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Environmental impact assessment framework by integrating scientific analysis and subjective perception

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ABSTRACT: Environmental impact assessment is widely recognized as an effective tool for supporting the sustainable development of the environment through policy, plan and program decision-making processes. Traditional approach of environmental impact assessment generally focuses on scientific analysis and neglects subjective utilities on the project development. This paper proposes a framework of environmental impact assessment process by integrating subjective perception and scientific analysis. This framework suggests that environmental impacts and their consequent effects are analyzed and calculated based on the inventory analysis, but the non-market loss arising from the construction of the sensitive facility is estimated by contingent valuation method and the relative importance of affecting groups in affecting the ongoing of project development is evaluated by analytical hierarchy process. Eventually, a mathematical model is presented to determine the optimal compensation amount under a targeted refusal rate. Also, a case example is presented to illustrate this approach that integrates the objectively scientific assessment for potentially environmental impacts and individual subjective perception on the non-market value of environmental damages arising from the project development.

Keywords: *Analytical hierarchy process; Contingent valuation method; Environmental impact assessment; Logit model*

INTRODUCTION

Environmental impact assessment (EIA) is widely recognized as an effective tool for supporting the sustainable development of the environment through policy, plan and program decision-making processes and accepted as an important decision support tool in planning and decision-making processes of environmental assessment. It aims to integrate environmental considerations along with social and economic considerations into proposed policies, plans and programs (PPPs) to achieve the overall objective of sustainability and the adaptation of human being to the environment in the context of project design and subsequent construction work on site. A great number of literature focus on this issues (e.g. Noble, 2000; Partidario, 2000; Roudgarmi *et al.*, 2008a) for the discussion of methodology (e.g. Brown and Therivel, 2000; Verheem and Tonk, 2000; Noble and Storey, 2001; Ramanathan, 2001; Roudgarmi *et al.*, 2008b), or performance criteria (e.g. Nitz and Brown, 2000; Fischer, 2002) for performance evaluation.

The primary role of EIA is to provide a comprehensive assessment of the environmental characteristics of PPPs, to enhance the environmental awareness of management practices and eventually to achieve the goal of sustainability. It has been adopted as a platform among stakeholders for information communication about project developments so that the potentially environmental damages can be avoided or minimized.

Traditional EIA planning process generally reflects the idealism of rationalism and characterize with scientific analysis and rational thinking. EIA assumes that the provision of rational information through scientific analysis and data collection will suffice to improve decision-making (Kørnøv and Thissen, 2000; Rashidinejad *et al.*, 2008). This approach is logical, consistent and systematic to provide a clear basis and justification for decision making through the development of indicators to monitor specific aspects of environmental status such as air quality, water pollution and the change of landscape (Lawrence, 2000). It mostly employs a variety of technical qualitative and quantitative methods for assessor's evaluation, rating and decision on the impact of project developments, as well as its consequent effect. Some critics on this method have been presented (Burdge, 2003; Vanclay,

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2003). The major argument is that the rational process adopted in the EIA process should be implemented by humans (scientists) and unfortunately scientists in reality are affected by their internal value in implementing EIA. Lawrence (2000) provides some critiques on traditional EIA, including "autocratic tendencies, fails to consider resource and cognitive limits, overestimates ability to predict and control environment, insufficient consideration of extrarational (creativity), of synthesis (compared to analysis) and of nontechnical and nonscientific knowledge, experience and wisdom (scientific, technical, and quantitative bias), fails to adequately consider the collective nature of planning and the central role of dialogue, fails to consider inequities and the political nature of planning and fails to integrate substantive issues".

EIA in practice is conducted by a series of procedures through scientific analysis, data collection and calculation. Currently, the assessment on environmental impact is conducted by calculating environmental damages (category endpoints) in linking with environmental effects (impact categories) through the use of environmental indices that are based on the selection of a number of key parameters or weighting factors. These factors are analyzed and determined through scientific analysis in association with the impact on ecosystems, resource consumptions, economic losses and human health and thus these weighting factors in each environmental effect are predetermined. The job of assessors is to aggregate the data and form an overall index based on a data base or an inventory. The relationship of environmental effects to environmental damage is assumed to be deterministic in regardless of individual subjective perception on damages. The selection of impact categories, category indicators and characterization models, including the criteria for environmental relevance in general depends on a group of technicians who focus on scientific analysis and ignore individualistic perception.

Such a quantitative method is easy to perceive and avoid misinterpretation, but it sometime loses the ability to measure most social and economic impacts (e.g., risk perception on health impacts, environmental inequity, vulnerability and sustainability). These quantitative methods also have limitations in application due to the limitation and uncertainty of human knowledge. For example, the interaction between project construction and the environment is still largely unknown. EIA still faces a lot of problems due to diverse perspectives, environmental values and norms pertaining to stakeholders, and uncertainty of science (Partidario, 1999; Tang *et al.,* 2008) and thus it requires a process of learning and negotiation among multiple actors.

