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Resources, Conservation and Recycling 48 (2006) 166–196
Resources Conservation & Recycling
www.elsevier.com/locate/resconrec

Socioeconomic metabolism in Taiwan: Emergy synthesis versus material flow analysis

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Received 9 August 2005; received in revised form 29 December 2005; accepted 27 January 2006
Available online 9 March 2006

Abstract

The concept of socioeconomic metabolism can be traced back to 19th century and can provide a useful framework for both natural and social scientists to study the interrelations between human societies and their natural environments. Many studies on socioeconomic metabolism incorporated material flow analysis, but there are still many unresolved methodological issues such as its units, aggregation techniques, and omitted energy flows. The importance of the relationships between land use and socioeconomic metabolism has also been raised recently. In order to combine material flows and energy flows, this paper incorporates emergy synthesis to overview the socioeconomic metabolism of Taiwan during 1981–2001. Due to the lack of natural resources, the extraction of domestic non-renewable materials has decreased since 1980s and have to be supplemented by import. The requirements of imported energy flows has increased substantially with industrial development. Difference between results from material flow analysis and emergy synthesis is also discussed. It is found that material flow analysis alone could not identify the essential fact of Taiwan's increasing dependence on energy use. Furthermore, the qualitative characteristics of materials flows are also neglected. The analysis of the relations between land use and socioeconomic metabolism indicates that the changes of land use affect the socioeconomic metabolism in Taiwan. However, due to the lack of information, whether the change of socioeconomic metabolism has triggered land use change still need further investigation.

Keywords: Emergy synthesis; Material flow analysis; Land use change; Socioeconomic metabolism; Taiwan

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doi:10.1016/j.resconrec.2006.01.005

1. Introduction

Environmental awareness in the 1960s triggered an interest in studying society's metabolism with a new perspective (Ayers and Kneese, 1969; Boyden et al., 1981; Meadows et al., 1972; Odum, 1971; Wolman, 1965), one which cut across the boundaries between the natural sciences and social sciences. Ever since the publish of the Brundtland Report, the notion of sustainable development has emerged as a key means to stimulate dialogue across the natural social sciences. Metabolism is a concept adopted from biology, which refers to the physiological processes within a living organism that describes the energy flow connected to the conversion of matter for reproduction. Extending this concept to the social sciences, metabolism can be seen as a main feature in the analysis of human interactions with the natural environment.

The organization of flows of materials and energy between human societies and their natural environments should be concerned with sustaining the metabolism of the societies. Socioeconomic metabolism (alternatively termed societal metabolism or industrial metabolism) is currently one of the research area of the human dimensions of global change project of the International Human Dimension Programme (IHDP). The concept of socioeconomic metabolism can be traced back to 19th century as the biophysical perspective of ecological economics (see Martinez-Alier, 1987). It has also been frequently examined in the field of human ecology (e.g. Boyden et al., 1981; Rappaport, 1971; Wolman, 1965). The notion of socioeconomic metabolism can provide a useful conceptual framework for both natural and social scientists to study the interrelations between human societies and their natural environments. Social scientists can study socioeconomic dynamics as a consequence of the changing patterns of material and energy flows while the natural scientists can analyze the effects of these flows to natural processes (Haberl, 2001).

After review of research on the application of metabolism to the social sciences from 1860 to 1998, Fischer-Kowalski (1998) noted that consensus for a theoretically stringent approach is emerging. Currently, most of the work on socioeconomic metabolism focus on the accounting of the inputs and outputs of materials flows of a specified society. The establishment of material flow accounts (MFA) as regularly collected statistical information has been implemented in some countries. For example, industrial countries such as Austria, Japan, Germany, and Sweden have established material flow accounts (Eurostat, 2001). MFA regards the socioeconomic system as the core of analysis and emphasizes inputs and outputs of this system. Specifically, these accounts look at the amount of materials extracted from nature, used and transformed in one way or another within society, and returned into natural system as wastes or emissions. However, there are still many unresolved issues using material flow analysis, such as its units, aggregation techniques, and omitted energy flows.

The synthesis of socioeconomic material and energy flows would greatly enhance our understanding of the driving forces of our ecological economic system. Monetary valuation of ecosystem services and natural capital may be useful to demonstrate their economic value but is insufficient to measure the intrinsic worth of the life support function of ecosystem (Costanza et al., 1997). Energy flows are not only one of the most important unifying concepts in ecosystem development (Odum, 1988). They are also the only common measure that connects ecosystems and economic systems (Hall et al., 1986). Consequently, using