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Review Article

Environmental and Health Effects of Water and Carbon Footprint in Sustainable Nutrition

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Abstract

Nutrition is a multifaceted concept. It is important for both the environment and individuals. Carbon and water footprints are the methods used to evaluate the environmental outputs of nutrition and are directly related to the nutritional habits and consumption of individuals. The existing dietary habits in Turkey differ under the influence of many factors and are changing day by day. In this review, eating habits in Turkey will be evaluated in terms of sustainable and healthy nutrition and possible approaches will be mentioned.

Keywords: *Environmental and Health Effects; Water; Carbon Footprint; Sustainable Nutrition*

Introduction

While the concept of a healthy and environmentally sustainable diet is not new, there is renewed interest in it due to the growing concern about future global food security and climate change. Dietary intakes in the UK account for around 20 - 30% of total annual greenhouse gas emissions (GHGE), with the largest contributors coming from high consumption of meat and dairy products [1].

One study looked at the difference in greenhouse gas emissions between meat-eaters, fish-eaters, vegetarians and vegans in the UK. Experiment participants were selected from the EPIC-Oxford study, a validated food consumption frequency questionnaire was used in the evaluation and average greenhouse gas emissions were estimated for a standard 2000 calorie diet for all trial participants. When the daily greenhouse gas emissions in kilograms of carbon dioxide emissions are analyzed in the groups equalized by gender and age, it is seen that those who consume large amounts of meat have the highest average, respectively, those who consume large amounts of meat, those who consume moderate amounts of meat, those who consume low levels of meat, those who consume fish, vegetarians and vegans seen. It has been observed that the greenhouse gas emission levels of meat consumers are approximately twice that of vegans and it has been stated that reductions in meat consumption will reduce greenhouse gas emissions [2].

Accordingly, dietary recommendations to help mitigate climate change (i.e. reduce GHGE) are focused on reducing consumption of meat and dairy products. Looking at the targets, it is aimed to reduce the greenhouse gas levels in 1990 by 80% by 2050 with the change in food consumption patterns in the United Kingdom, while the national targets of the European Union are 20 - 30% compared to 1990 levels until 2020, and the United Kingdom until 2050. Similarly, there is a reduction of 70% to 80%. While it is stated that increasing the efficiency in the food supply chain may be effective in reaching the targets, it is stated that it is difficult to achieve the desired greenhouse gas emission in 2050 without a significant change in diet [3,4].

When we look at the food cultures, for example in the west, meat has an important place as a food group. In the last 10 years, while vegetable protein has remained stable, meat consumption has increased regularly. Looking at the world in general, it is predicted that the demand for animal products will increase significantly in the coming period and meat consumption will more than double between 1999 and 2050 [5]. Considering the general consumption of foods of animal origin, it is seen that the rates have increased from 15.4% to 17.7% in the last 5 years. When evaluated on the basis of consumers, it is seen that the increase is mostly caused by developing countries and economies, while the rate remains constant in developed countries [6].

When comparing diet models, it is stated that diet models with a high percentage of foods of animal origin, when compared to plant foods, may be associated with higher greenhouse gas emissions and agricultural land. Meat products contain high quality protein and essential micronutrients and can be a rich source of nutrients. However, it is also known that especially processed meats are effective in increasing the risk of some chronic diseases [7-11]. As a result of high consumption of vegetables, fruits and whole grains in diets, it is seen that the risk of developing chronic diseases such as cancer and cardiovascular diseases, which are the main causes of death in industrialized countries, is low. Although consumption of this type of food is higher in Southern European countries based on the fact that it is healthier, animal foods, animal products and animal fats are more common in Northern European countries [12].

In another study conducted in France, approximately 1 in 5 French adults followed a sustainable diet with high nutritional quality, resulting in a 20% reduction in greenhouse gas emissions at no extra cost. In line with the results of this study, it is stated that it is possible to both increase nutritional adequacy and reduce greenhouse gas emissions with smarter nutritional options such as a decrease in meat and alcohol intake, an increase in the consumption of plant-based foods, and moderate food intake. Despite all this, the relationship between a healthy diet and low greenhouse gas emissions is not clear [13].

While recent research has shown that it is possible to achieve a viable diet that meets dietary requirements for health and has a lower GHGE, it should not be assumed that a healthy diet will always have a lower GHGE. With different food combinations, it is also possible to consume a diet that meets dietary requirements for health but contains high greenhouse gases [1].

In a study, the health effects of the sustainable nutrition approach were evaluated on the basis of Western diets and attention was drawn to the decrease in mortality rates and mortality risks. The reduction in consumption of red meat and processed meats, an increase in the consumption of vegetables and fruits, and less energy intake with a sustainable diet are associated with the positive effects of these diets on health. However, it is also a fact that sugar has a low environmental impact per energy compared to other foods, or that fruits and vegetables can cause higher greenhouse gas emissions per energy than dairy and non-ruminant meats. In addition to all these, it is not possible to completely remove foods of animal origin from the diet in many cultures; Adequate consumption of meat and dairy products as sources of high-quality protein and micronutrients is important for public health [12].

Understanding what constitutes a sustainable diet is important in this direction, and research shows that understanding sustainable diets is poor and there are many diets [1].

Purpose of the Study

In line with all this information, the purpose of this review is the aim is to evaluate the current situation in Turkey in terms of the effects of nutrition on the environment and health and achievable targets.

Greenhouse gas emission (GHGE) forecasts with life cycle approaches (LCA)

There are various gases in the atmosphere. The rays from the sun pass through the atmosphere and warm the earth, and the existing gases in the atmosphere keep some of the heat on the earth and prevent heat loss. The greenhouse effect is defined as the insulating effect with the atmosphere retaining heat. Climate change, on the other hand, occurs as a result of the release of greenhouse gases, which cause global warming, to the atmosphere.

Under the Kyoto protocol, carbon dioxide (CO_2), methane (CH_4), dinitrogen monoxide (N2O), and refrigerant gases (hydrofluorocarbons, perfluorocarbons and sulfur hexafluoride) are defined as greenhouse gases. These gases are known as carbon dioxide (CO_2) equivalents and their effects on global warming differ from each other. While methane (CH_4) is about 25, dinitrogen monoxide (N_2O) is 296, refrigerants are thousands of times more effective than CO_2 [1].

While some of the gases occur naturally, the biggest factor causing the increase in the release of these gases has recently been shown as human activities [14].