As traditional EIA can not adequately address social issues. Social impact assessment (SIA) emerges as a separate tool from EIA and is adopted as a means of addressing social issues arising from development initiatives (Gilpin, 1995). It aims to identify the intended and unintended effects that arise from the project development in order to develop sustainable policy, programs or projects (Burdge, 2003; Vanclay, 2003) and is practically seen as an integral part of EIA process and thus a stakeholder analysis should be conducted to identify the interests in the project (Connelly and Richardson, 2005, Rauschmayer and Risse, 2005). SIA process is viewed more as a critical socio-political process rather than a rational, analytic process and devotes more effort to the resolution or avoidance to the environmental conflicts and the development of social and environmental justice and community empowerment (Gagnon, 1993; Lawrence, 2000). Hence, SIA process must involve with public participation and dialogue that ranges from only informing the public to allowing the discourse in co-production (e.g. Healey, 1997; Woltjer, 2000). These dialogues are central to social interactions (Ortolano, 1997; Lockie, 2001) in avoiding misinterpretation or adverse social and economic impacts and effective in reducing some social and economic impacts to acceptable levels and enhances community benefits (Vanclay, 2002). Through the cooperation among stakeholders in the society participation can develop more widely acceptable policies.

The traditional EIA approach has been conducted on the construction of sensitivity facilities in Taiwan for more than two decades. The stakeholders, especially the neighboring residents, kept a continuous opposition to the operation of these facilities or plants even though the information release claimed no harms to the people or the environment. Therefore, an ideal framework for environmental assessment is required in consideration of the different parties involved in the project development.

In this paper, a new framework for EIA is presented by taking stakeholders' opinions with scientific

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analysis. It attempts to provide a sound and practical approach by integrating subjective perception on the diverse, culturally-based values of a planned site with objective data involving physical damages by means of scientific analysis that are selected by most rational-thinking policy makers. After a theoretical framework is presented, a case study is conducted by applying the proposed framework as an assessing tool to evaluate the dollar amount of compensation and the targeted refusal rate. The conceptual framework presented in this paper is expected to be extended to apply and test on some project developments in the practical world.

MATERIALS AND METHODS

Firstly, the background of Taiwan's EIA process and the relevant aspects are discussed to gain some highlights on the currently operating EIA system. Secondly, the contingent valuation method (CVM) is used to determine the weighting factors of each impacts (or effects) to balance the disutility of the sacrifice (the affected people) and incorporate AHP to determine the relative importance of the affecting groups in affecting project development. Based on the case of the project for the construction of a MSW incineration plant with capacity of 600 ton/day at Wutuli, Linei Shiang, Yunlin County (Linei Incinerator hereafter), an analysis example is conducted.

Background of EIA process in Taiwan

Environmental impact assessment act (EIAA) was the first environmental law in Taiwan , legalized and started to implement in 1994. It is designed to call for a comprehensive assessment of environmental consequences, to prevent or mitigate the adverse environmental impacts that are caused by developments, to regulate minimum requirements for ensuring the achievement to meet the social objectives and to prescribe the assessment procedures, the composition of assessors and the level of details of the outcome report to ensure information transparence. Although, Taiwan has implemented EIA for more than 10 years, the environmental conflicts, however, still maintain at a quite high level. Nuisance petition cases have gradually increased over time according to Taiwan EPA report (Fig. 1). The increase in nuisance petition cases in Taiwan reflects that the slacks of the currently operated EIA still exist. The practice of EIA remains less than satisfaction and improvements in the quality of EIA decisions are required (Curran *et al.,* 1998; Hazell and Benevides, 2000).

On the other hand, the total cases applying for EIA ranged from 77 cases in 2003 to 155 cases in 1999 and the approval rate (including, conditional approval) ranged from the bottom of 57.83 % in 1996 to the peak of 81.65 % in 2001 after the implementation of EIAA starting from December 1994. The cases requiring for

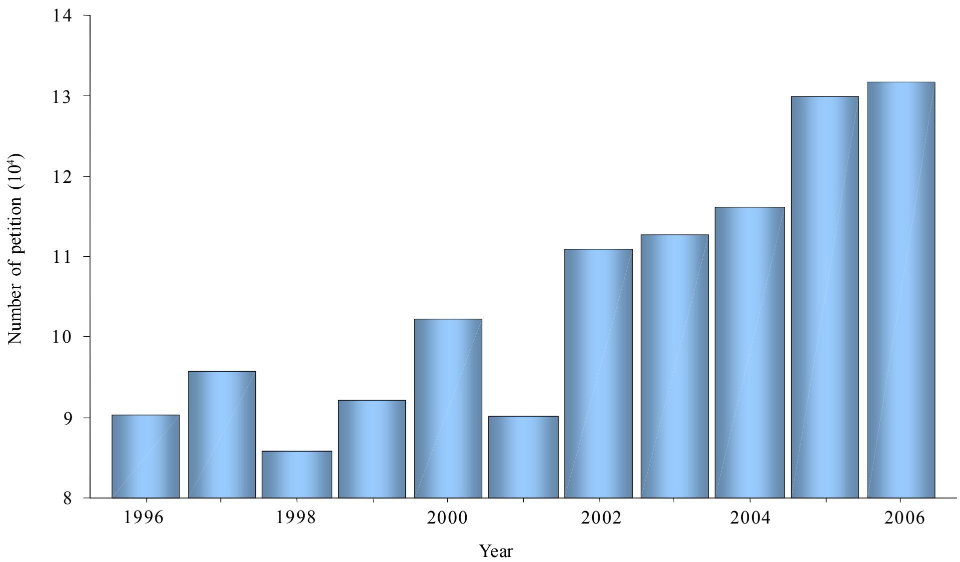

Fig. 1: Nuisance petition cases

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Table 1: The cases of environmental assessment handled

year	Approved[a]	second stage	reject	total cases	Acceptance rate	second stage rate
1996	96	55	15	166	0.578313	0.331325
1997	132	26	22	180	0.733333	0.144444
1998	127	10	22	159	0.798742	0.062893
1999	155	13	63	231	0.670996	0.056277
2000	114	10	43	167	0.682635	0.059880
2001	138	7	24	169	0.816568	0.041420
2002	86	2	23	111	0.774775	0.018018
2003	77	2	21	100	0.770000	0.020000
2004	108	2	18	128	0.843750	0.015625
2005	95	2	20	117	0.811966	0.017094
2006	85	1	21	107	0.794393	0.009346

