Journal of Cleaner Production 66 (2014) 577–587

Contents lists available at ScienceDirect

Journal of Cleaner Production

journal homepage: www.elsevier.com/locate/jclepro

Evaluation of the soft measures' effects on ambient water quality improvement and household and industry economies

Yoshiaki Tsuzuki [a, b, *]

[a] Faculty of Engineering, Architecture and Information Technology (EAIT), The University of Queensland, Queensland, Australia
[b] Research Centre of Coastal Lagoon Environments (ReCCLE), Shimane University, Japan

ARTICLE INFO

Article history:
Received 24 November 2012
Received in revised form
25 October 2013
Accepted 26 October 2013
Available online 5 November 2013

Keywords:
Cleaner consumption
Household sustainable consumption
Import effect matrix
Input–Output Table
Pollutant discharge calculator
Soft measures

ABSTRACT

Various ecological footprint calculators, carbon footprint calculators and water footprint calculators have been developed in recent years. The basic concepts of ecological behaviour record notebooks and of carbon dioxide emission calculators have been developed since the late 20th century. The first carbon dioxide emission calculator was developed in 1991. Likewise, water pollutant discharge calculators have been developed to estimate the effects of soft measures introduced into households to reduce pollutant discharge since 2004. The soft measures which have been developed in Japan may consist of a wider framework, household sustainable consumption, which has been developed in Europe, and can be referred to cleaner consumption. In this research, summarisation of the short history of ecological behaviour record notebooks and ecological footprint calculators in Japan since the 1980s was conducted, and the soft measures in households to reduce pollutant discharge were evaluated for their effects on ambient water quality improvement as well as household and industry economies. Effects of the soft measures on related industry economies were investigated using an Input–Output Table analysis and the effects of the imported goods were evaluated with an import effect matrix, which was developed in this research. The effects of the soft measures on household expenditures were estimated to be a decrease by 2.5% or USD 285 person $^{-1}$ year^{-1} in 2003–2006. The results show that the soft measures positively affect the chemical fibre industry and significantly affect the detergent industry. Analysis of the import effect matrix proved that the six industries were tightly related through extensive amounts of imported goods. The soft measures in households may lead to household sustainable consumption and thus reduce disadvantageous human impacts on water environments. The effects of the measures introduced to improve the environment should be qualitatively and quantitatively evaluated to avoid redundant concerns and discord between the environment and the economy, which may be worried when the relationship is not well understood.

1. Introduction

Several kinds of footprint indicators have been developed since the 1990s. These have been related to energy and material flows, life-cycle assessment, environmental risk assessment and land-based pollutants (Herva et al., 2011). They have been variously categorised as environmental footprints (EnvF), social footprints (SF), economic footprints (EconF), combined environmental, social and/or economic footprints and composite footprints (Čuček et al., 2012). EnvF includes carbon footprint (CF), water footprint (WF), energy footprint (EneF), emission footprint (EmF), nitrogen footprint (NF), land footprint (LF) and biodiversity footprint (BF).

Efforts and activities have been conducted to disseminate public information on how to reduce greenhouse gas (GHG) emissions including carbon dioxide (CO_2) in several countries. For example, in the UK, information dissemination on measures to reduce CF has been conducted by a cross-government initiative

Abbreviations: BF, biodiversity footprint; CF, carbon footprint; CO_2, carbon dioxide; EcolF, ecological footprint; EconF, economic footprints; EHF, effect of the soft measures on household expenditures; EmF, emission footprint; E-MRIO, environmental multi-region Input–Output analysis; EneF, energy footprint; EnvF, environmental footprints; GHG, greenhouse gas; HSC, household sustainable consumption; IAP, indoor air pollution; IEM, import effect matrix; LF, land footprint; METI, Ministry of Economics, Trade and Industries of Japan; MOE, Ministry of the Environment (Japan); MRIO, Multi-region Input–Output; NF, nitrogen footprint; NIES, National Institute for Environmental Studies of Japan; NGOs, non-government organisations; NO_x, nitrogen oxides; OECD, Organisation for Economic Co-operation and Development; SF, social footprints; SPM, suspended particulate matter; SSRN, Social Science Research Network; TAPA, total annual project amounts; WF, water footprint.

* Faculty of Engineering, Architecture and Information Technology (EAIT), The University of Queensland, Queensland, Australia. Tel.: +61 7 3365 3912; fax: +61 7 3365 4599.
E-mail addresses: y.tsuzuki@uq.edu.au, tsuzuki.yoshiaki@gmail.com.

0959-6526/$ – see front matter © 2013 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.jclepro.2013.10.047

named ACT ON CO_2 (UK Government, 2012). The Energy Saving Trust (2012) is a non-profit organisation which provides information and advice for households and industries on energy consumption, energy generation, and GHG emissions. Transport Direct (2012) is a non-profit service providing information on CO_2 emissions from transportation funded by the government sectors.