Agriculture contributes to land degradation and anthropogenic greenhouse gas emissions. It is thought that about 30% of global greenhouse gas emissions are caused by agriculture and related differences in land use. Looking at Europe and the United Kingdom in this context; In the UK, where food systems account for about 19% of greenhouse gas emissions, it is estimated that the impact of land use can reach up to 30%. In Europe, where the food system constitutes the largest industrial sector, agricultural production and food consumption constitute approximately 20 - 30% of greenhouse gas emissions [3,15,16].

'Life Cycle Analysis' (LCA) is the most widely used method in calculating ecological impacts; According to the International Organization for Standardization (ISO) 14040:2006 and International Organization for Standardization (ISO) 14044:2006 international standards it is defined as 'compiling and evaluating the inputs, outputs and possible environmental impacts of a product system during its lifetime'. In this method, the effects of a whole or a certain stage of a product's life cycle on one or more ecological indicators can be estimated. Input-output analysis is another method used to estimate the ecological impact of products and services. With this method, the average ecological impact of a particular product group can be estimated. Nowadays, there are methods that use input-output analysis along with life cycle assessment.

Greenhouse gas emission estimations include greenhouse gas emissions that occur as a result of the production, transformation, distribution, use and additionally the end of life of foods [17,18]. In this context, looking at the entire life cycle of a product can help make a more accurate decision in terms of sustainability [19].

The potential environmental impacts and consumptions of a single food product have been evaluated before diets. There are many studies in the existing literature to measure the environmental impact of single food products with LC approaches. Red meat, dairy, seafood, rice, poultry, fruits and vegetables, grains and legumes are a few of the examples that use LC approaches in assessment [20]. Among these, studies on the potential environmental effects of meat and dairy products come to the fore and many international organizations and peer-reviewed articles emphasize emissions when compared to plant-based food products [20]. A large part of this is thought to be due to the agricultural phase of life cycle analysis (LCA) [19]. Reduction in meat consumption is seen as the main strategy to reduce global greenhouse gas emissions, as animal food production causes higher greenhouse gas emissions compared to plant food production [7].

In a study, when the use of land and water in food production and greenhouse gas emissions are compared, it is revealed that environmental impacts decrease in ruminant meat, other meats, dairy products and plants, respectively [21].

Table 1 shows the greenhouse gas effects of foods from different food groups produced in England [16]. When the food groups are examined, there are also differences in greenhouse gas emissions and land uses due to the different methods used. Since the environmental effect also depends on the productivity during production, the environmental effects of food groups vary according to the places where they are produced [22].

Low GHGE (< 1.0 kg CO_2e/kg renewable weight)	Medium GHGE (< 1.0 - 4.0 kg CO_2e/kg renewable weight)	High GHGE (> 4.0 kg CO_2e/kg renewable weight)
Potatoes	Chicken, milk, butter, yogurt, eggs	Beef
Pasta, noodles	Rice, breakfast cereal	Lamb
Bread	Sauces on bread	Pig
Oat	Nuts, seeds	Turkey
Vegetables (onions, peas, carrots)	Biscuits, cakes, sweets	Fish
Fruits (apple, pear)	Fruits (strawberry, banana, melon)	Cheese
Citrus, plum, grape	Salad ingredients	
Beans, lentils	Vegetables (mushrooms, green beans, cauliflower, broccoli, zucchini)	
confectionery, sugar		

Table 1: *Greenhouse gas effects of foods from different food groups produced in the UK*
GHGE: Greenhouse Gas Emissions, CO_2e: Carbon Dioxide Equivalent.

The contribution of different food groups to total greenhouse gas emissions is expressed as a percentage of all food groups combined.

As can be seen in table 2, while meat and dairy products cause the highest greenhouse gas emissions, there are also variations between countries due to differences in productivity [22].

Food Products Group	Holland (%)	Sweden (%)	Great Britain (%)
Meat, meat products and fish	28	35	38
Bread, biscuits, cake, flour	23	15	15
Bread, biscuits, cake, flour	13	10	5
Potatoes, fruits and vegetables	15	19	6
Oils and fats	3	4	10
Beverages and sweetened products	15	*	20
Other nutrients	3	17	3

Table 2: *Greenhouse gas effects according to the places where food product groups are produced.*
**Written in other foods category.*

In addition to the environmental burden of agriculture and food production processes, food consumption and nutritional preferences have been evaluated in relation to their environmental impacts since the mid-1980s. Gussow and Clancy (1986) first drew attention to the importance of investigating the use of natural resources in food consumption, suggesting that nutrition education should not only include information about human health, but also agricultural practices, environmental science and economics. Next, Gussow [23] proposed to evaluate and compare different dietary patterns around the world according to their effectiveness in soil, water and energy use. Studies evaluating the relationship between food consumption and the environment started to take place in Europe for the first time in the literature. With the Environmental Impacts of Products (EIPRO) research initiated by the Joint Research Center (JRC) Institute for Advanced Technical Research (IPTS) in 2004, it has been determined that food is one of the main causes of environmental impacts from consumption in Europe [24]. Subsequently, in a study published in 2009 aiming to measure the environmental impacts associated with food consumption and common dietary habits in EU-27 countries [25]. In the EU, food and beverage consumption has been determined to account for 22 - 31% of total GHG emissions from general consumption [25,26]. In the EU, food and beverage consumption accounts for 22-31% of total GHG emissions from total consumption [25,26], revealing that: Consumer preferences for what to eat and drink have a significant impact on the amount of greenhouse gas emissions. Outside of Europe, there are some outstanding studies evaluating the relationship between food consumption and the environment conducted in Australia [27-29], Canada [30], China [31-33], India [34], New Zealand [35] and Qatar [36]. However, there is a lack of research on the environmental effects of food consumption (average diet) in Turkey [20].

Water footprint assessment of food consumption

There are many studies used to calculate the agricultural demand for water. Water Footprint Assessment, the methodology developed by the Water Footprint Network (WFN), is one of the methods of quantifying water use. The concept of water footprint (WF) was first proposed by Hoekstra in 2002 to calculate water use throughout the supply chain of products and processes [37]. Since then, WF has been used as an indicator for freshwater use of products or services [38]. WF of production and WF of consumption are handled differently

when calculating water use of products and services. The first is the total amount of direct and indirect water use from regional water resources. The second includes the total amount of direct and indirect water use of both regional and foreign water resources [39]. WF of consumption is calculated by adding WF of production and imports of virtual water; When the total amount of water used in foreign waters and virtual water exports are subtracted; the total amount of water used by foreign consumers [38].