[a] This column consists of cases that are approved or approved with conditions
Source: Taiwan EPA (2007)

the Phase II EIAs drop sharply after 1998 and then declined to be lower than 2 % after 2002 (Table 1). A simple statistical analysis is made and it is found that number of nuisance petition cases is more or less correlated with the acceptance rate of project developments (Pearson correlation coefficient $r = 0.469$ with p value of 0.145 for 11 observations). This result shows that people perception on the environmental pollution (measured in nuisance petition cases) has a large gap with the outcome of EIA decisions. These gaps may be caused by the diverse environmental concerns on project developments among stakeholders (such as the authorities, local and affected people, environmental groups and others), arising from subjective perception. The current EIA procedure employed by Taiwan is depicted in Fig. 2 in which the assessment process is categorized into two phase: Phase I assesses the potential impacts based on the environmental assessments (EAs) in which the potentially environmental impacts are scientifically calculated by project developers (PDs). EAs are presented to and reviewed by EIAC that consists of 7 governmental officials and 14 scholars/experts appointed by Taiwan EPA. The meeting of EIAC in Phase I environmental impact assessments (EIAs) generates four outcomes, including approval, conditional approval, refusal and the requirement of Phase II EIAs. If the project development requires phase II EIAs, a preliminary environmental impact statement (PEIS) should be completed by the project developer based on the detailed environmental survey and impact analysis. Before the presentation of PEIS, Taiwan EPA will invite stakeholders (the involving scholars, NGOs, the affected residents and the project developers) to define the goals and the scopes that require for the process of impact analysis and assessments according to Article 10 of EIAA. In the meantime, the feasible alternatives, the impact items, the methods for surveying, forecasting, analysis and the environmental impact assessment should be determined. Based on the commonly accepted goals and scopes determined by stakeholders, PEIS should contains at least: 1) the current status of the site, 2) the possible impacts and its affected scope of development, 3) the forecast, analysis and assessment of environmental impacts, 4) the corresponding strategies to minimize the impacts, 5) alternatives, 6) environmental management plans, 7) the responses to public opinions, 8) conclusions and 9) costs for the implementation of environmental management and protection strategies. Agency of Industrial Development (AID) needs to call for a public hearing and make a filed investigation with stakeholders after reviewing PEIS. The public opinion will be transferred to EIAC for further evaluation. Theoretically, EIAC is independently responsible for the decision of acceptance of PEIS by subjectively allocating the weights among environmental effects and eventually makes a decision whether to accept the project development. If PEIS is approved, a detailed design and implementation of project should follow and form a formal environmental impact statement, accompanied with an environmental protection plan for project construction according to the final EIA report and review conclusions before the construction work starts. The environmental protection plan and the relevant documents in association with EIAs should be seen as a part of the engineering contract and all the relevant documents, including the environmental management plan and contract should

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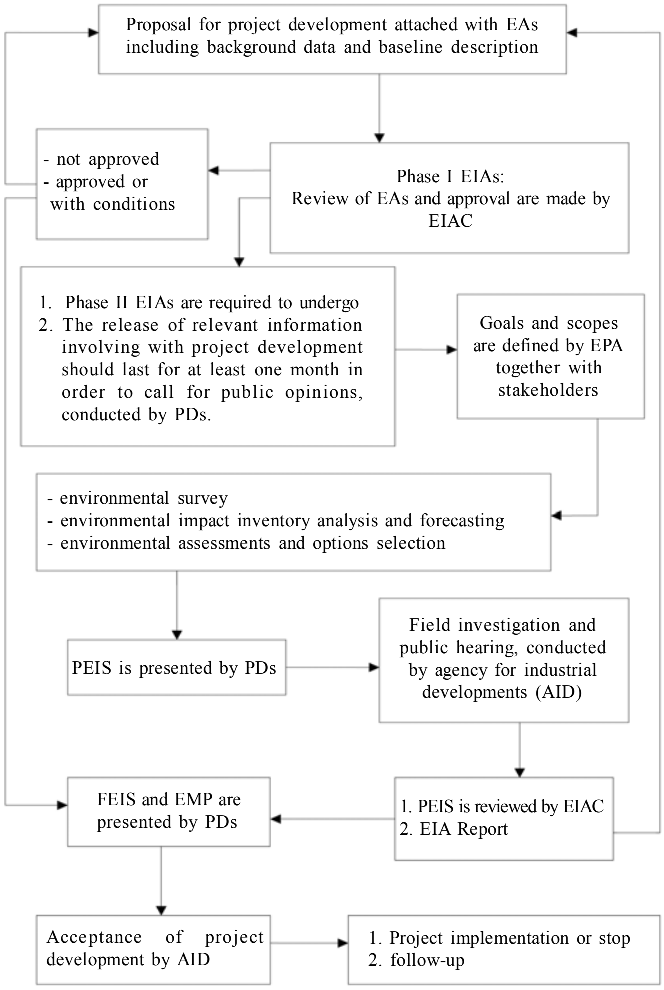

Fig. 2: EIA implementation procedures in Taiwan

be submitted to the EPA before starting construction.

