

**FOOD ENVIRONMENTAL SUSTAINABILITY IN BOSNIA, ITALY AND SERBIA:
WATER, ECOLOGICAL AND CARBON FOOTPRINTS**

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Abstract

Fundamental changes in food consumption and production patterns are indispensable for achieving sustainable development. The paper aims at analysing food production and consumption environmental sustainability in Bosnia, Italy and Serbia by comparing the water, ecological and carbon footprints. The paper is mainly based on secondary data from different sources: FAOSTAT; Water Footprint Network; Global Footprint Network; etc. FAO food balance sheets data were used to characterise the food consumption patterns in Bosnia, Italy and Serbia. The water footprint of food consumption in each country was calculated using water footprints per commodity. All the three countries have an ecological deficit. Carbon footprint is higher in Italy than in Serbia and Bosnia (1.17 gha/capita/yr). Water saving in Italy is higher than in Bosnia (1,890 Mm³/year) and Serbia. Total food supply in Italy is much higher than in Bosnia (3082 kcal/capita/day) and Serbia. The share of plant-based energy in the diet is higher in Bosnia (84.7%) with respect to Italy and Serbia. Water footprints of food supply are similar in Bosnia (1849.70 Mm³/capita/year) and Italy but lower than in Serbia. Water footprint of a Bosnian citizen is 0.08% higher than an Italian one and 22.86% lower than that of a Serbian. The highest water footprint is the green one. Meat and dairy products represent more than a half of the water footprint. Adoption of more sustainable food consumption and production patterns can bring about not only significant human health benefits but also reduce the food consumption environmental footprints on natural resources especially water.

Key words: *Food; footprint; Bosnia; Italy; Serbia.*

Introduction

The participants to the United Nations Conference on Sustainable Development (Rio+20) recognized that fundamental changes in the way societies consume and produce are indispensable for achieving global sustainable development. Therefore, they recalled the commitments made in the Rio Declaration on Environment and Development, Agenda 21 and the Johannesburg Plan of Implementation and adopted the 10-year framework of programmes on sustainable consumption and production (United Nations, 2012).

There is growing evidence on the impact of diet on health, including increased risk of obesity, cardiovascular diseases and cancers, and also of its role as a social indicator (Reddy *et al.*, 2009). However, sustainability of food systems and consumption patterns is about more than health concerns as it regards also environmental impacts. Agriculture is the largest single

source of greenhouse gas emissions in the food chain (Carlsson-Kanyama, 1998). Diets are a significant factor in a number of critical sustainability issues such as climate change; public health; social inequality; biodiversity; energy, land and water use; etc. (Reddy *et al.*, 2009).

Many studies provided a strong evidence for a beneficial effect of higher conformity with the Mediterranean dietary pattern on risk of death from all causes, including cardiovascular diseases and cancers (Giugliano and Esposito, 2008). In the Mediterranean region, there have been unprecedented changes in lifestyles and food consumption patterns during the past few decades. Diet change is the result of the dual phenomenon of the spread of the English-speaking countries dietary model and of globalization (Padilla, 2008). The adhesion to the Mediterranean Diet (MD) by getting the food proportions and composition defined in the new Mediterranean Diet pyramid can not only influence human health but also the environment (Sáez Almendros *et al.*, 2012).

The paper aims at analysing food environmental sustainability in Bosnia, Italy and Serbia by comparing the water, ecological and carbon footprints.

Material and methods

The paper is mainly based on secondary data from different sources: FAOSTAT Food Balance Sheets; Water Footprint Network; Global Footprint Network; etc. The current Bosnian, Italian and Serbian food consumption patterns were characterised using data from the FAO food balance sheets 2006 (FAOSTAT, 2010). In this paper, three environmental footprints have been taken into consideration *i.e.* Ecological Footprint (EF), Carbon Footprint (CF) and Water Footprint (WF).

The EF on a national scale was fully explained by Ewing *et al.* (2010, 2010b). The EF measures appropriated biocapacity, expressed in global average bioproductive hectares, across six major land use types (*i.e.* cropland, grazing land, fishing grounds, forest land, carbon footprint, and built-up land). The EF methodology uses a consumer-based approach; for each land use type. The EF of consumption (EFC) is thus calculated as: $EFC = EFP + EFI - EFE$; where: *EFP* is the EF of production; *EFI* and *EFE* are the ecological footprints embodied in imported and exported commodity flows, respectively. Biocapacity refers to the capacity of ecosystems to produce useful biological materials and to absorb waste materials generated by humans (GFN, 2011).

