ARTICLE IN PRESS

Renewable and Sustainable Energy Reviews xxx (xxxx) xxx–xxx

Contents lists available at ScienceDirect

Renewable and Sustainable Energy Reviews

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

Carbon and water footprint accounts of Italy: A Multi-Region Input-Output approach

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A R T I C L E I N F O

Keywords:
Footprint analysis
Multiregional Input-Output model
Balance of emissions
Water use embodied in trade
Italy

A B S T R A C T

This paper analyses the CO_2 emissions and the water use embodied in international trade in Italy. It is well documented that consumption of goods places a considerable strain on the environment and this phenomenon is further exacerbated by imports for domestic usage, which entail exploitation of water and environment. In this respect, the analysis focuses on the determination of Italian carbon and water footprints, which are two indicators able to determine how the human activities affect the environment, through the Multiregional and multindustry Input-Output model based on the World-Input-Output Database. The results show that CO_2 emissions and water use associated with Italian imports were greater than CO_2 emissions and water use associated with Italian export, mainly because the exploitation of resources in Italy is higher in the consumption phase than in production processes.

1. Introduction

The environmental exploitation and deterioration causing global warming and climate change have received a lot of attention at national and international level in the recent years. In particular, the environmental agendas of governments and international organisations focused on the increase in greenhouse gases (GHG) emissions and the water scarcity [1]. Indeed, the reduction of GHG emissions represents the worldwide target to be achieved in order to contain the global warming since the IPCC first assessment report was released in 1990 [2]. This document inspired the establishment of the United Nation Framework Convention on Climate Change (UNFCCC) that led to the ratification of Kyoto Protocol in 1997 [3]. This brought out the exigency to understand what activities generates GHG emissions and how they can be effectively reduced.

Focusing on the first aspect, in a context characterised by a significant growth of international trade it becomes crucial to take into account the contribution of trade to the global warming and climate change [4]. Indeed, it has been widely accepted that the increase in international trade has generated a significant growth in economic activities around the globe [5] and has changed the production and consumption perspectives, leading to a split of goods and services locations of production and consumption. Many production processes located in developed countries are purchasing goods and services from developing countries, which may results in the relocation of natural resources, energy use and pollution to developing countries [6]. Even though the Kyoto agreement has set clear targets to be achieved by each country, the contribution of international trade in GHG emission (or alternatively the shift of GHG emissions among countries) constituted a minor issue and it was not addressed in the discussion during the meeting. Nevertheless, the transformation of GHG emissions among countries and regions through international trade has become a relevant issue in recent time. The weight of global GHG emissions related to exports has reached the 30% of global emissions in 2013 [6] and this global trend is confirmed by several countries statistics on emissions [7–14].

Whereas the introduction of the Clean Development Mechanism (CDM) in the Kyoto Protocol as a tool to address the global emission was not effective [15], the traditional production-based approach of emissions accounting should be accompanied by a consumption-based approach. Following this line, emissions embodied in imports and exports should be considered in addition to the emissions generated from production activities within a country boundary to determine the amount of emissions directly and indirectly generated in a country [16]. Indeed, the international trade can be seen as an opportunity to implement the climate policy through a set of trade based mechanisms like border tax adjustments [17–19].

In this paper, we decide to follow the footprint approach that has the capability of ascertaining as to how the human activities weight on environment [20].

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http://dx.doi.org/10.1016/j.rser.2017.05.277
Received 5 October 2016; Received in revised form 23 March 2017; Accepted 29 May 2017
1364-0321/

Please cite this article as: Ali, Y., Renewable and Sustainable Energy Reviews (2017), http://dx.doi.org/10.1016/j.rser.2017.05.277

The “carbon footprint” term and concept in particular, became widely used in the debate on responsibility and abatement actions against global climate change since a decade ago. Despite its popularity, this term does not have a definition or a methodology of calculation universally accepted, but the definition suggested by Wiedman and Minx [16] seems to provide a broadly answer to many criticisms. According to these authors “the carbon footprint is a measure of the exclusive total amount of carbon dioxide emissions that is directly and indirectly caused by an activity or is accumulated over the life stages of a product” [16]. This definition include only CO_2 in the analysis since many of the other pollutants are difficult to be quantified because of data availability. In addition, this definition refrains from expressing the carbon footprint as an area-based indicator allowing the more accurate representation in tonnes of carbon dioxide and including emissions generated through international trade.

Similar to the carbon footprint is the “water footprint” concept that was developed in recent years to provide a consumption-based indicator of water use [21]. Indeed, the unsustainable use and contamination of freshwater, also called the “water crisis” issue, has been considered another relevant threat not only to the health of ecosystem, but also to human societies and food security [1]. Water is a limited natural resource and during the last decades, its use has been increasing at more than twice the population growth rate [22]. The depletion of aquifers, the deterioration of water quality and rivers running dry are only some examples of the global unsustainable water resources management [23]. The water footprint is an important indicator introduced to provide a virtual measure of the water embodied in goods and services produced in one location. It can be defined as the water consumed to produce goods and services along the full supply chain [24] and lately it is widely used to measure the hidden links between human consumption and water use and between global trade and water resources management [25,26].