The proposed framework of EIAs

In practice, there is at present neither a consensus-based approach nor a satisfactory method to guide the assignment of weightings for the assessment of environmental impacts or the relative importance among stakeholders in EIA process. In order to balance the weakness of subjective weighting or rating on environmental impacts, many mathematical methods are presented. For example, analytic hierarchy process (AHP) has been employed for the use in calculating weighting factors of each environmental effect in EIA through a multi-dimension process in consideration of multiple criteria and multiple stakeholders by Ramanathan (2001). He proposes that AHP can work for capturing the perceptions of stakeholders on the relative severity of different socio-economic impacts. And thus it can help policy makers in prioritizing their environmental management plan, and can also help in allocating the budget available for mitigating adverse socio-economic impacts. The application of AHP for socio-economic impact assessment can help the authorities to decide how well an environment management plan is appropriate for a project development. Several shortcomings of AHP are also raised by Ramanathan (2001) and should be overcome, including 1) the measurement of scale, 2) the choice of methods for estimation of priorities, 3) the rank reversal phenomenon, 4) the lacking of axiomatic framework, and 5) the required number of judgments for comparison among alternatives. Furthermore, AHP

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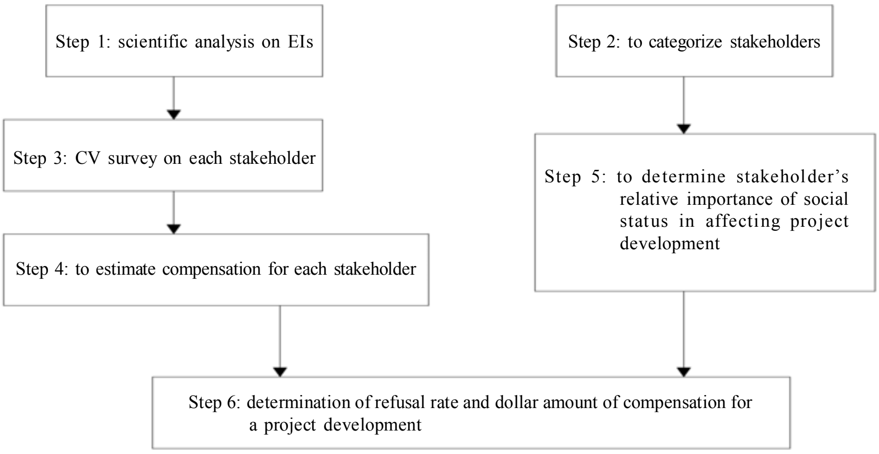

Fig. 3: The framework of Phase I EIAs

neglects the relative importance of different stakeholder in affecting the political decision on the project development. It also does not provide an objective criterion of acceptance (or refusal) and thus the final decision is made by the simple majority of EIA Council (EIAC) voting.

Some researchers emphasize to integrate the economic valuation of environmental goods or loss in EIA (Aunan *et al.,* 2004; Mestl *et al.,* 2005; Lindhjem, *et al.,* 2007) for the comparison between environmental protection and social and economic development to achieve more efficient use of scarce resources (Arrow *et al.,* 1996) and less impacts to human health and ecosystem (Mestl *et al.,* 2005). Lindhjem *et al.* (2007) argue that "economic analysis of mitigation measures should be conducted, as well as evaluation (not only analysis and prediction) of impacts "(p. 3). McDaniels and Trousdale (2005) employ decision methods of multi-attribute analysis to evaluate non-market losses due to adverse impacts as a basis for determining compensation. Presently, the implementation of all PPPs in Taiwan should pass EIA process in which the stakeholder participation is allowed in the EIA practice. Stakeholders, however, play as a monitor or a supervisor to present different or even opposite perspectives only. Eventually, whether to accept the project development is still subject to the decision of EIAC who are supposed to be rational thinking and in negligence of social impacts. In other words, the weights among environmental effects arisen from project development are subjectively determined by the members of EIAC. In order to avoid the shortcoming of traditional EIA that has been discussed in the previous section, this paper incorporates the affected people's perspectives in association with economic valuation methods on environmental goods/bads into the EIA framework. Lindhjem *et al.* (2007) argue that economic valuation methods have been applied to assess environmental impacts of projects and policies in the practical world and shown to be beneficial to the EIA process.

Methodologies for valuing environmental goods are in general categorized into two broad categories: stated preferences by asking people directly to value an object, for example, in a so-called contingent valuation survey and to reveal their willingness to pay or to accept for hypothetical environmental changes. On the other hand, revealed preferences is conducted by observing people acting in real-world settings and derived indirectly how people value different aspects of the environment, for example, travel cost methods and hedonic price methods. In this paper, CVM is adopted as a tool to evaluate the weights among the environmental impacts and the dollar amount of compensation for the acceptance of a project development. The CVM is used not only for the evaluation of an environmental sensitive facility, but also for damage assessment and the calculation of compensation payments in the practical world. A brief discussion for the application of CVM can be found from a great number of literatures. Based on the previous discussion, a framework shown in Fig. 3 to

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replace Phase I EIAs of Fig. 2 by incorporating CVM to estimate the dollar amount of compensation for sensitive facility and AHP to determine each stakeholder's relative importance of social status in affecting project development. This framework involves six steps as follows:

Step 1: Determination of attributes generating negative impacts

In practice, stakeholder cannot fully understand the wide impacts and high complexity of the project development and thus EIAC should be responsible to identify and pick up the possibly potential impacts based on scientific analysis.