According to Hoekstra (2011), water consumption is calculated as the sum of water demand and pollution [38]. In this sense, WFA allows the researcher to evaluate water use in terms of three main components: green, blue and grey water. Green water use is the amount of water supplied to plants by precipitation and stored in the unsaturated part of the soil until it evaporates or evaporates through plants [39,40]. Blue water use is the amount of water used from freshwater sources. Irrigated farmlands use both blue and green water, while rain fed farmlands use only green water sources. Gray water use is the total amount of water polluted as a result of production or consumption [38].

The concept of WF is widely used in the literature to measure the magnitude of agricultural water use [39]. The global WF of anthropogenic activities between 1996 and 2005 was calculated by Hoekstra and Mekonnen [41] as 9087 Gm^3/year. In addition, he calculated the total WF of agricultural production as 92% of the total WF, which was determined to be equal to the sum of water use in crop production, pasture and animal production.

The studies on the accounting of water use, consumption and pollution associated with dietary consumption are more recent in comparison with GHG emissions. Firstly, Hoekstra and Hung (2002) calculated the consumptive water use (green and blue WF) of main crops according to the geographical area they were produced [42]. Following that, Hoekstra and others [38] developed a guide to standardize the WF assessment.

Green, blue and grey WFs of many crops and livestock products were calculated based on published guidelines [43,44]. Given global estimates of water consumption of food products, animal food products are more water-intensive than plant-based ones [45].

A study conducted in a Tunisian population showed the variation in WFP of different food product groups between 1980 and 2010. The divisions of the pyramids are proportional to the per capita consumption of the studied groups of food products. While the rate of grain consumption in Tunisia's general food consumption decreased, there was an increase in the rate of vegetables, fruits, dairy products and meat. Consumers' diets have become more diverse, but at the same time higher WFP (1586 m^3/person/year) values have been set, mainly due to the increase in meat consumption [46].

There is a difference in water consumption among animal food products, particularly due to the farming system and the region where the farming takes place (Table 3).

Animal Products	Water Required (liters/kg)*	Water Footprint (m^3/ton)*
Chicken Meat	3500	4325
Pig	6000	5988
Beef	43000	15415
Sheep	51000	10412
*m^3/ton= 1/kg		

Table 3: *Amount of water needed to produce 1 kg of animal-oriented food product (Tabularized from [43,45]).*

The WFs calculated were used in numerous diet-related water use studies. New methodologies to quantify the water use were established. Water use in LCA (WULCA) developed by the United Nations Environment Programme (UNEP)/Society of Environmental Toxicology and Chemistry (SETAC) Life Cycle Initiative is, in general terms, a framework to quantify and assess the use of freshwater resources with an LCA methodology [47].

In order to reduce the water footprint of food consumption, it is necessary to embrace the concept of ecological consumption, balance the diet structure, and consciously control the consumption of food, meat and other water-intensive products. The concept of ecological consumption focuses on ecological needs based on the ecological environment, limits consumption to the self-carrying capacity and purification capacity of the ecological environment, and aims to diversify the coordinated development, harmonious coexistence between man and nature, that is, moderate consumption, green consumption and low carbon consumption. Ecological consumption requires not only ecological consumption motivation, but also ecological consumption processes and outcomes [48,49]. Individuals are direct participants in consumption. They should develop awareness of ecological and environmental responsibility, actively change consumption concepts and advocate green and low carbon consumption.

On the other hand, a big problem related to food consumption is food waste. A large amount of food is lost or wasted in the production and consumption process [50]. One study found that in 2010, China lost or wasted about 19% of its grain, equivalent to wasting 135 billion m^3 of water footprint. Consumer waste accounts for the largest portion of total food waste [51]. Therefore, in order to reduce the water footprint, we need to pay attention to reducing food waste.

In the same study, it was determined that if the inhabitants of China could reduce food waste by an average of one tablespoon (about 5 grams) per day, China would not lose 2.6 million tons of grain and save a water footprint of 1.79 billion m3 every year [50].

Turkey nutrition habits, health and environmental impacts

Turkey is located in both Europe and Asia with the Mediterranean Sea to the south, so it has Mediterranean dietary influences on the coastal side and European and Asian influences in other parts of the country [52]. The Turkish diet consists of three meals a day and is mainly based on wheat products such as bread, but also includes rice, corn, legumes and meat. Fats in the diet include olive oil in some regions, sunflower oil or margarine instead of butter in the eastern region. Yogurt is the main dairy product consumed. Vegetables and fruits are part of the daily intake in Turkish diets and although lamb and beef are included in Turkish cuisine, their intake has decreased due to rising prices. Desserts such as Turkish delight and baklava also occupy an important place in Turkish cuisine [53]. In addition to traditional Turkish cuisine, fast food consumption has increased in the last 30 years. While the younger generation of Turks generally prefer American-style fast food chains, the older generation prefers Turkish-style fast food (such as doner kebab) [54]. Fast food consumption was also found to be associated with household characteristics (size, number of children, employment of spouse, socioeconomic level). Other factors, such as price, health habits, and household characteristics, also have an impact on the type of food typically consumed.

Turkish people's eating habits vary spatially, temporally and socio-economically [55]. Again, it is true to say that the basic food of the Turkish people comes from cereals and cereals. According to statistics provided by the Ministry of Health (MoH), 44% of daily calorie intake in Turkey comes from bread. When looking at other cereals and cereals, the rate rises to 58% [55].

According to the 2017 data of the Turkey Nutrition and Health Survey, the average and standard deviation values of the daily food intake of all individuals aged 15 and over are given in table 4 [56].

Foods	Total (≥15) (n:12453)		
	x̄	SD	%95GA
Milk and milk products	118.2	146.91	184.5-191.9
Meat, Eggs, Legumes and Oilseeds	144.7	105.62	142.1-147.3
Bread and Cereals	272.3	146.64	268.8-275.9
Fresh Vegetables	256.2	166.54	252.4-260.1
Fresh Fruits	158.8	192.18	154.3-163.4
Dried Fruits	2.6	10.79	2.4-2.9

Table 4: *The arithmetic mean (x̄), standard deviation (SD) and 95%CI (Confidence interval) values of daily food intake of all individuals aged 15 and over.*

While consumption of food of animal origin is at the center of dietary patterns in developed countries, according to the Food and Agriculture Organization of the United Nations (FAO) [57], the consumption of grains and cereal products is ranked as the most consumed food groups in Turkey. In addition, red meat is consumed in Turkey as the main animal protein source, primarily lamb and beef. According to the Agricultural Economy and Policy Development Institute of the Ministry of Agriculture and Forestry (TEPGE) (2020), per capita consumption of red meat in Turkey is lower than in developed countries. However, when red meat consumption is evaluated in the last five years, it has been determined that annual consumption per capita has increased [58]. In addition, in terms of fruit consumption, although Turkey is one of the world's leading fruit producers, Turkish consumers do not eat enough compared to developed countries [59].

