EXECUTIVE SUMMARY

Summary of the methodology adopted in the report: *Il costo nascosto del consume di carne in Italia: impatti ambientali e sanitari.*

Authors: Alessandro Arrigoni (Demetra Onlus), Guido Scaccabarozzi (Demetra Onlus), Caterina Villa (Demetra Onlus), Francesca Allievi – critical reviewer (University of Turku), Giovanni Dotelli – critical reviewer (Politecnico di Milano).

The aim of the study is to estimate the potential environmental and health costs associated with meat consumption in Italy in one year. The reference year considered for the assessment is 2018.

To reach this goal, the potential environmental impacts are quantified through Life Cycle Assessment (LCA): a standardized methodology that analyses the environmental performance of a product/activity over its entire life cycle, from the extraction of raw materials to the final waste treatments (ISO, 2006a, 2006b). Health impacts are assessed through the number of years that are potentially lost (or gained) in Italy due to meat consumption. Once quantified, both the environmental and health impacts are translated into monetary value using the external costs proposed by the CE Delft research centre (Bruyn et al., 2018). The methodology adopted in the study is summarized in Figure 1.

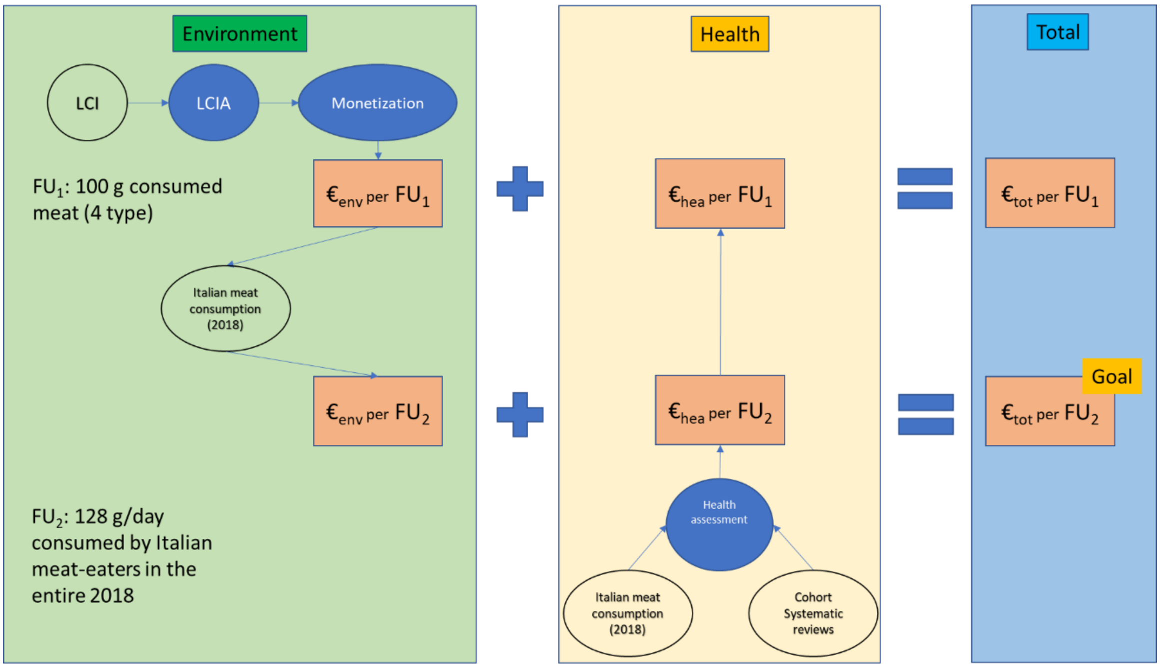

Figure 1. Schematic framework of the research. LCI: Life Cycle Inventory, LCIA: Life Cycle Impact Assessment, FU: Functional Unit.

