Resources, Conservation and Recycling 89 (2014) 76–85

Contents lists available at ScienceDirect

Resources, Conservation and Recycling

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

Assessment of physical economy through economy-wide material flow analysis in developing Uzbekistan

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ARTICLE INFO

Article history:
Received 4 December 2013
Received in revised form 7 May 2014
Accepted 14 May 2014
Available online 8 June 2014

Keywords:
Uzbekistan
Economy-wide material flow analysis (EW-MFA)
Industrial metabolism
Resource use indicators
Material efficiency

ABSTRACT

In this paper, we assess the physical dimensions of Uzbekistan's economy during 1992–2011 by using the economy-wide material flow analysis (EW-MFA) method, which is an internationally recognized tool for such assessments. There have been a number of studies using methodological standardization of EW-MFA, but to the best of our knowledge, it has never been used to assess the metabolism of Central Asian economies, especially, in this case, the Republic of Uzbekistan.

Our analysis strives to empirically evaluate macroscopic economic activities by considering the accounting of material flows. The material flows data-set comprises of consistent data for domestic extraction, imports, and exports, as well as other derived MFA-based indicators.

The derived indicators are internationally compared for further evaluation of national economic development performance in a given period. The indicators of direct material input (DMI) and total material requirements (TMR) showed a slight increase in 1992–2011 with an average annual increase of 2.79% and 2.34%. The trends of TMR, DMI, domestic material consumption (DMC) and material efficiency, which is indicated by GDP/DMI, displayed lower values than other industrialized countries referenced in the international comparison. Although national economic performance data showed particularly remarkable success, indicators measuring material inputs and DMC reveal an insignificant increase during the period of study. During the second decade of study period, relative decoupling has occurred which indicated that the economic indicator (GDP) grows faster than DMC and other macro indicators grow.

1. Introduction

The concept of sustainable development concerns not only the natural environment but also human societies and economies (Xu and Zhang, 2007). Sustainability has been defined by the United Nations as a global process of development that minimizes the use of environmental resources and reduces the impact on environmental sinks using processes that simultaneously improve the economy and the quality of life (UN World Commission on Environment and Development 1987). Sustainable development has many definitions, however, the most frequently quoted definition is, "Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs," (the Brundtland Commission 1987).

Over the past few decades, however, demand for natural resources has accelerated to the extent that it is now widely considered a serious threat to well-functioning economies and societies because of the associated environmental issues such as climate change, biodiversity loss, desertification and ecosystem degradation (Millennium Ecosystem Assessment, 2005; Wuppertal Institute, 2005; EPA Network, 2006; Stern, 2007; WWF, 2012; UNEP, 2013; IPCC, 2014). A main driver of human induced environmental changes has been the growing social or industrial metabolism, that is, the inputs of materials and energy into socio-economic systems and the corresponding outflows of wastes and emissions (Ayres and Simonis, 1994; Fischer-Kowalski and Haberl, 2007). The notion of a socio-metabolic transition is used to describe fundamental changes in socioeconomic energy and material use during industrialization (Krausmann et al., 2011).

Studies of industrial metabolism aim to provide an understanding of the functioning of the physical basis of our societies', the linkages of processes and product chain webs within the anthroposphere and the exchange of materials and energy within the environment (Ayres, 1989). During the last 15 years, material and energy flow analysis have emerged as significant methods for tracking the flows of materials and energy, respectively, and for comparing the natural ecosystem and the industrial system (Erkman, 1997).

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http://dx.doi.org/10.1016/j.resconrec.2014.05.004
0921-3449/

In the last 20 years, several methods have been developed that allow for the quantification of the use of natural resources by modern societies (Daniels and Moore, 2002).

One of the key methods is economy-wide material flow accounting and analysis (EW-MFA), internationally recognized as an important tool for analyzing social metabolism (in order to understand its operation) and as the basis for evaluation and a possible restructuring in terms of sustainability. EW-MFA reveals the physical growth of industrial economies and the increasing shift of material flow burden between environmental media and toward other countries (Bringezu and Schütz, 2003). The increasing interest in the physical basis of economies is also reflected in the large and growing number of economy-wide material flow accounts on a national level.