The first food-based nutrition guidelines were published in Turkey in 2004. The latest dietary guidelines, Turkey Dietary Guidelines (TDG) were published in 2016 [60] by the Ministry of Health (SB). The guidelines classify foods under 5 main food groups [60] as shown in table 5.

Food Group	Recommended Consumption [170] (for an average healthy adult)	1 portion equivalence in measurement unit	Notes
Milk and Dairy (including yogurt, ayran and cheese)	3 portion/day	-240 ml milk -200 - 240 ml yogurt -40 - 60 gr cheese	
Meat, poultry, fish, eggs, legumes, nuts, seeds	2,5 - 3 portion/day	-80 gr cooked meat/chicken -150 gr fish -130 gr legumes -30 gr nuts (hazelnut/walnut) -2 eggs	Fish ≥ 2 portion/week Eggs = 3-4 portions/week Legumes ≥ 2-3 portions/week Nuts and Seeds ≥ 1 portion/day
Fresh Vegetables and Fresh Fruits	3 - 4 portion/day 2 - 3 portion/day	150 gr cooked green leafy vegetables -(50 - 100 kcal)	- Fruits and Vegetables ≥ 5 portions/day - Green leafy vegetables ≥2,5 - 3 portion/day - Fruits ≥ 2 - 3 portion/day
Bread and cereals	3 - 7 portions/day	-50 gr bread -70 gr macaroni -90 gr bulghur -90 gr rice -30 gr breakfast cereal	Food commodities: wheat, oat, rye, rice, barley, corn Foods: Bread, rice, macaroni, noodles, couscous, bulghur, oat, barley and breakfast cereals

Table 5: *The key food groups and the recommended consumption amounts in Turkey dietary guidelines (Tabularized from [60]).*

Results from national and local surveys have shown that the average Turkish diet is sufficient to meet the recommended daily energy intake and most nutrients. However, consumption of animal protein, calcium, vitamin A and riboflavin was found to be lower than recommended [61,62]. Regarding this situation, Turkish people are faced with two types of health problems: micronutrient deficiencies and nutrition due to chronic diseases [61]. While micronutrient deficiencies are an important problem of preschool children and women of childbearing age [61,62], obesity and coronary heart disease are more common in Turkish adults [63,64].

However, Turkey has a different consumption pattern mostly depending on cultural, demographic and geographical aspects. In addition, there have been constant significant changes in food consumption patterns in Turkey in recent years. The most influential factors and changes related to these are urbanization, migration to big cities, the increasing share of women in the workforce, changes in socio-economic and demographic factors, developments in technology and the increase in ready-to-eat food consumption. In particular, the increase in the female workforce has triggered the transformation of consumption patterns into ready-to-eat foods. The changes experienced in recent years have also affected the nutritional habits of consumers and the demand for animal products over time, with the differences in the income level, purchasing power and social status of consumers. As the income level increases, the replacement of carbohydrate foods to some extent by protein foods can be given as an example [65].

On the other hand, food expenditures take a higher share in household expenditures day by day. Households spend 20.8% of their expenditures on food. This increase in expenditures also causes an increase in food waste, mostly resulting in food waste.

At the household level, consumer food waste is a major concern [66-68]. According to the United Nations Environment Program (UNEP) report, there is 93 kg of waste per capita per year in Turkey, which is approximately 30% above the global average of 74 kg of food wasted per capita every year [57]. Of all EU-27 countries, to put Turkish food waste in context, Luxembourg has the highest household level food waste at 54.4 kg per capita and the Netherlands the lowest at 28.2 kg [67]. Similarly, the Food Sustainability Index (FSI), developed by the Barilla Food and Nutrition Foundation (BCFN) in collaboration with The Economist Intelligence Unit, ranks Turkey 57th among 67 countries [69]. France, the Netherlands and Canada are the leading countries in this index. Russia, Bulgaria and the United Arab Emirates take the last place [69]. In this context, food sustainability scores of Turkish people were found to be relatively low compared to other countries, especially due to the very low food loss and waste scores. On the other hand, Turkey ranks 33rd in the nutritional difficulties dimension of the FSI, with an above-average score in quality of life (32 out of 67), life expectancy (43 out of 67) and diet subdimensions. patterns (47th out of 67) [69].

Topics selected based on the planetary boundaries approach proposed by Rockström., *et al*. [70]; climate change, land system change, fresh water use and biogeochemical flows are examined on the basis of effects related to agricultural production. As an indicator of climate change, the percentage of agricultural global greenhouse gas emissions for Turkey and the EU28 has been calculated from data provided by FAO for 2010 [71].

The world average rate for agricultural greenhouse gas emissions is 10%. The values of 8.5% for EU28 and 9% for Turkey have been determined, and these values are below the world average for the agricultural greenhouse gas emission rate. Land system change is assessed with the indicator; percentage of agricultural area to land area, calculated from the data provided by FAO [71]. Approximately 40% of global lands are used for agriculture. The ratio of agricultural land use is higher for EU28 (44%). Agricultural land use rate in Turkey is above the world and EU28 average and is equal to 50%. Freshwater use is evaluated based on the ratio of agricultural water withdrawal to total water withdrawal collected from the AQUASTAT database [72]. The global rate of agricultural withdrawal is about 70%. Agricultural water withdrawal for EU28 countries is calculated excluding Bulgaria, Finland, Greece, Ireland, Italy and Portugal as there is not enough data to evaluate the mentioned countries. Agricultural production accounted for approximately 70% of total water withdrawal globally in 2010 and more than 80% in Turkey [71,72]. From 1974, the total area equipped for irrigation infrastructure to provide adequate water for crops has increased by more than 65% globally, more than doubled in Turkey (145% increase) (Calculated from [71]). The change in

biogeochemical flows attributable to agricultural production is assessed by the percentage of synthetic fertilizer emissions in total agricultural emissions calculated from data provided by FAO for 2014 [71].