The CF is a measure of the exclusive total amount of CO₂ emission that's directly and indirectly caused by an activity or is accumulated over the life stages of a product (Wiedmann and Minx, 2008). The carbon Footprint is calculated as the amount of forest land required to absorb given carbon emissions (Ewing *et al.*, 2010).

The WF is the demand of freshwater resources required to produce goods and services and it represents a measure of human's appropriation of freshwater resources measured in terms of water volumes consumed (evaporated or incorporated into a product) or polluted per unit of time (Mekonnen and Hoekstra, 2011). The water footprint concept is closely linked to the virtual water concept (Hoekstra and Chapagain, 2007). The water footprint includes the use of blue water (ground and surface water), green water (rain water or moisture stored in soil strata), and grey water (pollution) (Hoekstra *et al.*, 2011). Water footprint of food consumption in each country was calculated using average water footprint per ton of commodity per country, weighted based on origin (Mekonnen and Hoekstra, 2011).

Results and discussion

Ecological and carbon footprints and biocapacity in Bosnia, Italy and Serbia

Italy has a higher EF of consumption compared to Bosnia and Serbia. Concerning the EF of production, Italy has the highest value compared to Bosnia and Serbia. Bosnia presents the highest biocapacity per capita (1.6 gh/capita) among the three countries (Ewing *et al.*, 2010).

Net importing countries import more biocapacity than they export and have an ecological footprint of consumption greater than their ecological footprint of production (*e.g.* Italy). The opposite is true for net exporting countries (*e.g.* Serbia). All the three countries have an ecological deficit – as the ecological footprint of consumption is higher than the total national biocapacity: Italy (3.8 gh/capita), Bosnia (1.1 gh/capita) and Serbia (1.2 gh/capita). The highest carbon footprint was recorded in Italy (2.66 gha/capita/yr), followed by Serbia (1.27 gha/capita/yr) then Bosnia (1.17 gha/capita/yr). In Serbia and Italy, the carbon footprint is alone higher than the total national biocapacity (Tab. 1).

Tab. 1. Ecological footprint and biocapacity, 2007 (Source: Ewing *et al.*, 2010).

		World	Bosnia	Italy	Serbia	Europe
		2.70	2.7	4.99	2.4	4.68
Ecological Footprint (global hectares per capita)	Ecological Footprint of Consumption					
	Carbon Footprint	1.44	1.17	2.66	1.27	2.54
		2.70	2.47	3.08	2.44	4.31
	Ecological Footprint of Production					
	Total Biocapacity	1.78	1.6	1.14	1.2	2.89
	Ecological Deficit	0.9	1.1	3.8	1.2	1.8

Water footprint of national production and consumption in Bosnia, Italy and Serbia

According to Mekonnen & Hoekstra (2011), the global water footprint was 9087 Gm³/yr (74% green, 11% blue and 15% grey) in the period 1996-2005 and agricultural production contributes 92% to this total footprint. Moreover, the water footprint of the global average consumer was 1385 m³/yr in the period 1996-2005. Serbia is the country with the largest water footprint of consumption (2390 m³/yr) compared to Bosnia (1256 m³/yr) and Italy (2303 m³/yr). The differences can be partially explained by differences in consumption pattern and by water consumption and pollution per unit of product per country. The share of water footprint of agricultural products consumption in the total water footprint of national consumption is 94.9% Bosnia, 89.4% in Italy and 61.85 in Serbia. Regarding production side, Italy is the country with the largest total water footprint of production (70392.1 Mm³/yr) followed by Serbia (28898.8 Mm³/yr) then Bosnia (3057.9 Mm³/yr). In all countries, the water footprint related to agricultural production (crop production, grazing, and animal water supply) takes the largest share in the total water footprint within the country: 99% in Bosnia, 85.4% in Italy, and 58.6% in Serbia.

The total volume of international virtual water flows related to trade in agricultural and industrial products was 2320 Gm³ yr⁻¹ (68% green, 13% blue, 19% grey) of which 76% is related to crop products trade (animal products trade contributes 12%). Italy presents a water saving of 62,157 Mm³/year which is higher than Bosnia (1,890 Mm³/year), while Serbia presents a negative virtual water balance (-1,779 Mm³/year), which means that it has a net virtual water export.

