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Determinants of Carbon and Water Footprints of Food Consumption in an Italian Population

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INTRODUCTION

The environmental impacts of food consumption, specifically carbon footprint (CF) and water footprint (WF), are gaining increasing importance in the context of global sustainability and public health. As global food demand is expected to increase by 35% to 56% between 2010 and 2050 [1] substantial shifts in dietary habits are required to sustain a growing global population while aligning with the One Health approach [2], and the 2030 agenda for the accomplishment of Sustainable Development Goals (SDGs) established by the Food and Agriculture Organization (FAO) [3]. However, dietary choices are influenced by a complex interplay of factors, including socioeconomic status, cultural traditions, and individual preferences [4]. This study evaluates the contribution of different food groups to environmental footprints and examines how health determinants such as gender, age, BMI, geographic location, and adherence to the Mediterranean diet (MD) influence these impacts. The goal is to better understand how dietary habits affect environmental sustainability and to provide data-driven recommendations for policy development.

OBJECTIVES

To estimate the average daily CF and WF of the study sample, leveraging estimates from the SU-EATABLE LIFE (SEL) Database [5]. Furthermore, the study will identify the food groups with the highest and lowest environmental impact and explore how dietary impact varies based on gender, age, Body Mass Index (BMI), education level, geographic region, and adherence to the MD measured through the Mediterranean Adequacy Index (MAI).

METHODS

This cross-sectional study utilised data from 2,831 participants in the third INRAN-SCAI Survey, conducted across various regions of Italy in 2005-2006. We calculated the environmental footprints by multiplying the daily consumption of each food item (n = 878), classified using the European Food Safety Authority (EFSA) FoodEx2 system, by the footprint coefficients from the SEL database. For items without direct matches (e.g., canned beer), we assigned median values from related food commodity subcategories as proxy conversion factors. We excluded approximately 35% of items lacking reliable conversion data, leaving 617 food items with assigned footprint values. In addition to dietary data, we considered sociodemographic and anthropometric variables including age, sex, BMI, education level, and geographical area of residence. We evaluated adherence to the MD using the MAI score [6,7]. We excluded foods incompatible with the MAI framework (e.g., alcoholic beverages other than wine, mixed processed dishes, coffee), representing less than 7% of total energy intake in the population. We performed the comparisons of CF and WF across sociodemographic variables using two-sided t-tests and one-way analysis of variance (ANOVA) to examine differences by sex, BMI, geographical area of residence, and education level. We used multiple linear regression models to investigate associations between environmental impact indicators and individual characteristics, with CF and WF as the dependent variables in separate models. Independent variables included age, sex, BMI, educational level, geographical area, total energy intake, MAI score, and energy density of food consumed (kcal/kg).

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RESULTS

The average CF was 3.53 kg CO_2eq/day, and the average WF was 3,330.96 L/day. The mean daily CO_2 emissions per kcal consumed were 1.88 g CO_2eq (SD = 0.05), while the average WF per kcal was 177.12 L (SD = 34.87). Red meats (1.08 kg CO_2eq; 657.24 L) and dairy products (0.28 kg CO_2eq; 708.62 L), were the largest contributors to CF and WF. Overall, meat accounted for 68.7% of the total CF and 27.5% of the total WF, and dairy products, contributing 20.0% to CF and 21.3% to WF. Moreover, subjects with the highest adherence to MD (above the population mean) showed reduced CF (9.84 vs. 11.01 kg CO_2eq) and WF (9,356.0 vs. 10,348.3 L) compared to lower adherence. Males had higher environmental impacts (3.92 kg CO_2eq; 3,691 L) than females (3.21 kg CO_2eq; 3,037 L) ($p<0.001$), as well as younger individuals (3.76 kg CO_2eq; 3,491 L) versus older adults (3.12 kg CO_2eq; 2,948 L) ($p<0.001$). In multiple linear analysis, beyond sex, age, education and geographic area of residence, subjects with higher adherence to the MD were linked to a lower environmental impact both in term of CF (β = -0.239) and WF (β = -206.4), independently on kcal intake.

CONCLUSIONS

Animal-based foods, particularly red meat and dairy products are the primary drivers of the environmental impact of diets in Italy. Health determinants, including gender, age, and adherence to the MD, significantly influence individuals' environmental footprints. Specifically, males and younger individuals exhibit higher environmental impacts, whereas stronger adherence to the MD is associated with lower environmental burdens. Transitioning towards more plant-based, sustainable dietary patterns is crucial not only for reducing the environmental burden of diets but also for addressing pressing global challenges such as climate change and water scarcity. These findings further highlight the complexity of environmental impacts linked to dietary behaviours and emphasises the importance of considering multiple factors, including further socio-demographic and lifestyle variable. Dietary shifts, when combined with targeted policy intervention aimed at specific populations and strategic modifications in food systems, have the potential to promote more sustainable diets and address the urgent environmental challenges facing our planet.

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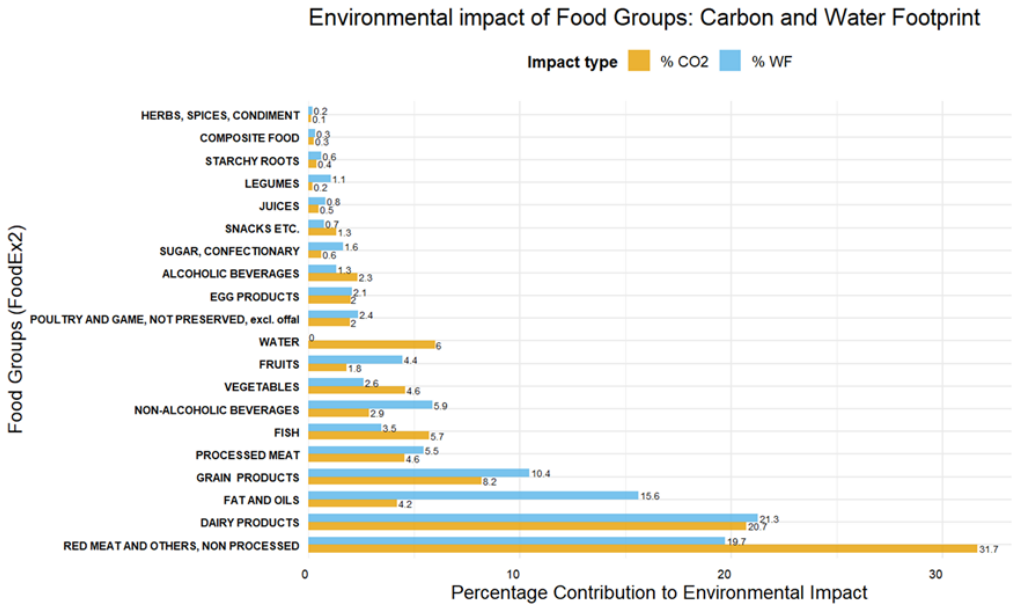

Figure 1. Contribution of food groups according to a modified FoodEx2 classification

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