A Proposal of Methodology to Calculate Triple I Intended for CO2 Ocean Sequestration

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ABSTRACT

To mitigate the global warming, ocean sequestration of CO2 has been proposed. Because the technology has risks on deep ocean ecosystems, its implementation needs public acceptance through environmental impact assessment, in which an index that makes easy the comparison between benefits and risks is useful. Recently, Triple I was developed as an inclusive index for both environmental and economical aspects, consisting of ecological footprint, ecological risk, human risk, cost, and financial benefit. The present paper presents a methodology to calculate Triple I by picking up CO2 ocean sequestration as an example of large-scale technology using oceanic space. When calculating the Triple I, the technology was compared with the effects of ocean surface acidification and its consequent impacts in the deep ocean.

KEY WORDS: Triple I; Global warming; CO2 ocean sequestration; Ecological footprint; Ecological risk; Ocean surface acidification.

INTRODUCTION

The climate change caused by the increase of greenhouse gases in the atmosphere has become an international problem (IPCC, 2001). Especially, CO2, the atmospheric concentration of which rises rapidly by anthropogenic activities, causes not only the global warming but also the ocean surface acidification (OSA), and exerts a large influence on ecosystems of both lands and seas (Orr, et al., 2005). CO2 ocean sequestration (COS) in the middle-depth layers (1500 – 2500 m) at sea-sites with the water depth of about 5000 – 6000 m (COS) has been proposed as one of its countermeasures (IPCC, 2005).

The benefits of COS are artificial acceleration of carbon fixation process in the ocean and an ease of OSA, while there is a concern on its risks: impacts on ecosystems by CO2 exposure (e.g. IPCC, 2005; Sato, 2004; Sato, et al. 2005; Kamishiro and Sato, 2007). Therefore, the evaluation of the benefits and risks of COS is required, considering the emergency of the global warming and the capacity of renewable energies. To do so, some kind of indices can be useful to judge whether a large-scale technology that use oceanic or coastal space like COS is effective and acceptable from both economical and environmental point of views.

Recently, the Inclusive Impact Index (Triple I) was developed for this purpose (Otsuka, 2006). Triple I is defined by

\[ III = \Delta EF + \Delta ER + \frac{\Sigma EF}{\Sigma GDP} \left( \Delta HR + \Delta (C - B) \right) \]

where III is the Triple I, EF is the ecological footprint in global ha, ER is the ecological risk described by EF in gha, \( \Sigma EF/\Sigma GDP \) is the ratio between domestic EF and the gross domestic product (GDP) and this actually means the coefficient between ecological and economical activities, HR is the human risk including the risks of human health and social resources in currency like Japanese yen (JPY), C is the cost, and B is the financial benefit. \( \Delta \) indicates the difference between those with and without the implementation of target technology, the latter of which means the so-called business-as-usual (BaU) for instance. The details of EF can be referred to the literature (e.g. Wackernagel and Rees, 1996; Chambers, et al. 2000).

Triple I is a novel concept because ER, which is difficult to quantify in currency, is treated as footprint (area) and added to EF in gha and those in yen are combined by using \( \Sigma EF/\Sigma GDP \).

This study aims to propose a methodology to calculate Triple I by picking up COS as an example of a large-scale technology in the ocean. Particularly, to quantify ER is focused on in this study. Because ER is not easy to obtain in many cases, sometimes Triple I without ER and HR, which is called Triple I Light, is used for simplicity. In general, ER is defined by the production of quantified damage of an endpoint and its occurrence probability (Nakanishi, 1995). The endpoint of ER is usually assumed to be the extinction of a particular species. In this study, as an endpoint of ER of both OSA and COS, species extinction of marine organisms in three oceanic spaces, i.e. coastal seas, surface pelagic ocean, and deep ocean, are considered.

SCENARIO DEFINITION

Once OSA takes place, there must be environmental impacts on the ecosystems in the deep ocean, in which food web starts with the flux from the surface layer. This must also lead to risks in the middle-depth layer.