

論文の内容の要旨

論文題目 **Integrated Assessment of Co-benefits from Methane Recovering-based CDM Projects: Case Studies in Thailand**
(メタン回収型CDMにおける統合的コベネフィット評価 :
タイにおける事例からの分析)

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Clean Development Mechanism (CDM) for greenhouse gases emission reduction has allowed developed countries with emission reduction commitment to earn emission reduction credits from where it makes the investment worthwhile (mostly in developing countries). Together with earned credits, local sustainability benefits, called co-benefits, have been also expected to achieve in invested host countries. In recent years, comprehensive analysis for project prioritization to invest CDM projects by integrating local benefits rather than only CDM financial study has been challenging for decision making process. This study aims to develop methodologies to value co-benefits on improved water quality by implementing methane recovery CDM project to non-aerobic open lagoon treatment system. Competitive two factories (i.e., ethanol and crude palm oil plants in Ayutthaya and Krabi provinces in Thailand) were chosen as studied sites to develop an valuation model in terms of financial, environmental and societal valuation metrics.

In terms of CDM business, financial assessment is basically required for allocating investment funds with functions of certified emission reductions (CERs) and electricity revenues. Both studied sites were estimated low transaction costs of 12.36-35.87 USD/tCO₂e compared with averaged carbon price of carbon taxation scheme, 35 USD/tCO₂e. Ayutthaya site produced more CERs than Krabi site in a certain crediting period, however, it costed the higher CER generating cost from a higher investment cost and less operating days. Although, the methane recovery CDM projects had been proven to not be “business-as-usual” projects but electricity sale was a major revenue. Krabi site was more attractive for investors in terms of internal rate of return (IRR) and net profit percentage by more electricity produced, 29.57% and 191.84%, respectively with 20-year CER crediting period. Investors should be induced to invest gas generators at full coverage of produced

biogas for increasing profitability and viability of projects.

Apart from CDM financial assessment, the indicators for co-benefits from CDM projects by assessing environmental impacts from high-strength wastewater operation in ethanol and crude palm oil plants, point-source pollutants originated from a factory and infiltrated pollutants from an open lagoon, received wastewater from a factory were separately valued. The valuation of point-source is chosen to be a co-benefits indicator of environmental impact due to the purposes to expand its applicability by simple assessment and give direct relation to the societal valuation from a view of cleaner public water. From the results of the point-source pollutant valuation, Ayutthaya site resulted a higher environmental alleviation from the methane recovery CDM than Krabi site. Ayutthaya site costed 75,134 USD/y over the cost of Krabi site, 66,250 USD/y because a larger UASB size required in Ayutthaya site. The cost of UASB treatment was the determining factor to differentiate the costs of environmental impact and define environmental alleviation from methane recovery CDM project. As for the valuation of infiltrated pollutants, it estimated the cost of 16,384 and 11,044 USD/y for Ayutthaya and Krabi sites, respectively. The results of pollutants removal cost showed that cost to treat nitrate rather than cost of oxygen supplement by assuming that nitrified ammonium is all nitrified under lagoons, was the most valuable contaminant and differentiated environmental impacts between project sites.

In order to integrate social involvement to co-benefits assessment, a part of this study framework analyzed the spacial scales of water quality perception to examine how stakeholders at different administrative scales attached on different preference values between the studied sites. Questionnaire survey was used to elicit willingness-to-pay (WTP) using 3 different starting bid values of 20, 50 and 100 THB per household/month for sub-samples of local respondents (Ayutthaya and Krabi residents) and national respondents (Bangkok residents) with closed-end double-bounded question for one step improvement in rivers' water quality from status quo. Water quality perception showed 79% of respondent agreed to pay with different mean WTPs, varied across sub-samples. As for local respondents, households in Ayutthaya gave the higher WTP than Krabi at an average of 77.9 THB per household/month (28.8 USD per household/y). Whereas, Bangkok residents gave the higher WTP, of 75.3 THB per household/month (27.8 USD per household/y), for improved water quality in Krabi than Ayutthaya. By analysis of censored regression model, in general perspective of water quality services, the most endogenous variables for Ayutthaya's rivers associated with the WTP were household income and members.

Nevertheless, for Krabi's rivers, education and attitude factors became more considerate by the reason of acknowledged public benefits in terms of land use in the province. From the reasons mentioned, it is suggested to consider the importance of spacial scale in water quality perception to be measured and compared separately for the analysis of co-benefits assessment.

Due to simplified methodologies of financial, environmental, societal assessment for co-benefits CDM prioritization, it could give an ease to widen utilization or application in CDM wastewater works. This method could be used in a comparison basis between projects as supporting informations for allocating CDM finance with co-benefits integration. To compare values of environmental impacts between projects, the methodologies of point-source pollutants valuation for environmental impact applied with the studied sites. They gave low financial barrier for assessing the benefit values from the CDM projects without instrument investment to assess environmental impact which increase transaction cost to burden the CDM by its simplicity of methodologies. The infiltrated pollutants valuation could not estimate an actual benefit value, unless, the comparison of costs on environmental impact before and after CDM implementation is assessed. In order to compare values of social preferences between projects, it could be applied to studied sites with contingent valuation method regarding their preferences for improvement of river water quality from status quo in current situations in each site. Nevertheless, questionnaire survey was the most time-consuming for this study because it requires a credible number of samples and explanation of the hypothetical market for river quality.

In the integrated valuation study, Multi-criteria Decision Analysis (MCDA) for comparing and ranking different project/site alternatives by monetary indicators from financial, environmental, and social assessments was elaborated with outranking method (pair-wise comparisons). The key indicators were illustrated in the value tree for making decision matrix and separated into different models of CDM investment. This method was proven to express comparative quantifiable scores with the concerns in "profitability", "transparency" and "community participation" for discussions on individual indicator and the absolute results. In partial ranking, Ayutthaya site competed over Krabi site in the indicators of total produced CERs, environmental impacts, and local WTP except the indicators of IRR, net profit, and national WTP. The discrete preference scales between positive and negative preference flows resulted for all indicators except CER generating cost which is opened to be the justifiable indicator in decision making process. In complete ranking, Ayutthaya site competed over Krabi site for scenario A and B&C from viewpoints of CDM subsidizers and

investors, which are benefited from lower cost of CER investment and co-benefits recognition. Co-benefits indicators have significant effects on the change of ordered preference scores and differentiated comparative score with the score of 0.038 (or 3.8% in difference). From the all pair-wise results of preference choices in equal weighting approach, the UASB investment is more preferred for Ayutthaya and Krabi sites than the investment of UASB coupling with gas generators. Whilst, by considering incremental GHGs reduction in the scheme of electricity sale, Ayutthaya site obviously became the best-fit site for the both investments of only UASB and UASB coupling with gas generators by importance of lower CER generating cost in scenario B&C. This comparative method provided a guideline or a starting point for what will be developed or expanded to applicability of the co-benefits CDM approach in voluntary assessment by project developers or even in the international mechanism integrated with price premium, rather than a present checklist approach based on “Do no harm” and “Scoring” practice. From that reason, researches on improving the framework is required, considering on the reduction of uncertainties, expanding of the types of CDM implementation and criteria pollutants for environmental and economic impacts assessment, indicating a boundary of impacts/benefits, and justification of MCDA in decision-making process.