Step 2: Categorization of stakeholders

Stakeholders with different environmental perspective may choose different environmental behaviors toward a project of an environmentally sensitive facility or the conservation park for endangered specie (Chen and Huang, 2004). They may provide different valuations on the project development and thus they may accept compensation, but require different amount or even hold a completely opposite position to this project development. They will execute their political power in affecting the ongoing direction and progress of project development.

Step 3: Conducting an environmental survey on each group of stakeholders

In this step, the samples are drawn from each group and asked how much they are willing to accept a dollar amount for the construction of an environmentally sensitive facility neighboring to their home. Theoretically, an individual will choose 'yes' to accept the project of an incineration plant when he feels $\Delta y + w_1 \Delta R + w_2 \Delta H + w_3 \Delta Q \geq 0$, where Δy represents monetary compensation, ΔR is economic loss, ΔH denotes the health impact, ΔQ is the impairment of ecological system, ΔR, ΔH, $\Delta Q \leq 0$ and w_1, w_2, w_3 are the weight of each category of impacts, $w_1, w_2, w_3 \geq 0$. Therefore, the following discrete outcomes of the response are observable:

$$D = \begin{cases} 1, & \Delta y \geq -w_1 \Delta R - w_2 \Delta H - w_3 \Delta Q \\ 0, & \Delta y < -w_1 \Delta R - w_2 \Delta H - w_3 \Delta Q \end{cases} \qquad (1)$$

In other words, the response is positive (D = 1) when the indirect utility for the construction of the project is equal or greater than the indirect utility without the construction, i.e:

$$\Pr(\Delta=1) = \Pr(V(I + \Delta y + w_1 \Delta R + w_2 \Delta H + w_3 \Delta Q | X, \varepsilon)\ V(I | X, \varepsilon)) \qquad (2)$$

Where, I is the disposable household income, X is a vector of observed social demographic characteristics, V is indirect utility function and ε is a scalar variable representing the disturbance of unobserved personal characteristics. It is assumed that the indirect utility function V is monotone increasing for any fixed (X, ε), then there exists an inverse function Λ such that

$$I + \Delta y + w_1 \Delta R + w_2 \Delta H + w_3 \Delta Q = \Lambda(V(I + w_1 \Delta R + w_2 \Delta H + w_3 \Delta Q | X, \varepsilon) = \Lambda(V_1) \qquad (3)$$

and

$$\Lambda(V(I | X, \varepsilon)) = (V_0) \qquad (4)$$

Substituting Eq. 4 and Eq. 5 into Eq. 3 yields

$$\Pr(D=1) = \Pr(\Delta y \geq \Lambda(V_0) - w_1 \Delta R - w_2 \Delta H - w_3 \Delta Q)$$

Stakeholder with different age, education, class and ethnicity may express diverse trust on the sources and shows different environmental concerns. Hence, a weight evaluation conducted by stakeholders with different demographical characteristics may generate complete different impacts. Traditionally, dichotomous choice responses are regressed against a constant, the bid amount (BID), and a vector of socioeconomic variables (X) using a logistic function. A logit model is employed in this paper for computing the stakeholder acceptance rate of the project, and thus, the probability to accept the construction of the project is

$$\Pr(D=1) = p = \frac{\exp(w_1 \Delta R + w_2 \Delta H + w_3 \Delta Q + \lambda' X, \varepsilon)}{1 + \exp(w_1 \Delta R + w_2 \Delta H + w_3 \Delta Q + \lambda' X, \varepsilon)} \qquad (5)$$

The logistic function Eq. 5 estimates the probability that an individual is willing to accept the construction of an environmentally sensitive facility under a given amount of damages and a set of socioeconomic characteristics. It can be converted to

$$\ln \frac{p}{1-p} \quad \alpha_0 + \alpha_1 w_1 \Delta R + \alpha_2 w_2 \Delta H + \alpha_3 w_3 \Delta Q + \alpha_y \Delta y + \lambda' X + \varepsilon \qquad (6)$$

Where, λ' is a transpose vector of coefficients for

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demographical variables X, α_y is coefficient for dollar amount of WTA and α_0, α_1, α_2, α_3 are regressive coefficients. The estimated values of w_1, w_2 and w_3 are incorporated into Eq. 6 to calculate the subjective aggregate damages of a project for assessor committee decision.

Step 4: Obtaining each group's estimated results

The observed data of ΔR , ΔH , ΔQ , Δy and X responded by the members of group *i* of stakeholders are used to estimate Eq. 6. The estimated results are obtained and expressed as follows:

$$\ln\frac{p_i}{1-p_i} = a_{0i} + a_{1i}\ \Delta R + a_{2i}\ \Delta H + \alpha_{3i}\ \Delta Q + a_{yi}\ \Delta y + B_i^{'} X \quad (7)$$

Where, α_{0i} is estimated intercept for *i*th stakeholder, α_{1i} is the estimated coefficient for $\alpha_1\ w_1$ for *i*th stakeholder, α_{2i} for $\alpha_2 w_2$, α_{3i} for $\alpha_3\ w_3$, α_{yi} for α_y, and $B_i^{'}$ for $\lambda_i^{'}$.

