequately considered [37]. Various communication platforms should also be established to shorten the opinion gaps between the relevant social groups. A similar observation was found in the UK case study. Three results were concluded as being helpful for promoting offshore wind farm: (1) more extensive stakeholder participation; (2) a standardization of compensation claims; (3) readily providing scientific data for judgment [38].

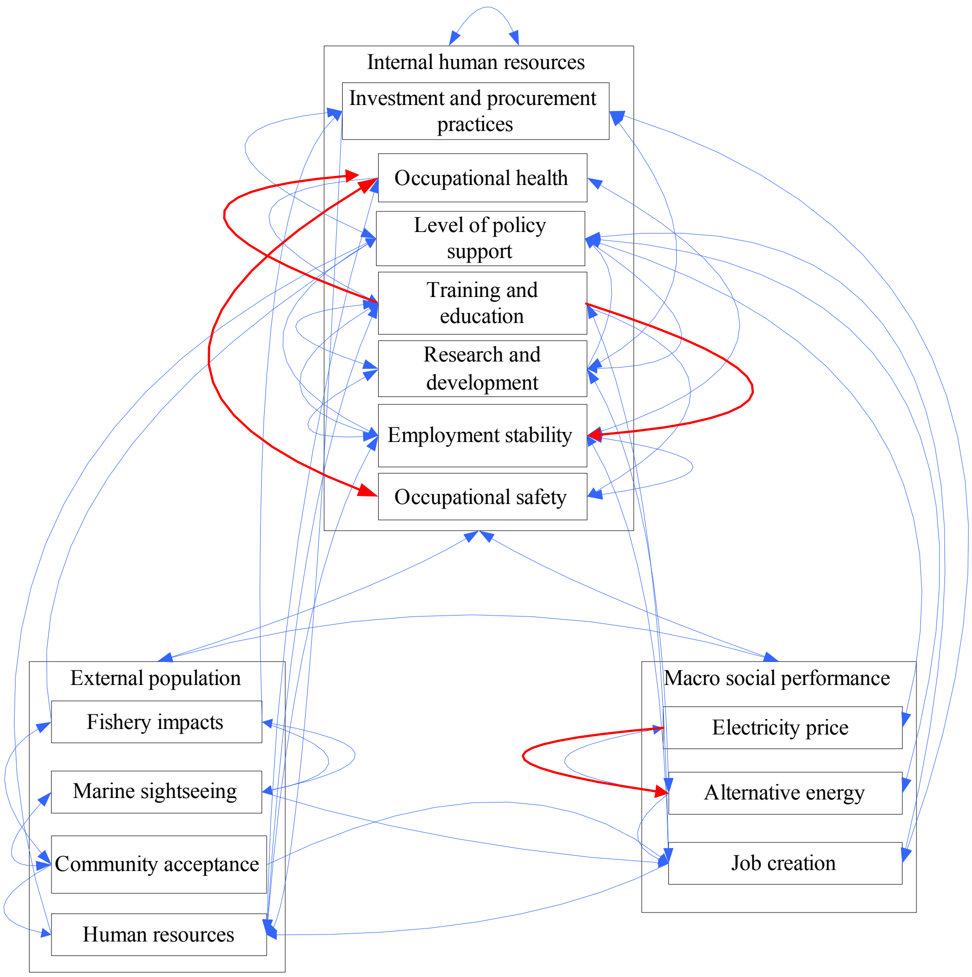

Figure 4. The interrelations of the indicators.

The application of multiple methodologies in this study is a problem-oriented approach. The framework of social sustainability assessment consists of three main parts. First, we constructed social sustainability indicators. The RST and SCOT were used. The same approach was applied to construct port sustainability indicators [22]. Second, DST was used to measure the performance of indicators. A similar case of transport sustainability measurement was conducted by applying DST [26]. Finally, ANP was used to integrate the indicators. The same application can be found in the evaluation of knowledge-sharing effectiveness [39].

Table 5. Indicator measurements and integration by relevant social groups.

Indicator	Utility			Weight			Social Impact Index		
	I	G	A	I	G	A	I	G	A
Investment and procurement practices	0.050	0.025	0.272	0.112	0.032	0.015	0.006	0.001	0.004
Occupational safety	0.190	0.325	−0.089	0.042	0.068	0.043	0.008	0.022	−0.004
Occupational health	0.130	0.225	0.389	0.031	0.037	0.033	0.004	0.008	0.013
Level of policy support	0.010	0.000	−0.044	0.075	0.037	0.017	0.001	0.000	−0.001
Training and education	0.190	0.125	0.361	0.026	0.042	0.018	0.005	0.005	0.006
Research and development	0.100	0.250	0.489	0.030	0.039	0.012	0.003	0.010	0.006
Employment stability	0.290	0.350	0.283	0.041	0.040	0.033	0.012	0.014	0.009
Marine sightseeing	0.170	0.300	−0.250	0.038	0.067	0.018	0.006	0.020	−0.005
Community acceptance	0.110	0.375	0.122	0.076	0.078	0.036	0.008	0.029	0.004
Human resources	0.120	0.350	0.156	0.030	0.073	0.039	0.004	0.025	0.006
Fishery impacts	0.160	0.150	−0.394	0.121	0.074	0.037	0.019	0.011	−0.015
Electricity price	0.170	−0.325	0.072	0.199	0.091	0.202	0.034	−0.029	0.015
Alternative energy	0.400	0.350	0.017	0.095	0.165	0.108	0.038	0.058	0.002
Job creation	0.330	0.275	0.206	0.082	0.162	0.389	0.027	0.044	0.080

I denotes the representatives of industry; G denotes the representatives of government; A denotes the representatives of academia.

5. Conclusions

Because an environmental impact assessment (EIA) carries legal weight, it might block the development of an offshore wind power farm. A social impact assessment (SIA) does not carry similar legal weight, and cannot prevent development. Stakeholder participation and SIAs have become increasingly crucial processes in Taiwan's society. This study developed an indicator system for measuring the social sustainability of an offshore wind power farm. Systematic and scientific processes were employed for indicator construction, measurement, and integration within this tailor-made framework.

The case study of Taiwan's offshore wind farm shows a positive social impact index. However, the fishermen still protest. Moreover, the representatives of academia decry the negative utility and social impact indices of occupational safety, level of policy support, marine sightseeing, and fishery impacts. The findings can assist the government in building a coordination platform for the investors and the fishermen. A compromise regulation is necessary to set the boundaries of the fishing area to ensure that fishermen retain their fishing rights and investors retain their offshore wind turbines. Future research should consider ongoing fishery impacts caused by the new offshore wind power farm, including positive and negative impacts on various fish species.

Author Contributions: Tzay-An Shiau conceived and designed the analytical framework. Ji-Kai Chuen-Yu performed the analytical process and analyzed the data. and Tzay-An Shiau wrote the paper.

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