Greenhouse gas emissions associated with synthetic fertilizers are total NO emissions, expressed as CO_2 equivalents. Global greenhouse gas emissions due to the use of synthetic fertilizers are 13%, which is lower than the EU28 and Turkey average. About a third of agricultural emissions are associated with the use of synthetic fertilizers (28%) in Turkey, which is higher than the EU28 average (19%). Regarding agricultural production, the activities that contribute most to greenhouse gas emissions in Turkey are animal husbandry, nitrogen fertilizer use, stubble burning; It is the burning of leftover crops after grain harvesting and paddy production [73]. Most of the contribution to emissions comes from the non-CO_2 greenhouse gases CH_4 and N_2O. Livestock production is responsible for the emission of CH_4 due to the digestion of animals. In addition, the use of nitrogen fertilizer is responsible for N_2O emission due to the storage of animal manure in an oxygen-free environment. As a waste management activity in agricultural production, stubble burning is responsible for both CH_4 and N_2O emissions from the incineration process.

Forward step

What can be done to shift people's diets?

Reduce overconsumption of calories

The first dietary change aims to reduce excessive calorie consumption. Overconsumption of calories occurs when dietary calories exceed the estimated energy requirements for an active and healthy life. Unnecessary calorie consumption leads to unnecessary use of inputs (e.g. land, water, energy) as well as negative environmental impacts associated with excess calorie production. This dietary change targets countries and populations that currently have high caloric intakes and those with a high caloric intake projected by 2050. It is thought that this could help reduce the number of obese and overweight people, while also providing significant potential savings in healthcare costs [74].

What is the issue with overconsumption of calories?

The number of obese and overweight people is high and increasing day by day. In 2013, 2.1 billion people were overweight or obese [75], more than two and a half times the number of chronically malnourished people in the world. Globally, 37 percent of adults over the age of 20 were overweight and 12 percent were obese in 2013 [76].

A number of efforts have been made to explain the global increase in the number of obese or overweight people. Factors identified include increased consumption of high-fat, energy-dense foods, decreased physical activity as a result of increased sedentary work, and changing forms of personal transportation, all associated with increased urbanization [75]. These factors have been associated with increased access to low-cost convenience and processed foods and sugar-sweetened beverages, increased dining out, persuasive marketing by food and beverage companies, and government subsidies for food production that reduce the cost of food to consumers [77-79].

Limiting energy intake across the population to an amount necessary to maintain a healthy body weight has been suggested as another way to reduce greenhouse gases, and this also includes the obesity epidemic [80].

At the population level, there is a relatively strong correlation between energy intake and GHGE (r 0.57) [81], but as discussed earlier, focusing solely on reducing energy intake will not guarantee a reduction in dietary GHGE as it will depend on food types.

For example, if a high-protein, low-carb-based diet is adopted, this may help restrict energy intake, but is unlikely to reduce greenhouse gases if the diet is high in meat and dairy products.

Overconsumption and obesity can be considered a form of food wastage in terms of global food security as a result of consuming more food than necessary and thus placing more demand on food production (high GHGE). Various authors have suggested that, in addition to contributing to GHGE through excessive food consumption, obesity may indirectly affect overweight or obese individuals through increased physical mass [82-84]. Some studies have estimated additional fuel costs in terms of greenhouse gases (GHGE) of motorized transporting individuals with greater body weight [85], while others have estimated the savings that global body weight loss could provide in terms of inspired CO_2 (inhaled CO_2 is proportional to body mass) [82].

Grykavw., *et al*. [82] estimate that sustained body weight loss of 10 kg among all obese globally could reduce emissions by 0.2% based on reductions in inspired CO2 alone. However, a potential limitation of this study is that the weight loss diet is based on a six-month high-protein, low-carbohydrate diet that is excluded from the greenhouse gas calculation. In absolute terms, these are very small reductions in GHGE and it will take many lifestyle changes to achieve a significant reduction in GHGE.

Rather, mutually beneficial activities can be thought of as having a positive impact on GHGE and health by reducing motor transport or reducing sedentary activity (e.g. screen time) by increasing physical activity and reducing energy use [85].

Reducing consumption of meat and meat products

Switching to a more plant-based diet can bring health and environmental benefits, but changing established diets dominated by animal-based products won't be easy. When attitudes towards reducing meat intake have been investigated in various studies, most of the resistance to it is the view that people enjoy eating meat and that an 'appropriate' meal should contain meat [86,87]. Additionally, although to a lesser extent, people report a lack of knowledge about meat substitutes or a plant-based diet that will not contain enough protein (this view is more common among men than women). This is an interesting and important observation.

It is unclear where this misconception about the amount of protein needed for a healthy diet comes from, but it may have been exacerbated by the focus on high-protein and low-carb diets popularized by the media for body weight loss. In a recent study evaluating healthy eating information (based on Eatwell plate ratios), more than 80% of respondents correctly stated the recommended ratio of fruit/vegetables, dairy products, and high-fat/sugar foods for a healthy diet [88]. However, the majority of individuals (> 65%) were found to confuse the recommended amount of starchy carbohydrate foods with protein foods for a healthy diet. Participants assumed that protein should make up about one-third of the diet, while starchy foods should only make up about 12% (when the reverse is true for a healthy diet). Starchy foods are often perceived by the public and some health professionals as 'fattening' and they should be restricted [89], which is reinforced by promotions of 'low carb' diets. These beliefs need to be changed as they pose a significant barrier to achieving a healthy and sustainable diet.

Reducing consumption of meat and meat products lowers GHGE, but the magnitude of the reduction in GHGE is dependent on the foods that replace this food group in the diet. Berners-Lee., *et al*. [90] created a series of dietary scenarios showing that an 18 - 31% reduction in greenhouse gases can be achieved by replacing meat with a variety of different foods. The diet with the lowest GHGE contained almost one-third more 'added sugar' than other diet scenarios because sugar tended to have lower emissions than many other foods. It was also the cheapest diet. Typically, GHGE is expressed as kg CO_2e/kg food product, and by this definition meat and meat products have a higher GHGE than fruits and vegetables. However, GHGE, expressed as kg CO_2e/kJ energy of food, means that some fruits and vegetables have higher GHGE than meat due to their energy density [1].

On the other hand, reducing meat consumption can be given as an example of shifting consumption patterns to less water-intensive food products as a way to reduce the consumption water footprint. This may be possible because consumption patterns are affected by pricing, labeling of products, health issues, and the provision of other incentives that enable people to change their consumption behavior, such as awareness of water needs in the production of goods and services [91].

Mekonnen and Hoekstra (2012) found that the average WFP worldwide between 1996 and 2005 was approximately 1385 m^3/person/year. In a study conducted in a Tunisian population, it was determined that the contribution of food products to consumer WFP increased to approximately 357 m^3/person/year between 1980 and 2010, and that 290 m^3/person/year (81%) of this increase was due to the increase in meat and poultry consumption. Related to this, the same study states the necessity of a more "effective" diet regarding the use of water resources [44].