Step 5: Determination of stakeholder's relative importance v_i among stakeholders in affecting the project development by AHP

As EIA requires public supports and there is more than one group of stakeholders who seek for their interests and concern on environmental impacts, the judgment variations on the impacts from stakeholders should be considered. When the support from each group of stakeholders may affect the implementation of project development, the relative importance among stakeholders in affecting project development is needed to examine. In this paper, it is sugessted to use AHP for performing the aggregation, including the geometric mean method and arithmetic mean method (Saaty, 2000) to determine stakeholder relative importance v_i in affecting project development. The characteristic of AHP that using pairwise comparison includes following properties, including: 1) Hierarchic representation and decomposition, 2) priority discrimination and synthesis, and 3) legal consistency (Wang, 2004). In the AHP, the reciprocal matrices of pairwise comparisons are constructed. Using these pairwise comparisons, the weight for each attribute can be estimated. The details can be found in many textbooks.

Step 6: determination of compensation amount (WTA) and refusal rate

It is assumed that the policy maker aims to minimize the compensation Δy to obtain the refusal rate for each group of stakeholder by establishing a target refusal rate $\bar{q}$ that is predetermined based on the past working experience and political consideration. Thus, the problem is expressed as

Min. Δy (P1)

s.t.

$$(1)\ \ln\frac{1-q_i}{q_i} = a_{0i} + a_{1i}\ \Delta R + a_{2i}\ \Delta H + \alpha_{3i}\ \Delta Q + a_{yi}\ \Delta y + B_i^{'} X \quad (8)$$

for *i* = 1, 2, .. , k (9)

$$(2)\ \sum_i v_i q_i \le \bar{q}$$

The Largrange function of Problem (P1) is expressed as:

$$L = \Delta y + \sum_i \lambda_i \left(\ln\frac{1-q_i}{q_i} - \alpha_{0i} - \alpha_{1i}\ w_{1i}\ \Delta R - \alpha_{2i}\ w_{2i}\ \Delta H - \alpha_{3i}\ w_{3i}\ \Delta Q - \alpha_{yi}\ \Delta y + \lambda_i^{'} X\right) + \lambda_q\left(\sum_i v_i q_i - \bar{q}\right) \quad (10)$$

The first order conditions for the solution are obtained by taking differentiation of Eq. 10.

$$0 = \frac{\partial L}{\partial \Delta y} = 1 - \sum_i \lambda_i\ \alpha_{yi} \quad (11)$$

$$0 = \frac{\partial L}{\partial q_i} = -\ \lambda_i\ \left(\frac{1}{1-q_i} + \frac{1}{q_i}\right) + \lambda_q\ v_i \quad (12)$$

for i= 1, 2, … , k

The optimal refusal rate q_i for each group of stakeholder and dollar amount of compensation Δy can be obtained by the simultaneous Eqs 8 - 9 and 11 - 12.

RESULTS AND DISCUSSION

The project development of a MSW (municipal solid waste) incineration plant has drawn great concerns from the public for its potential environmental impacts. In 1997, Taiwan EPA (Environmental Protection Administration) planned to set up a MSW incineration plant in Yunlin County. After a process, Linei Shiang (a place in Yunlin County) was selected as the location

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Table 2: The potential impacts after operation of this project

Impact Category	Description
Water Quality	Wastewater is recycled and reused completely. In case of emergent shutdown of operation, about 240 CMD (cubic meter per day) of treated wastewater is released to neighboring rivers, amounting to 0.023 % of river flow of 11.95 CMS (cubic meter per second). No contamination on the neighboring river can occur.
Air Quality	The designed capacity of flue gas was 180 Nm^3/h containing CO: 100 ppm; SO2: 80 ppm; NO2: 180 ppm; HCl: 40 ppm; and TSP: 20 mg/Nm3 at the chimney. Maximum 24 h-observation value of emissions in the air measured at 2.5 km southern of the planned site are SO2: 7.35 ppb; NO2: 23.3 ppb; HCl: 1.18 ppb; TSP: 119 μg/Nm^3; Cd: 0.0021 μg/Nm3 and Hg: 0.0042 μg/Nm^3, 8-h observation value for CO is 715 ppb and monthly observation for Pb is 0.023 μg/Nm^3. All of these emissions are far below statutory standards.
Traffic, noise and vibration	During the operation period, traffic frequency is about 320 trucks per day and max. 80 trucks per hour, leading to an increase of 2.9 % on the traffic loading of the neighboring traffic system. Noise level is kept below 50 db at a distance of 500 m far from the planed site.
Waste emissions	Daily 120 ton of ash, mainly consisting of SiO2, CaO, Fe2O3, Al2O3, etc., is generated. The ash will be solidified and transferred to land filling site.
Animal and plant ecology	All the pollutions emitted by this plant are far below the allowable concentration that may affect animal and plant ecology and thus their impacts are negligible. For example, SO2 emissions of 7.35 ppb is far below the allowable concentration of 0.3 ppm for animal health significantly for 12 months continuous observation, the allowable concentration of 0.5 ppm that may lead to urgent impacts and 0.18 ppm for plant for 8 h continuous exposure.
Recreation resource and amenity	The area of the planned site occupies 7.5 ha only and the building of this plant is designed to be compatible with the scenery. No historic relics or spots remain near the planned site. Noise level is controlled below 50 dB to minimize the impacts on recreation and amenity.
Socio-economic impacts	About 47 employees are required to operate this plant and thus its impacts on labor market in this region are negligible. As the location of this plant is far from inhabitant area, its impacts on living life is negligible.

for this project. According to the design, burning temperature was controlled at 850-950 ºC for 2 s to assure complete oxidation with energy recovery system and the flue gas was treated by scrubber, air-bag filter and other post treatments before emissions. This system was claimed to be capable of assuring to achieve the minimization of the dioxin emission below 0.1 ng/Nm3 and other pollutants (Table 2).