There have been a number of studies using methodological standardization of EW-MFA. In Gonzalez-Martinez and Schandl (2008), the biophysical perspective of the Mexican economy is presented by accounting for the country's material inputs, and the dynamics of natural resource usage are analyzed for given periods. For Hungarian economic performance, material flow based indicators such as direct material input and total material requirements are used as environmental sustainability indicators (Hammer and Hubacek, 2003). Through an assessment of the mass flow of raw materials and commodities in the Italian economy, the material flow balance of the physical economy and substantial environmental aspects of the country are depicted (de Marco et al., 2001). For the period 1970–2009 the biological features of the Argentinean economy are examined using a social metabolism approach (Perez Manrique et al., 2013). The development of material consumption of three transition economies: Czech Republic, Hungary and Poland are explored and benchmark their material consumption against average values for the member states of the European Union that represent a typical market economy (Kovanda and Hak, 2008). Although in peer-reviewed literatures, Uzbekistan has been looked at in international studies (Schandl and West, 2010; CSIRO, 2008) but to the best of our knowledge, there is no research undertaken on Uzbekistan's metabolic profile by assessing material flows associated with the transition from centrally planned to a market economy. This study is considered a first attempt to explore the metabolic performance of the national economy, industrial metabolism, and environmental impacts of Uzbekistan using EW-MFA based indicators.

The research is guided by the following topics and interests: How the Uzbekistan economy is displayed using EW-MFA-based indicators; what main driving forces are behind the economic growth of the country using the EW-MFA perspective; what level of Uzbekistan's physical economic performance is depicted by the EW-MFA using the associated international comparisons; and which alternative approaches must be taken for country's future sustainable development.

To address these questions, we structure the paper as follows. Firstly, we present a brief explanation of the most important definitions and concepts applied (Section 2). The main part of the article is described in the presentation and in the discussion of the main EW-MFA indicators for Uzbekistan during the time series for 1992–2011 (Section 3). Secondly, we illustrate the trends of several macro indicators that could draw discussion on the country's future long-term perspectives and macro policy (Section 4). Finally, conclusions are reached in the last part of the article.

2. Definition and methods

The different types of material flow analysis depend on the primary interest of the analyst (Bringezu and Moriguchi, 2002). If we are interested in certain substances or materials (e.g., because they

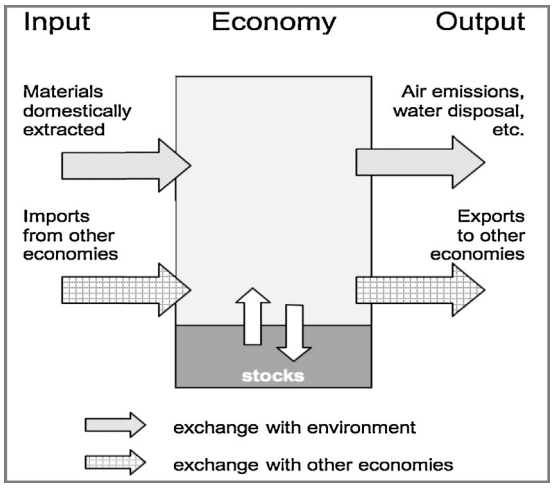

Fig. 1. Scope of economy-wide material flow accounting and analysis (EW-MFA) method.
Adapted from Eurostat (2001).

are related to specific impacts), we may study, for instance, the flows of substances such as heavy metals, chlorine, and carbon or the flow of bulk materials such as wood, energy carries, or plastics. However, if we are interested in the specific effects associated with products, we can perform a life-cycle assessment (LCA) and study the flows associated with the relevant product chain. By contrast, if we are interested in the metabolic performance of regions or national economies, we should systematically consider all material flows in order to characterize the total throughput of materials and employ the EW-MFA method.

EW-MFAs are consistent compilations of the overall material inputs into national economies, the changes of material stock within the economic system and the material outputs to other economies or to the environment (Fig. 1).

2.1. Material flow based indicators

In the EW-MFA framework, materials are tracked from the extraction of national resources to the stocks and accumulation within the economy, and finally to the waste and emissions dispensed into the environment (Xu and Zhang, 2007). A large number of resource-use indicators can be derived from the EW-MFAs, which provide a comprehensive description of the biophysical metabolism of societies (Fig. 2). These indicators can be grouped

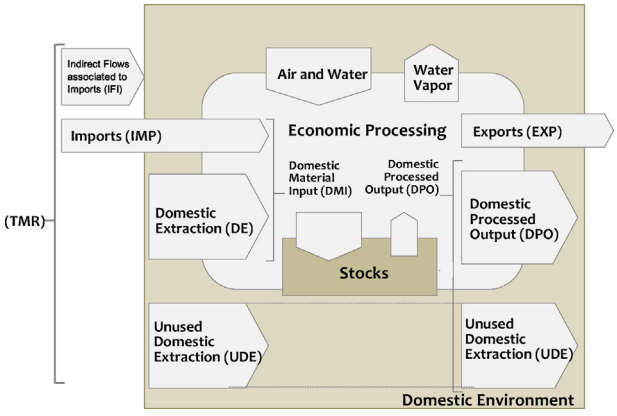

Fig. 2. Material flow categories and main indicators in the economy-wide material flow accounting and analysis (EW-MFA) method.
Matthews et al. (2000), amended.