Shift from beef specifically

The third dietary change focuses on reducing beef consumption or shifting its consumption to other animal- and plant-based foods. It targets countries and populations that have been high consumers of beef compared to the world average over the past 50 years or are predicted to become high consumers by 2050. This dietary change focuses on reducing beef consumption rather than eliminating it [74].

The term "beef" includes cattle, bison, buffalo, buffalo, yak, and four-horned and spiral-horned antelopes. This shift focuses on cattle because they are the most important source of beef in terms of quantity consumed by humans. Beef is widely consumed around the world, except in countries such as India and Nepal, where it is considered sacred by most Hindus [74].

Average beef consumption per capita is quite high in countries where animal husbandry is developed, which has large pasture areas and feed raw materials are produced. According to FAO's 2011 data, some countries with high per capita beef consumption are New Zealand (47.6 kg), Argentina (43 kg), Australia (40.6 kg) and the USA (37 kg). According to the average of 2009/2011; Per capita beef consumption in Turkey is 4.5 kg, which is below the world beef consumption average.

Countries with high consumption of sheep meat per capita; Mongolia (45.1 kg), Turkmenistan (26.1 kg), New Zealand (20.5 kg). Pork constitutes the majority of red meat consumption in EU and OECD countries. Pork consumption per capita in the EU is 32 kg. According to the 2009/2011 average; Sheep meat per capita in Turkey consumption is 3.58 kg, which is above the world sheep meat consumption average. According to the world average of the same years, per capita beef consumption is approximately 7 kg and mutton consumption is 1.18 kg [92].

The previous dietary change required reducing excessive consumption of beef-based protein. This dietary change highlights the importance of reducing beef consumption, for two reasons in particular. First, beef demand is expected to nearly double between 2006 and 2050. Second, cattle have one of the lowest energy conversion efficiencies of all animal-based foods, resulting in very high resource use and environmental impact per unit of beef produced.

However, overall demand for beef is projected to increase by 95 percent between 2006 and 2050 [93]. This growth will result in an increase in production. The global cattle population is estimated to grow from 1.5 billion to 2.6 billion between 2000 and 2050 [94]. They manage only a fraction of the world's cattle, although traditional herders generally use dry, native grazing land with great efficiency. Without significant increases in productivity in the remaining pasture lands, increased beef demand risks, if left unchecked, further expansion of pastureland into native forests and savannas [95].

Nearly doubling rates in beef production will result in high environmental impacts because beef is a particularly unproductive animal product. Wisenius., *et al*. (2010) estimate that only 1 percent of cattle feed energy is converted to human edible calories. For protein, the conversion efficiency from "protein in" to "protein out" is only 4 percent [96]. On the other hand, by this estimate, dairy, pork, poultry, farmed fish and shrimp, and eggs convert animal feed into edible food 6 to 13 times more than beef [97]. While sheep and goats are also extremely inefficient - with conversion efficiencies similar to beef - they are consumed in smaller quantities around the world. Beef represented 12 percent of global animal-based protein consumption in 2009, compared to just 2 percent for sheep and goat combined [98].

Beef consumption has by far the largest impact on resource use and the environment compared to all commonly consumed foods due to its low efficiency in converting feed inputs into human edible calories and proteins. According to a US study, beef production requires 28 times more land per calorie consumed than the average for other categories of livestock [99]. With the exception of Antarctica, a quarter of the Earth's land mass is used as pasture [100]. Beef production consumes two to four times more freshwater per unit of protein delivered than other livestock categories, and up to 7.5 times more freshwater than plant-based foods [41,98]. Overall, beef is a global food production product. make up one-third. The water footprint of livestock production is greater than any other category of livestock [44].

However, even with a growing population, reducing WFP to sustainable levels can be achieved by acting in accordance with agricultural and trade policies and encouraging changes in consumption patterns. Possible changes include modified food policies to replace beef consumption with ovine meat, poultry, and some aquatic products, and the promotion of vegetable and fruit-based diets. Forage crops with a low water footprint consisting mainly of green WFP and contributing high to dry matter should be encouraged to ration with low WFP. The efficient use of green water is also important to minimize the depletion of blue water resources. Another opportunity to improve the water efficiency of the livestock sector involves the utilization of crop residues.

Conclusion

These studies serve the purpose of emphasizing the importance of considering the whole diet rather than single food items and the nutritional and environmental impacts of substitute foods. The findings of these studies are based on modeling dietary scenarios, and future research needs to explore what substitutes people are willing to make in real life and the health and greenhouse gas implications of these substitutions [1]. Price policies, subsidies, substitutions can contribute to reducing WFP. Changing consumption habits cannot be achieved in a short time, but awareness campaigns and school education programs will have a long-term impact on changing consumption patterns [46].

Bibliography

1. JI Macdiarmid. "Is A Healthy Diet an Environmentally Sustainable Diet?". In 'Future Food and Health', Aberdeen (2013).

2. D Tilman and M Clark. "Global Diets Link Environmental Sustainability and Human Health". *Nature* 7528 (2014): 515-518.

3. A Briggs., *et al*. "Simulating The Impact on Health of Internalising the Cost of Carbon in Food Prices Combined with A Tax on Sugar-sweetened Beverages". *BMC Public Health* (2016): 6-107.

4. G Masset., *et al*. "Which Functional Unit to Identify Sustainable Foods?". *Public Health Nutrition* (2015): 2488-2497.

5. P Jallinoja., *et al*. "Future of Sustainable Eating? Examining the Potential for Expanding Bean Eating in a Meat-Eating Culture". *Futures* (2016): 4-14.

6. B Bodirsky., *et al*. "Global Food Demand Scenarios for the 21st Century". *Plos One* (2015): 39-201.

7. G Masset., *et al*. "Identifying Sustainable Foods: The Relationship Between Environmental Impact, Nutritional Quality, and Prices of Foods Representative of the French Diet". *Journal of the Academy of Nutrition Dietetics* 114 (2014): 862-869.

8. P Scarborough., *et al*. "Modelling the Health Impact of Environmentally Sustainable Dietary Scenarios In the UK". *European Journal of Clinical Nutrition* 66 (2012): 710-715.

9. MJIDF and CJ. "Eating Like There's No Tomorrow: Public Awareness of the Environmental Impact of Food and Reluctance to Eat Less Meat As Part of a Sustainable Diet". *Appetite* 114 (2016): 487-493.