Taiwan EPA attempts to achieve that the project should conform to local and regional environmental baseline standards. The preliminary screening on the proposal presented decided that Phase 2 EIAs were required to undergo. The PEIS with the field survey and public hearing minutes for the planned project of Linei Incinerator were submitted to Taiwan EPA according to Article 13 of EIAA. The major potential impacts described in PEIS included 7 issues, demonstrating to be little or negligible (Table 2). However, controversies involving contamination of water supply, site alternatives and preservation of the blue-winged pitta were kept going without solutions during the review process. Some environmental groups insisted on opposing this project and emphasized the negative impacts of project construction on the conservation of blue-winged pitta and on human health due to dioxin emissions. Even though, the PEIS for this project was approved by EIAC with some minutes of revisions according to the comments raised by EIAC during the process. The final report on PEIS specified that this project was acceptable with the adoption of a number of additional clauses.

The construction of this project started in 2002 after tender opening and contract signing and completed in 2005 under the circumstance of the

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continuously strong opposition of some local environmental groups and politicians. When Ms. Su, the leader of the opposite groups, was elected the county mayor of Yunlin in 2006, she immediately ordered to stop the operation of the newly built plant as soon as she took office. Until now (2008), this incinerating plant has not been re-considered for operation. This paper follows the proposed framework described in the previous section and conducts an experimental design to determine the relative importance of diverse environmental impacts and the compensation amount.

Step 1-3: Two classes of students are selected to represent two different groups of stakeholders through a purposive sampling. One is graduate students majored in environmental studies and believed to have more in-depth understanding on the environmental impacts of a development project while the other is graduate students.

They are asked how much of dollar amount they will accept for the acceptance of such a project like Linei Incinerator under a variety of hypothetical conditions. The questionnaire consists of two parts: questions regarding the respondent's socio-economic status and the relevant information (operating condition and emissions). Before surveying, the respondents are fully informed of the background of the case example. In other words, the background of the case example including, the data of air pollutant emissions and possibly potential impacts of emissions from the operation of the planned project (listed in Table 2) is presented to respondents on surveying.

The distance of the planned site to the respondent's home is designed to reflect the respondent's perception with health impacts ΔH. In a similar way, the distance of the planted site to the habitat of Blue-winged pitta (Pitta brachyura Temminck and Schlegel) is specified to reflect the respondent's concern with the impairment of ecological system Q. The respondents are asked if they agree to accept the project (incineration plant) constructed about 1 km, 10 km, 50 km or 100 km far from their home or the habitat of Blue-winged pitta. The other impacts are captured by intercept of Eq. 6. The respondents are also asked how much he is willing to accept the construction of this project as compensation. The answer of 'yes' represents the compromise between the compensation and respondent's subjective perception on the value of the impacts generated by the project.

Step 4: The estimated models are obtained:

$$\ln\frac{p_1}{1-p_1} = -3.1463 + 0.2831\,\Delta H + 0.0945\,\Delta Q - 7.6 \times 10^{-7}\,I + 0.0016\,\Delta y \quad (13)$$

$$\ln\frac{p_2}{1-p_2} = -2.5168 + 0.198\,\Delta H + 0.0853\,\Delta Q - 5.9 \times 10^{-7}\,I + 0.0021\,\Delta y \quad (14)$$

Where, p_1 represent the acceptance rate of the environmentally sensitive facility by Group A and p_2 by Group B.

The empirical results are based on the responses that surveyed with students. Under this specification, there are two equations that may correspond to the respondent's environmental perception on this project. The parameters of the two groups are listed in Table 3. The results show that the parameters for compensation, health impacts and ecological impacts are significantly fitted to the model.

Step 5: The relative importance is v_A = 0.204 and v_B= 0.796 for the two groups, respectively according to the ATP procedures (Table 4). In the analytic hierarchical process, it must firstly construct a hierarchy of relative importance in affecting from the policy maker's view point that includes number of members in each group and its power in affecting public opinion (Fig. 4). Based on the pairwise comparison scale, a preference multiplicative matrix is built up. The weights of the two attributes are calculated by finding the eigenvalues of the matrix.

Step 6: In this paper, the average distance of respondent's home and the habitat of Blue-winged pitta to the planned site are assumed to be the same of 10 km. The household income is assumed to be NT$ 1,000,000 for group A and NT$ 800,000 for Group B. In other words, ΔH = 10, ΔQ = 10 and I = 1,000,000 are assumed in Eq. 13 and ΔH = 10, ΔQ = 10 and I= 800,000 are used for Eq. 14. And thus, Eq. 13 and 14 are simplified as:

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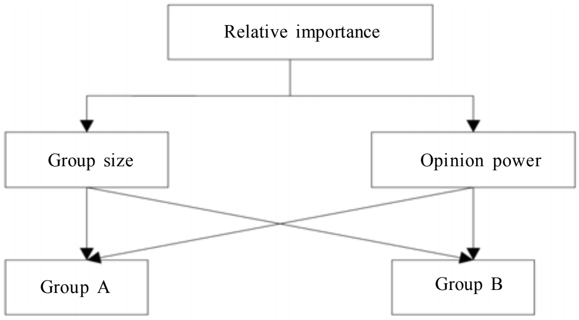