The main outcomes of the research are: (i) the environmental, health, and total costs for 100 g of four different types of meat (i.e., beef, pork, poultry, and cured meat); (ii) the total environmental, health, and total costs due to meat consumption in Italy in 2018; and (iii) a preliminary comparison of the external costs arising from the consumption of 100 g of animal protein with the ones arising from a plant-based alternative.

Environmental Sphere

Two functional units (i.e., the reference to which inputs and outputs are normalized) are chosen for this study. First, the potential environmental impact of four different types of meat (i.e., beef, pork, poultry, and cured meat) are quantified and compared on a per 100 g basis (FU_1 in Figure 1). Then, a functional unit equal to a daily consumption of 128 g of meat by the total omnivorous Italian population for one year (2018) is used to evaluate the annual potential environmental impacts (FU_2 in Figure 1). The daily amount of 128 g corresponds to the average consumption of meat by the Italian meat-eaters, adding up the four types of meat considered in the study.

The life cycle of meat is investigated from the production of the materials and energy used in the farm through the final distribution of the packaged product and its consumption. Even though some differences exist in the life cycle of the four types of meat examined (e.g., farming activities, feed production), nine common macro unit processes (UPs) are identified: (i) energy production, (ii) feed production, (iii) farming activities, (iv) slaughtering, (v) processing, (vi) packaging, (vii) distribution, (viii) meat consumption and, finally, (ix) waste treatment. Each UP (e.g., feed production) is modelled considering different inputs (e.g., seeds, fertilizers, water), outputs (e.g., amount of feed produced, co-products), and emissions (e.g., N_2O linked to fertilization). To carry out this phase (i.e., life cycle inventory), secondary data from LCA databases (i.e., Agri-food 4.0 and Ecoinvent 3.6), scientific literature, public databases, and reports are used.

From the overall inflows and outflows, the potential impact on 14 different environmental categories is assessed via the ReCiPe impact assessment method (Huijbregts et al., 2017). The impact categories considered are:

- climate change,
- ozone depletion,
- terrestrial acidification,
- marine eutrophication,
- freshwater eutrophication,
- human toxicity,
- photochemical ozone formation,
- particulate matter formation,
- terrestrial eco-toxicity,
- marine eco-toxicity,
- freshwater eco-toxicity,
- ionising radiation,
- land use,
- water use.

The life cycle impact assessment (LCIA) phase allows to quantify the potential environmental impacts per FU on each category (e.g., the grams of equivalent CO_2 emitted per 100 g of beef meat consumed to assess the potential impact on climate change).

The LCIA results are then converted in monetary impact on the society using the environmental prices proposed by the CE Delft research centre (e.g., 0.056 $€_{2015}$ per kg CO_2eq), and the results for the different categories are aggregated to obtain a single score. This step is called monetization of impacts, and the costs calculated indicate the loss of welfare due to one additional kilogram of pollutant emitted to the environment. The conversion factors proposed by the CE Delft are used because: (i) they are developed from the same characterization model (ReCiPe) used for the impact assessment (Bruyn et al., 2018); and (ii) they were already used by the European Commission to estimate the external cost of transport (European Commission, 2019). A sensitivity analysis on the monetary values provided by CE Delft is performed to test the robustness of the results.

The same methodology is followed to quantify the potential environmental impact and cost of a plant-based protein source (i.e., soy and pea). In this case, to account for the food "function", the comparison with meat is performed not only on a mass basis, but also in terms of protein content (i.e., 100 g of protein).

Health Sphere

Based on systematic reviews of cohort studies (Bechthold et al., 2019; Schwingshackl et al., 2017), a correlation between meat consumption and the risk of contracting four diseases: colorectal cancer, type 2 diabetes mellitus, stroke, and coronary heart disease (Springmann et al., 2020, 2018). A causal relationship for these diseases is found only for the consumption of red and processed meat, whereas the disease association with poultry meat is not clear (Springmann et al., 2020). For this reason, poultry meat is not included in the health assessment.

The risk ratio of contracting the selected diseases by an average Italian omnivorous are estimated from: (i) the dose-response curves for the different diseases presented in the systematic reviews; and (ii) the daily intake of red and processed meat. Red and processed meat are considered as separate independent risk factor (Springmann et al., 2018).