10. G Masset., *et al*. "Reducing Energy Intake and Energy Density for a Sustainable Diet: A Study Based on Self-selected Diets in French Adults". *The American Journal of Clinical Nutrition* 99 (2014): 1460-1469.

11. H Saxe. "The New Nordic Diet Is an Effective Tool in Environmental Protection: It Reduces the Associated Socioeconomic Cost of Diets". *The American Journal of Clinical Nutrition* (2014): 1117-1125.

12. L Aleksandrowicz., *et al*. "The Impacts of Dietary Change on Greenhouse Gas Emissions, Land Use, Water Use, and Health: A Systematic Review". *Plos One* (2016): 657-697.

13. S Dernini and E Berry. "Mediterranean Diet: From a Healthy Diet to A Sustainable Dietary Pattern". *Frontiers in Nutrition* (2015): 2-15.

14. Ö Keleş. "The Effect of Learning Cycle Model on Students' Reducing Ecological Footprints". *Gaziantep University Journal of Social Sciences* 3.10 (2011): 1143-1160.

15. F Soussana J. " Research priorities for sustainable agri-food systems and life cycle assessment". *Journal of Cleaner Production* (2014): 19-23.

16. J Macdiarmid., *et al*. "Sustainable Diets for the Future: Can We Contribute to Reducing Greenhouse Gas Emissions by Eating a Healthy Diet?". *The American Journal of Clinical Nutrition* 96 (2012): 632-639.

17. A Drewnowski., *et al*. "Energy and Nutrient Density of Foods in Relation to Their Carbon Footprint". *The American Journal of Clinical Nutrition* 101 (2015): 184-191.

18. U Sonesson., *et al*. "Food Production and Emissions of Greenhouse Gases: An Overview of the Climate Impact of Different Product Groups: SIK Institutet för Livsmedel och Biotekni (2010).

19. J Macdiarmid., *et al*. Livewell: A Balance of Healthy and Sustainable Food Choices (2011).

20. D Başoğlu Acet. Dietary Pattern-Induced Greenhause Gas Emission And Water Footprint Estimations In Turkey (2017).

21. X Esteve-Llorens., *et al*. "Towards an Environmentally Sustainable and Healthy Atlantic Dietary Pattern: Life Cycle Carbon Footprint and Nutritional Quality". *Science of the Total Environment* 646 (2019): 704-715.

22. Health Council of the Netherlands, "Guidelines For a Healthy Diet: The Ecological Perspective (2011).

23. JD Gussow. "Mediterranean Diets: Are They Environmentally Responsible?". *The American Journal of Clinical Nutrition* (1995): 1383-1389.

24. A Tukker., *et al*. "Environmental Impact of Products (EIPRO): Analysis of the Life Cycle Environmental Impacts Related to the Final Consumption of the EU25". (2006).

25. A Tukker., *et al*. "Environmental Impacts of Diet Changes in the EU". (2009).

26. AP Weidema., *et al*. "Environmental Improvement Potentials of Meat and Dairy Products". *Journal Citation Reports* (2008).

27. GA Hendrie., *et al*. "Greenhouse Gas Emissions and the Australian Diet-Comparing Dietary Recommendations with Average Intakes". *Nutrients* (2014): 289-303.

28. S Friel., *et al*. "Towards Healthy and Sustainable Food Consumption: An Australian Case Study". *Public Health Nutrition* (2014): 1156-1166.

29. AJ Reynolds., *et al*. "Evaluation of The Environmental Impact of Weekly Food Consumption in Different Socio-economic Households in Australia Using Environmentally Extended Input–Output Analysis". *Ecological Economics* (2015): 58-64.

30. A Veeramani. "Carbon Footprinting Dietary Choices in Ontario: A life cycle approach to assessing sustainable, healthy and socially acceptable diets". University of Waterloo (2015).

31. A Chen., *et al*. "Ecological Footprint Analysis of Food Consumption of Rural Residents in China in The Latest 30 Years". *Agricultere Science Procedia* (2010): 106-115.

32. W Feng., *et al*. "A Bite of China: Food Consumption And Carbon Emission From 1992 to 2007". *China Economic Review* (2016): 1-14.

33. G Song., *et al*. "Dietary Changes to Mitigate Climate Change and Benefit Public Health in China". *Science of the Total Environment* (2017): 289-298.

34. H Pathak., *et al*. "Carbon Footprints of Indian Food Items". *Agriculture, Ecosystems and Environment* (2010): 66-73.

35. N Wilson., *et al*. "Foods and Dietary Patterns That Are Healthy, Low-Cost, and Environmentally Sustainable: A Case Study of Optimization Modeling for New Zealand". *PLoS One* 8.3 (2013): 1-10.

36. B Seed. "Sustainability in the Qatar National Dietary Guidelines, Among the First to Incorporate Sustainability Principles". *Public Health Nutrition* (2015): 2303-2310.

37. AY Hoekstra. "Virtual Water Trade: In Proceedings of the International Expert Meeting on Virtual Water Trade". *Value of Water Research Report Series* (2003).

38. AY Hoekstra., *et al*. "The Water Footprint Assessment Manual". (2011).

39. A Bidoglio and G Vanham. "A Review on The Indicator Water Footprint for The EU28". *Ecological Indicators* (2013): 61-75.

40. D Vanham., *et al*. "Water Consumption Related to Different Diets in Mediterranean Cities". *Science of the Total Environment* (2016): 96-105.

41. MM Mekonnen and AY Hoekstra. "The Water Footprint of Humanity". *Proceedings of the National Academy of Sciences of the United States of America* (2012): 3232-3237.

42. PQ Hung and AY Hoekstra. "Virtual Water Trade Value of Water" (2002).

43. AY Hoekstra and MM Mekonnen. "The Green, Blue and Grey Water Footprint of Crops and Derived Crop Products". *Hydrolgy and Earth System Sciences* (2011) 1577-1600.

44. AY Hoekstra and MM Mekonnen. "A Global Assessment of the Water Footprint of Farm Animal Products". *Ecosystems* (2012): 401-415.

45. D Pimentel., *et al*. "Water Resources, Agriculture and the Environment" (2004).

46. A Souissi., *et al*. "Impact of Food Consumption on Water Footprint and Food Security in Tunisia". *Food Security* (2019): 989-1008.

47. A Boulay., *et al*. "The WULCA Consensus Characterization Model for Water Scarcity Footprints: Assessing Impacts of Water Consumption Based on Available Water Remaining (AWARE)". *International Journal of Life Cycle Assessment* (2017).