Economic efficiency of land and water use

Natural resources use economic efficiency changes from a country to another as well as depending on the footprint that is used in calculation so the considered resource (i.e. Land, water). Economic efficiency of land use - EF/GDP - is the highest in Italy followed by Serbia then Bosnia. That means that a higher surface of land is needed in Bosnia in order to generate one million of national income than in Serbia and Italy. The situation is different regarding water. In fact, in this case the highest water use economic efficiency - WF/GDP - is recorded again in Italy, but followed by Bosnia then Serbia. It can be noticed that in both cases Italy does the best.

Characterisation of food consumption patterns in Bosnia, Italy and Serbia

FAOSTAT (2010) data show that dairy products are the most consumed food group in Italy and Serbia while vegetables are at the top of the list in Bosnia. Cereals represent the second most consumed food group in Italy; vegetables are ranked second in Serbia and dairy products in Bosnia. Meat consumption is much higher in Serbia (74.02 kg/capita/year) than in Bosnia (20.10 kg/capita/year). Total food supply in Italy (3649 2748 kcal/cap./day) is much higher than in Bosnia (3082 2748 kcal/cap./day) and Serbia (2748 kcal/cap./day). Moreover, the share of plant-based energy in the diet is higher in Bosnia (84.7%) with respect to Italy (74.2%) and Serbia (67.8%).

Water footprint of food supply in Bosnia, Italy and Serbia

Water footprint of food supply in Bosnia (1849.70 m³/cap./yr) is slightly higher than that recorded in Italy (1848.29 m³/cap./yr) but much lower than the total water footprint in Serbia (2397.78 m³/cap./yr). The analysis of the total water footprint of food supply in Bosnia, Italy and Serbia shows that the average water footprint of a Bosnian citizen is 0.08% higher than an Italian one and is 22.86% lower than that of a Serbian one (Fig. 1).

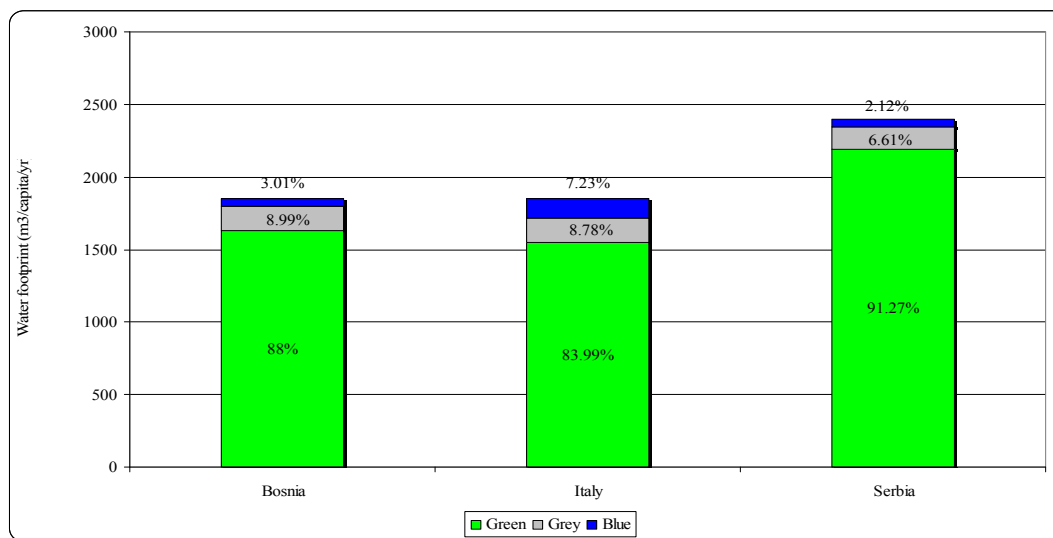


Fig. 1. Green, grey and blue water footprints of food supply in Bosnia, Italy and Serbia; 2006.

In all the three countries, the highest water footprint is the green one, followed by the grey then the blue one. That is also an indicator of the relevance of agricultural products since there is no green water footprint in the cases of industrial products and domestic water use. However, the shares of the three components of the water footprint change from a country to another. The grey component is the second highest in all the three countries. The highest share

of the blue water component in the water footprint is recorded in Italy; where water is used to irrigate Mediterranean crops (Fig. 1).