Fig. 4: Hierarchical structure of stakeholder relative importance

Table 3: Estimates of parameters of the logistic regression model

	CA	CB
Observations	32	34
Constant	-3.4163	-2.1568
	(0.1438)	(0.1713)
I	-7.6E-07	-5.9E-07
Household income	(0.6143)	(0.7411)
ΔH	0.2831	0.1980**
distance of the site to home	(0.1358)	(0.0324)
Δ Q	0.0945**	0.0853**
distance of site to the site of blue-winged pitta	(0.0133)	(0.0188)
Δ y	-9.3 E-04*	-0.0038**
	(0.0828)	(0.0267)
-2Loglikelihood	27.507	30.448
R^2	0.119	0.301

p-value in parenthesis
* significant at p < 0.1
** significant at p < 0.05

Table 4: A hypothetical case for evaluating relative importance of stakeholders

	Attributes		Relative importance
	Number of members	Power in affecting public opinion	$v = \sum_i w_i r_i$
	w_1= 0.1	w_1= 0.9	
Group A	0.6	0.16	0.204
Group B	0.4	0.84	0.796

Table 5: The optimal compensation (dollar amount of WTA) vs. target refusal rate

$\bar{q}$	5 %	10 %	15 %	20 %
q_1 (p_1)	0.075 (0.925)	0.142 (0.858)	0.200 (0.800)	0.249 (0.751)
q_2 (p_2)	0.039 (0.961)	0.086 (0.914)	0.137 (0.863)	0.186 (0.814)
v_1, v_2	0.20, 0.80	0.20, 0.80	0.20, 0.80	0.20, 0.80
Δ y	NT$ 1,576	NT$ 1,207	NT$ 944	NT$ 785

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$$\ln\frac{p_1}{1-p_1} = -0.1303 + 0.0016\,\Delta\,y \quad (15)$$

$$\ln\frac{p_2}{1-p_2} = -0.1558 + 0.0021\,\Delta\,y \quad (16)$$

Using Eq. 15 and Eq. 16 and E. 11 and Eq. 12, the results shown in Table 5 are achieved. The compensation amount is derived to be NT$ 785 to 1,576 per year. It seems to be reasonable to reflect student perception on the project development of an incineration plant. The example presented in this paper drawn from actual cases occurred in Taiwan is to illustrate the approach proposed in this paper. The responders in this paper are selected purposely from the students in my school and hence the outcome in the specific example presented here is hypothetical and for reference. It reflects practice of the actual case based on the framework presented in this paper. This approach introduces CVM and AHP into EIA process to satisfy current laws and regulation, but more importantly to improve the information content of environmental impact statements (EIS). The economic valuation method of CVM clearly demonstrates the importance of stakeholder's participation that provides an important role in determining weighting factor, affects the calculation of aggregate environmental damages and serves as a dominating role in affecting final decision of project development. It enables the final decisions of project approval meets both the prevention requirement of environmental impacts and the perception of stakeholders.

CONCLUSION

The decision on EIA process really involves a variety of perspectives and decision tools. Within this context, economists emphasize rational choice and generally suggest cost-benefit analysis to make good environmental policy while behavior theorists take an opposite perspective and suggest that public participation may help for the decision of a project development. This paper integrates the two perspectives and proposes a framework for EIA process in which scientists is responsible for the analysis and calculation of physically environmental impacts and stakeholders weight subjectively the relative importance of these impacts. This framework considers stakeholder perspectives and attitudes toward the facility construction, allowing them to express their utility on the impacts of each impact. With the integration between scientific analysis on the impacts and the weight determined by the subjective valuation, this approach is indeed able to achieve a surprising result that bridges the gap between scientific analysis and social valuation. This paper provides a newly different approach and makes several contributions. First, a framework and set of applied procedures are presented that integrate scientific analysis with subjective perception on value loss due to project development. The identification of potentially negative impacts is assessed by scientists based on scientific analysis while the valuation of environmental impacts is conducted by CVM through the survey on diverse stakeholders in the society. Stakeholder judgments about the importance of different aspects of negative impacts due to project development are considered in the EIA process to provide an aggregate characterization of the significance and implicit value of these losses.

Secondly, the relative importance among stakeholders reflecting their power in affecting project development may play an essential role to achieve an effective assessment and assure the successful of project implementation. The valuation on the relative importance of social status among stakeholders relies on a simplified version of AHP that serves as a basis for analyzing complex value tradeoffs in a wide array of contexts to characterize the political importance among stakeholders in affecting the project development. This approach does not rely on an individual decision maker (or a social actor) but makes a tradeoff among stakeholders to characterize the value of the losses.

The third contribution is to use compensation as a tool for the possible risks across time and space for all the stakeholders to reduce the opposition rate for the project development. The framework proposed in this paper provides an opportunity for compensation for the wide array of non-market impacts from project development and for promoting better communication among stakeholders and makes a trade off between rational thinking and psychologically subjective perception. Many important intangible values, such as loss of historical sites, or loss of opportunities for cultural antiques that are meaningful to the affected people, but are not obvious in contexts in the EIA process. The compensation mechanism works as a

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driving force for project developers to mitigate impacts and eventually it can and should be used to inform and shape future dialogue and negotiations between stakeholders and project developers.

Fourthly, this paper addresses not only on conceptual framework for EIA, but also the valuation methods for environmental impacts and the relative importance of social status among stakeholders in affecting project development to help policy making in EIA process. The presented framework provides the basis for quantitative and qualitative analysis of the impacts and further to linking of compensation and opposition rate, offer a comprehensive discussion to facilitate review and allow the EPA to consider fully the opinions of stakeholder involving the project. It highlights the usefulness of CVM and AHP in EIAs, but also reveals important methodological, practical and institutional gaps and challenges to the wider use of EIA in Taiwan.

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