From a global sustainable development perspective, the growing water requirements to produce traded goods is not a minor issue, as well as the carbon embodied in imports and exports. More precisely, due to the increasing globalization and the growth of export of water-demanding commodities, the problem of water scarcity become even more complicated, prolonging the restraints for water scarcity beyond the national boundaries [26].

Therefore, both carbon and water footprint indicators provide a measure of environmental pressure, or better, the human use of resources and the anthropogenic GHG emissions into the environment related to the production and consumption behaviour of a country or region [27]. In particular, the carbon footprint is expressed in terms of mass units (e.g. kg or tons) of carbon dioxide (CO_2) or carbon dioxide equivalents emissions (for other GHG) per unit of time or per unit of product [20]. The water footprint is measured in terms of water volume (e.g. L or m3) per unit of time, or unit of product whose amount can be expressed in various way (e.g. L per kg, L per kcal, L per g of protein etc.) [28].

In this article, a special attention is devoted to CO_2 emissions and water use resulting from the relocation of production among countries as a consequence of international trade. In this context, a large number of models were developed to estimate environmental pressures embedded in international trade of several countries and regions. Environmental multisectoral models in particular, provide an appropriate methodological framework to complete environmental pressure estimation at national and international level. These models are commonly used to determine the footprints indicators from a top-down perspective [16] in macro and meso-systems and can easily identify the footprint of many agents operating in the economic system, such as industries in production processes and households and government in consumption processes [29]. In particular, there is a considerable literature supporting the use of Multi-Regional Input-Output (MRIO) tables in quantifying the carbon and water footprint and the incidence if international trade on them [30–33].

We concentrate on the Italian case and develop a quantitative analysis of the carbon and water footprints with a particular attention to the measurement of CO_2 emissions and water use embodied in international trade. Indeed, in the last decade, Italian Government paid a great attention to environmental issues and in particular, to the control of CO_2 emissions and to the sustainable use of fresh water, anticipating in many cases, the environmental policies set forth by the EU. Even if these efforts results in a reduction of carbon emissions (around −23% with respect to 1990) and water footprint, the Italian environmental policies should be developed in order to meet with the EU targets of 2020.

In this respect, we are interested in detecting what is the incidence of CO_2 emissions and water use related to international trade, in order to enlarge the possibilities for the policy maker, to develop effective environmental policies. For this purpose, we perform a detailed analysis on the emissions and water use embodied in Italian exports and imports according to the consumer approach using a new set of high-resolution global multi-region input–output (MRIO) tables.

The article is organised in six sections explaining the methodology adopted, the results of the analysis and some final considerations. In particular, Section 2 provides a brief review on MRIO models and their contribution on environmental analysis; Section 3 describes in detail the dataset and the MRIO model used in this study; Section 4 discusses the results of the analysis for the carbon footprint and Section 5 for the water footprint; Section 6 offers some final considerations.

2. Background on environmental multisectoral approach

The multisectoral approach is one of the most frequently used methodology in determining the environmental pressure of human actions and footprint indicators [16]. Environmental extended Input-Output models in particular, allows evaluating the different agents' contribution on pollution when operating in the economic system both from production and consumption side [34–36]. They provide a useful instrument to understand the incidence of international trade to environmental damages, or in other words, the phenomenon of carbon dioxide and water use burden-shifting among countries [37–39].

In this respect, two different approaches to the use of Environmental extended Input-Output model can be identified. In the first approach, the regional model considers the bilateral trade with respect to different economies and the embodied environmental pressures (i.e. emissions, land use, water use, energy use etc.) as exogenous variables [16]. In the second model, the multiregional approach, each domestic technical coefficient is combined with trade flow matrices to determine the intermediate flows matrix. The second type MRIO model is also known as the true or full multiregional model. Several studies used the single region I-O and MRIO models to measure water and carbon footprint for Australia [40], UK [41], New Zeland [42] and China [33]. In other cases, MRIO model was used to perform a structural decomposition analysis to understand the variations in the UK production and consumption carbon emissions during the period from 1994 to 2004 [43]. More recently, there are the contributions of Steen-Olsen et al. [44] and Ali (2017) [45] that used the MRIO model to assess three kind of environmental footprints for the EU member states. Arto, et al. (2012) [46] used a MRIO model to quantify the water demand for production and consumption and the water flows for 33 countries and the rest of the world.

3. Data and methodology used in the analysis

3.1. Data

The recently constructed World Input-Output Database (WIOD) [47] represents the main data source of this analysis. WIOD is indeed, considered the first database providing a detailed annual time series on national input-output tables and international trade and satellite