Science of the Total Environment xxx (2016) xxx–xxx

Contents lists available at ScienceDirect

Science of the Total Environment

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

Mediterranean countries' food consumption and sourcing patterns: An Ecological Footprint viewpoint

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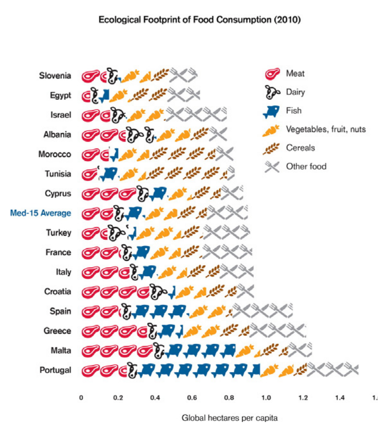
HIGHLIGHTS

- Ecological Footprint accounting is applied to Mediterranean countries' food sector.
- Food consumption and sourcing profiles for Mediterranean countries are investigated.
- Dietary patters are among the key drivers of the region's ecological deficit.
- France is the sole biocapacity self-sufficient country in terms of food provision.
- Calorie-adequate diets and changes in dietary patterns could reduce the Footprint.

GRAPHICAL ABSTRACT



ARTICLE INFO

Article history:
Received 12 September 2016
Received in revised form 24 October 2016
Accepted 25 October 2016
Available online xxxx

Editor: D. Barcelo

Keywords:
Mediterranean diet
Footprint
Food security
Food trade
Food consumption

ABSTRACT

Securing food for growing populations while minimizing environmental externalities is becoming a key topic in the current sustainability debate. This is particularly true in the Mediterranean region, which is characterized by scarce natural resources and increasing climate-related impacts.

This paper focuses on the pressure Mediterranean people place on the Earth ecosystems because of their food consumption and sourcing patterns and then explores ways in which such pressure can be reduced. To do so, it uses an Ecological-Footprint-Extended Multi-Regional Input-Output (EF-MRIO) approach applied to 15 Mediterranean countries. Results indicate that food consumption is a substantial driver of the region's ecological deficit, whereby demand for renewable resources and ecosystems services outpaces the capacity of its ecosystems to provide them. Portugal, Malta and Greece are found to have the highest per capita food Footprints (1.50, 1.25 and 1.22 global hectares (gha), respectively), while Slovenia, Egypt and Israel have the lowest (0.63, 0.64 and 0.79 gha, respectively). With the exception of France, all Mediterranean countries rely on the biocapacity of foreign countries to satisfy their residents' demand for food.

By analyzing the effect of shifting to a calorie-adequate diet or changing dietary patterns, we finally point out that the region's Ecological Footprint – and therefore its ecological deficit – could be reduced by 8% to 10%.

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http://dx.doi.org/10.1016/j.scitotenv.2016.10.191

1. Introduction

Humanity is facing deeply interlinked economic, social and environmental crises that stem, in large part, from current unsustainable patterns of consumption and production (Clay, 2011). Humanity is now consuming more resources than ever, both per person and in absolute terms (e.g., Galli et al., 2014; Steffen et al., 2015). Therefore, for achieving global sustainable development, fundamental changes in the way societies consume and produce are indispensable (UNEP, 2012a, 2012b).

By 2050 the world's population will reach 9.7 billion, 32% higher than today (UN-DESA, 2015). Urbanization will continue at an accelerated pace, and about 66% of the world's population will be urban (compared to 54% today) (UN-DESA, 2014). To feed this larger, urbanized and richer population, Alexandratos and Bruinsma (2012) projected that a 60% increase in agricultural production is needed to provide an adequate food supply from 2006 to 2050. According to Davis et al. (2016), the environmental burden from the food sector will likely grow in this same period, despite societal improvements in agricultural production efficiencies.

The provision of food is one of the vital services that nature provides to humanity (Fischler, 1988; Nordström et al., 2013). Nonetheless, the exploitation of nature to meet humanity's demand for food is among the major causes of environmental degradation (Foley et al., 2011; Gephart et al., 2016; Pinstrup-Andersen and Pandya-Lorch, 1998). The food we choose, its production and distribution chains, and the way in which we eat have multifaceted effects on our environment, society and economy (DeFries et al., 2004; Foley et al., 2005; Vitousek et al., 1997). This places food at the heart of the sustainability debate (Ehrlich et al., 1993). Moreover, the way in which humans acquire food, through agriculture and food systems, is one of the largest contributors to biodiversity loss, greenhouse gas emissions, and agrochemical pollution of ecosystems (MEA, 2005; IPCC, 2013; IAASTD, 2009).