Input–Output Table analysis has been applied to ecological footprint (EcolF) analyses such as energy use and expenditure in Sydney, Australia (Lenzen et al., 2004), integrated sustainable chain management of Australian industries (Foran et al., 2005), eco-efficiencies of tourism related to GHG emissions and total transport volume (Gössling et al., 2005), EcolF of tourists and residents (Patterson et al., 2007), income distributions, rebound effects and international trade (Weber and Matthews, 2008), and household energy usage (Shammin et al., 2010). Multi-region Input–Output (MRIO) models have been developed to calculate consumption-based emission and resource accounting (Wiedmann, 2009) and to calculate EcolF and WF through harmonisation of methods with CF accounting (Ewing et al., 2012). Using the MRIO model to calculate CF shows substantial cross-regional variation in terms of the amount of land appropriation, the mixture of land types, and geographical origins on consumption-induced ecological impacts (Zhou and Imura, 2011). A review of environmental multi-region Input–Output analysis (E-MRIO) has produced a comprehensive and systematic outline of potential policy applications (Daniels et al., 2011). The WF of soy milk and soy burgers is calculated, taking into consideration blue water (surface and ground water), green water (rainwater) and grey water[1] (pollution) (Ercin et al., 2012). Effects of international imports and exports on water resources have been investigated focussing on a concept of virtual water (Oki and Kanae, 2006; Hanasaki et al., 2010).

Sustainability of household consumption has been evaluated by several researchers. Themes and domains in the existing research on household sustainable consumption (HSC) have been diverse: energy, wastes, expenditure and shopping, incomes, household characteristics and consumer behaviours, air and water pollution, carbon and CO_2 emission, nitrogen oxides (NO_x) emission, water, wastewater, food, green products, quality of life, transportation, communication, material use, space and land use, construction and housing, house and garden sizes, building and housekeeping, goods and services, recreation, tourism, mobility and catering services (Caeiro et al., 2012). Both the existing production-based and newly developed consumption-based methods are found to be effective to estimate GHG emissions in a study in Oregon, USA (Erickson et al., 2012). Meat is found to be the largest contributor among diet-associated GHG emissions in a study in France (Vieux et al., 2012). CO_2 emissions from consumption activities in households in China including housing, transport, recreation and food are investigated (Fan et al., 2012). More than 98% of CO_2 emissions are found to be attributed to indirect emissions from building materials and labour inputs in a recent study in rural China (Zhang et al., 2012).

In the water, wastewater and solid waste sectors, indicators on water consumption and solid wastes are analysed in a report by the Organisation for Economic Co-operation and Development (OECD) (OECD, 2002). In contrast, investigation of indicators related to wastewater pollutant discharge has been limited (OECD, 2001, 2008a,b; Tsuzuki et al., 2012). The concept of WF is developed after the development of EcolF from the early 1990s (Hoekstra, 2009). Qi and Chang (2012) evaluate water supply systems, steel, cement, energy and carbon footprints using multiobjective programming methods in Florida, USA. A concept on sustainable water management and new water management paradigm has been developed (Pahl-Wostl et al., 2008, 2011). The dissemination on soft measures[2] in households to reduce pollutant discharge from municipal wastewater and to improve ambient water quality has proliferated by environment sections of the government and environmental non-government organisations (NGOs) in Japan since the late 1980s (Tsuzuki, 2006). The soft measures can be described as a kind of cleaner consumption because they are related to lifestyle changes and accompanied with resultant pollutant discharge reduction. There are many papers and materials on the soft measures written in Japanese but scientific papers in English are still limited (Ukita et al., 1986; Tsuzuki, 2006; Tsuzuki et al., 2012). Discussion on the progress and development of EcolF calculators and pollutant discharge calculators in Japan has been lacking and should be worthy to the international professional community. The effectiveness of the soft measures themselves has already been verified in various scales of catchments in Japan with populations from 100 persons (Ukita et al., 1986) to two million (Tsuzuki et al., 2012).

The major purpose of this paper is to investigate the effects of soft measures in households on household, industry, national and international economies. The effects of the soft measures on household and industry economies were investigated using Input–Output Table analysis methods and the pollutant discharge calculator[3]. The effect of each soft measure was calculated under reasonable conditions based on the assumptions of lifestyles usual for ordinary Japanese. Total effects of the soft measures on household economy were estimated by summing up all the effects of the soft measures. Six industries which were related to the soft measures were considered from a macro economics perspective in this paper: (1) food and drink; (2) chemical fibre; (3) soap, synthetic detergent and surfactant (hereafter referred to as detergent industry); (4) wastewater treatment; (5) water supply; and (6) solid waste management. The Japanese National Input–Output Tables for 2003–2007 were used for the analysis to find approximate magnitudes of the effects of the soft measures on the six industries as a preliminary study. Based on the results, some aspects of work undertaken within households were discussed including paid and unpaid works, and household consumption and degrowth.

2. Theories and methods

As background information of the research, short history of footprint calculator development in Japan (Section 2.1), CO_2 emission estimation methods using Input–Output Table analysis (Section 2.2), and explanation of soft measures in households and pollutant discharge calculators (Section 2.3) are described in this chapter. Analysis methods for the effects of soft measures on household economy and those on industry economy are described in the following sections.

2.1. Development of several footprint calculators in Japan

The basic concept of pollutant discharge calculators in Japan has been based on a notebook to record environment-friendly behaviours. The notebook was proposed by Morioka in 1980 (Morioka, 1986) (Table S1, see Supplement Materials). The concept

[1] In wastewater treatment and sanitation fields, grey water means municipal wastewater other than black water (toilet wastewater) (Gaulke, 2006; Tsuzuki, 2006).

[2] The soft measures were formerly referred to as pollutant load/discharge reduction measures, soft interventions or soft measurements in previous papers and presentations (Tsuzuki, 2006, 2010, 2012a; Tsuzuki et al., 2012).

[3] The pollutant discharge calculators were formerly referred to as environmental accounting housekeeping (EAH) books of municipal wastewater (Tsuzuki, 2006, 2010, 2012a; Tsuzuki et al., 2012).