Once the relative risk to contract a certain disease is assessed, the years of life lost (or gained) in Italy due to meat consumption are calculated. The total years lost in Italy for each disease, in terms of disability-adjusted life years (DALYs), are derived from the 2017 Global Burden of Disease study (Monasta et al., 2019). The DALYs indicates the sum of years of potential life lost due to premature mortality and the years of productive life lost due to disability.

Considering an Italian population (P) of 60,5 million people in 2018, divided between 56,2 million omnivorous (O) and 4,3 million non-meat eaters (V), the methodology adopted can be summarized with the following equations:

(i) $$R_{V_i} = \frac{DALY_{V_i}}{V}$$

Where R_{V_i} is the baseline risk factor for Italians to lose years of life (i.e., DALY) due to the disease i. In other words, it says the amount of DALY lost on average due to the disease i by the non-meat eaters. While the relative risk is usually calculated on the probability of contracting a certain disease, in this study the risk is associated to the probability of losing years of life due to the disease.

(ii) $$R_{O_{i,j}} = R_{V_i} \times \Delta R_{O_{i,j}}$$

Where j is the risk factor (i.e., the consumption of red or processed meat), and $R_{O_{i,j}}$ is the risk for the omnivorous population of losing DALYs due to the inclusion of the risk factor j in their diet. $\Delta R_{O_{i,j}}$ is the risk ratio of losing/gaining DALYs with respect to the baseline risk factor (i.e., R_{V_i}) due to the risk factor j. This value is extrapolated from the relative risk curves produced from cohort studies (Bechthold et al., 2019; Schwingshackl et al., 2018, 2017).

(iii) $$DALY_{O_{i,j}} = O \times (R_{O_{i,j}} - R_{V_i})$$

Equation iii is used to estimate the amount of DALYs lost by the omnivorous population due to the different risk factors j.

(iv) $$DALY_{P_i} = P \times R_{V_i} + \sum_j DALY_{O_{i,j}}$$

Equation iv verifies that the total amount of DALYs lost in Italy in 2018 due to the disease i (i.e., $DALY_{P_i}$) reported in the Global Burden of Disease study (Monasta et al., 2019) is equal to the sum of the baseline DALYs (i.e., $P \times R_{V_i}$) and the DALYs lost/gained due to the risk factors j.

To calculate the potential health costs for the Italian society due to meat consumption, the amount of DALYs lost/gained due to meat consumption are multiplied by the monetary cost of one DALY. The latter is considered equal to 55,000 €/DALY, and it represents the willingness-to-pay for an additional year of healthy life for an average European citizen (Bruyn et al., 2018).

A sensitivity analysis on the monetary value of one DALY and on the relative risk factors is performed.

Italian Meat Consumption

Meat consumption in Italy is estimated from the FAOSTAT database, which contains information on the annual amount of meat produced, imported in, and exported from the country ("FAOSTAT," n.d.). The amount in the database refers to the dressed carcass weight, excluding offal and slaughter fats. The apparent consumption is calculated adding up the Italian production and the imports, and subtracting the exports. Since FAOSTAT data include bones, cartilages, and other by-product, the edible consumption is estimated using the conversion factors of Springmann et al. (Springmann et al., 2020). Then, the actual amount of meat consumed by Italian omnivorous is calculated removing from the apparent meat figure the quantity of meat wasted during processing and packaging (5% of edible consumption in Europe), distribution (4% of packed meat), and during consumption (11% of distributed meat) (FAO, 2011),.

Since the FAOSTAT database does not include information on cured meat consumption, data were collected form the annual ASSICA report (L'industria delle Carni e dei Salumi (ASSICA), 2019). In the case of cured meat, the edible consumption is considered equal to the apparent one, and only waste during consumption is considered (11%). Data considered in the study do not include processed poultry meat, which is assumed to be entirely fresh, and frozen meat, due to the very low consumption (IIAS, 2019).

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