Environmental degradation in the Mediterranean has reached a level that requires immediate action (UNEP, 2010). With urbanization and rising incomes, typical dietary patterns are shifting towards consumption patterns based on animal products, requiring more water, land and energy (Pimentel and Pimentel, 2003; Gerbens-Leenes and Nonhebel, 2005; Lundqvist et al., 2008) and increasing greenhouse gas emissions (Carlsson-Kanyama and Gonzalez, 2009). A growing body of research is showing that changes in our food production and distribution systems and in our dietary choices can however achieve substantial reductions in food-related GHG emissions (Marlow et al., 2009; Garnett, 2011; Macdiarmid et al., 2012; Vieux et al., 2012).

The aims of this paper are thus to: i) provide a benchmark assessment of the pressure Mediterranean residents place on ecosystems within and outside their region due to their current food production, trade and final consumption patterns; and ii) identify changes in dietary choices that could lower such pressure and ease access to food resources – through both domestic production and trade – in the long run.

2. Methodology and data sources

Three main datasets and their associated methodologies are used in this analysis:

- Food supply data from FAO Food Balance Sheets (FAO, 2015a);
- Ecological Footprint data drawn from Global Footprint Network's National Footprint Accounts (NFAs) 2014 Edition, covering nearly 160 countries, for the year 2010 (GFN, 2014);
- Version 8 of the Global Trade Analysis Project (GTAP) Multi-Regional Input-Output (MRIO) model, which consists of 57 sectors – 12 of which are agricultural – and refers to 129 countries and regions for the year 2007 (GTAP, 2014; Narayanan et al., 2012).

2.1. Food supply

Countries' food supply data is used here to assess the quantity of each food commodity available for utilization within a given country during the course of a year. This data is drawn from the FAOSTAT database (FAO, 2015a) and refers to the supply concept defined by FAO and used in compiling national food balance sheets (FAO, 2001):

$$S_{d,u} = P_i + I_i - E_i + CS_i \quad (3)$$

where $S_{d,u}$ is the total food supply for domestic utilization, P_i is the amount of each food product i domestically produced,[1] I_i and E_i are the amount of each food product i imported and exported, respectively, and CS_i is the annual change in stocks (decrease or increase) of each food product i considered in the FAO food balance sheet.

On the utilization side, a distinction should be made between the quantities exported, fed to livestock, used for seed, processed for food and non-food uses, lost during storage and transportation, and the quantities provided as food supplies available for human consumption at the retail level. Distinction between food supply available for human consumption and real food consumption is not easily computed by the FAO food balance sheets and food consumption surveys would likely provide a more complete picture (FAO, 2001). We assume, however, that food supply data from the FAO food balance sheets provide a good first approximation of countries' apparent food consumption.

Food supply data is expressed in terms of quantity (kg yr^{-1} or g day^{-1}) and, through the use of appropriate food composition factors for all primary and processed products, in terms of caloric value/energy (kcal day^{-1}). By dividing food supply data by population data, per capita figures expressed in kcal cap^{-1} day^{-1}, are obtained (FAO, 2001).

2.2. Ecological Footprint analysis

The Ecological Footprint (Wackernagel et al., 1999) is a biomass-based resource accounting tool tracking key resource provisioning and one critical regulating ecosystem service (i.e., climate stabilization through carbon sequestration) that humans consume (aggregated into a metric called *Ecological Footprint*) and comparing it with the biosphere's supply of such provisioning and regulating services (aggregated into a metric called *biocapacity*) (Galli et al., 2014). Both metrics are expressed in hectare-equivalent units, or global hectares (gha), which represent productivity-weighted hectares (Galli, 2015). Full details on the calculation of the two metrics as well as their limitations can be found in Borucke et al. (2013).

Adopting a consumer-based approach, a country's Ecological Footprint is calculated by tracking the ecological assets (i.e. crop-, grazing-, forest-, fish-, built-up and carbon-uptake land) appropriated by national production activities and then adding the ecological assets embedded in imported goods and subtracting those embedded in exported goods (Galli et al., 2014). While country-level Ecological Footprint analyses are usually performed via a process-based approach relying on physical trade flows data (Borucke et al., 2013), the detailed tracking of countries' food consumption and sourcing profiles performed in this paper requires that the traditional Footprint method (Borucke et al., 2013; Wackernagel and Rees, 1996) be extended by means of the GTAP 8 Multi-Regional Input-Output (MRIO) model.

While a global model is used to run the analysis, results are provided for just 15 Mediterranean countries (Albania, Croatia, Cyprus, Egypt, France, Greece, Israel, Italy, Malta, Morocco, Portugal, Slovenia, Spain, Tunisia, and Turkey). The decision to focus on the Mediterranean region

[1] For primary commodities, production relates to the total domestic production whether inside or outside the agricultural sector (i.e. including non-commercial production and production in kitchen gardens). Production is reported at the farm level for primary crops (i.e. excluding pre-harvest and harvesting losses for crops) and livestock items and in terms of live weight for primary fish items. Production of processed commodities relates to the total output of the commodity at the manufacture level.