Meat contribution to the water footprint is the highest in all the three countries. In fact, in Italy, Bosnia as well as Serbia about a third of the water footprint is due to meat consumption. The contribution of vegetable oils to the water footprint is relevant in Italy but not in the case of Bosnia and Serbia. Dairy products are also another important contributor to water use. When considering both meat and dairy products, they represent in all the three countries more than a half of the total water footprint of food supply. The contribution of stimulants (*i.e.* coffee, cacao, tea) is particularly relevant in the case of Bosnia. The same thing is true for sugar and sweeteners in Serbia (Fig. 2).

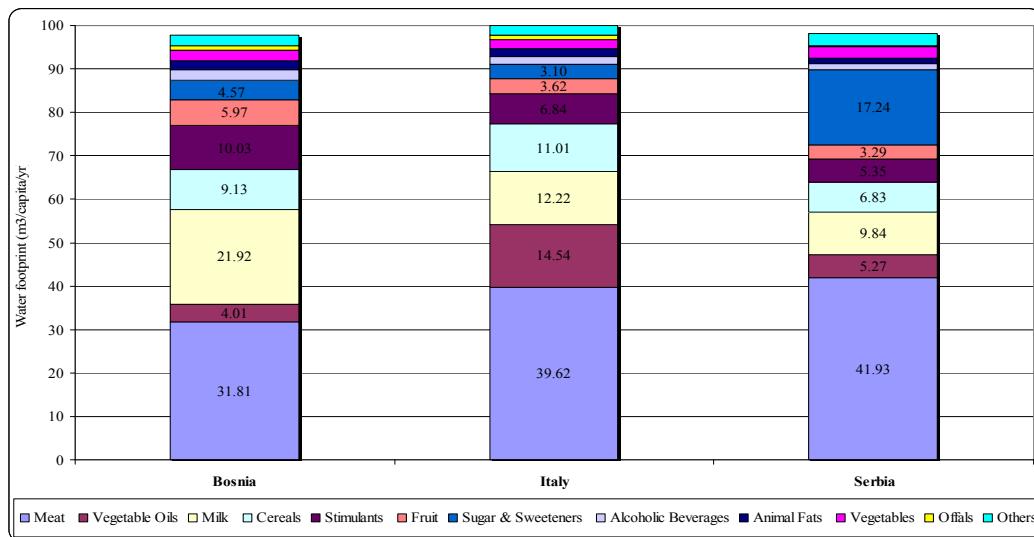


Fig. 2. Food product groups contribution to the total water footprint of food supply in Bosnia, Italy and Serbia; 2006.

The top ten contributor products to the total water footprint of food supply change from a country to another. In Bosnia, they are - in descending order: milk, wheat, bovine meat, maize, coffee, cocoa beans, poultry meat, potatoes, sunflowerseed oil, and offals.

Conclusions

Total food supply in Italy is higher than in Bosnia and Serbia. The share of plant-based energy in the diet is higher in Bosnia with respect to Italy and Serbia. Dairy products are the most consumed food group in Italy and Serbia while vegetables are mostly consumed in Bosnia. None of the three countries has an ecological reserve. In fact, there is an ecological deficit in all the analysed countries as the ecological footprint of consumption is higher than the biocapacity. The highest carbon footprint was recorded in Italy. Serbia is the country with the largest water footprint of consumption compared to Bosnia and Italy. In all countries, the water footprint related to agricultural production takes the largest share in the national total water footprint. Italy is the country with the largest total water footprint of production. Italy presents a water saving higher than Bosnia, while Serbia presents a negative virtual water balance. The average water footprint of a Bosnian citizen is 0.08% higher than that of an Italian one and 22.86% lower than that of a Serbian one. The green component is the most relevant one followed by the grey then the blue ones. Meat and dairy products represent in all the three countries more than a half of the total water footprint of food supply. The top contributors to the total water footprint of food supply in Bosnia are milk, wheat, bovine meat,

maize, coffee, cocoa beans, poultry meat, potatoes, sunflower seed oil, and offals. Adoption of more sustainable agro-food production systems and food consumption patterns in Bosnia, Italy, and especially, Serbia can reduce the food environmental footprints on the scarce natural resources especially water.

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