48. R Gao. "Indispensable Ecological Shift: From Non-ecological Consumption to Ecological Consumption". *Humanities Social Sciences and Education* (2017): 74-82.

49. S Yin. "A few Questions About Ecological Consumption". *Seeker* (2000): 14-17.

50. A Song., *et al*. "Food Consumption and Waste and the Embedded Carbon, Water and Ecological Footprints of Households in China". *Science of the Total Environment* (2015): 191-197.

51. J Liu., *et al*. "Food Losses and Waste in China and Their Implication for Water and Land". *Environmental Science and Technology* (2013): 10137-10144.

52. S Sahingoz and N Sanlier. "Compliance with Mediterranean Diet Quality Index (KIDMED) and nutrition knowledge levels in adolescents". *Appetite* (2011): 272-277.

53. A Batu and B Kirmaci. "Production of Turkish Delight". *Food Research International* (2009): 1-7.

54. A Akbay., *et al*. "Consumer Characteristics Influencing Fast Food Consumption in Turkey". *Food Control* (2007): 904-913.

55. The Ministry of Health of Turkey. "Department of Obesity Diabetes and Chronic Diseases, Current Situation of Obesity in Turkey" (2017).

56. Ministry of Health Republic of Turkey, "Turkey Nutrition and Health Survey". (2017).

57. United Nations Environment Programme, "Food Waste Index Report". (2021).

58. TEPGE, "Agricultural Products Markets".

59. TZOB. "Ekmek, Sebze ve Meyveyle Doyuyoruz".

60. Ministry of Health Republic of Turkey, "Turkey Dietary Guidelines". Ankara (2016).

61. FAO. "Nutrition Country Profile of Turkey" (2001).

62. A Pekcan. "Food and Nutrition Policies: What's Being Done in Turkey?". *Public Health Nutrition* (2006): 158-162.

63. A Onat. "Lipids, Lipoproteins and Apolipoproteins among Turks, and Impact on Coronary Heart Disease". *Anatolian Journal of Cardiology* 4 (2004): 236-245.

64. U Hodoğlugil and R Mahley. "Smoking and Obesity Make A Bad Problem Worse: Genetics and Lifestyle Affect High Density Lipoprotein Levels in Turks". *Anatolian Journal of Cardiology* (2006): 60-67.

65. N Doğan. "A Study on the Current Situation of Households Consumption of Red Meat, Chicken Meat and Fish Meat in the TRA1 Region (Erzurum, Erzincan, Bayburt)". *Turkish Journal of Agriculture and Natural Sciences* (2019): 285-295.

66. T Kymäläinen., *et al*. "Generation Z Food Waste, Diet and Consumption Habits: A Finnish Social Design Study with Future Consumers". *Sustainability* (2021): 21-24.

67. K Bräutiga., *et al*. "The Extent of Food Waste Generation Across EU-27: Different Calculation Methods and Threliability of Their Results". *Waste Management Research* (2014): 683-694.

68. K Schanes., *et al*. "Food Waste Matterrs: A Systematic Review of Household Food Waste Practices and Their Policy Implications". *Journal of Cleaner Production* (2018): 978-991.

69. Barilla Center for Food and Nutrition. "A Global Study on Nutrition Agriculture and Food Waste".

70. J Rockström., *et al*. "A Safe Operating Space for Humanity". *Nature* (2009): 472-475.

71. FAO. "FAOSTAT: Food and Agriculture Organization of the United Nations". (2016).

72. FAO. "AQUASTAT: Food and Agriculture Organization of the United Nations". (2016).

73. Ministry of Agriculture and Rural Affairs. "Agriculture of Turkey". *Ministry of Agriculture and Rural Affairs* (2005).

74. J Ranganathan., *et al*. "Shifting Diets For A Sustainable Food Future". *World Resources Institute* (2016).

75. WHO (World Health Organization), "Fact sheet N°311: Obesity and Overweight.". Geneva (2012).

76. SW Ng., *et al*. "Turning Point for US Diets? Recessionary Effects or Behavioral Shifts in Foods Purchased and Consumed". *American Journal of Clinical Nutrition* 3.99 (2014): 609-616.

77. S Gortmaker., *et al*. "Changing the Future of Obesity: Science, Policy, and Action". *Lancet* 9793 (2011): 838-847.

78. EA Spencer., *et al*. "Diet and Body Mass Index in 38,000 EPIC-Oxford Meat-Eaters, Fish-Eaters, Vegetarians and Vegans". *International Journal of Obesity* 27 (2002): 728-734.

79. TC Campbell., *et al*. "China: From Diseases of Poverty to Diseases of Affluence Policy Implications of The Epidemiological Transition". *Ecology of Food and Nutrition* 27 (1992): 133-144.

80. Sustainable Development Commission. "Setting the Table: Advice to Government on Priority Elements of Sustainable Diets" (2009).

81. F Vieux., *et al*. "Greenhouse Gas Emissions of Self-selected Individual Diets in France: Changing the Diet Structure or Consuming Less?". *Ecological Economics* 75 (2012): 91-101.

82. A Gryka., *et al*. "Global Warming: Is Weight Loss a Solution?". *International Journal of Obesity* 36 (2012): 474-476.

83. A Egger. "Dousing Our Inflammatory Environment(s): Is Personal Carbon Trading an Option for Reducing Obesity and Climate Change?". *Obesity Reviews* 9 (2008): 456-563.

84. P Edwards and I Roberts. "Population Adiposity and Climate Change". *International Journal of Epidemiology* 38 (2009): 1137-1140.

85. A Michaelowa and B Dransfeld. "Greenhouse Gas Benefits of Fighting Obesity". *Hamburg Institute of International Economics (HWWI)* (2006).

86. E Lea., *et al*. "Public Views of the Benefits and Barriers to the Consumption of A Plant-based Diet". *European Journal of Clinical Nutrition* 60 (2006): 828-837.

87. A Schösler., *et al*. "Can We Cut Out the Meat of the Dish? Constructing Consumer-oriented Pathways Towards Meat Substitution". *Appetite* 58 (2012): 39-47.

88. G Prior., *et al*. "Exploring Food Attitudes and Behaviours in the UK: Findings From the Food and You Survey 2010". *Food Standards Agency* (2011).

89. V Chan., *et al*. "Investigating How Both Consumers and Health Professionals Understand Healthy Eating Messages". *Scotland* (2012).

90. M Berners-Lee., *et al*. "The Relative Greenhouse Gas Impacts of Realistic Dietary Choices". *Energy Policy* 43 (2012): 184-190.

91. AY Hoekstra and A Chapagain. "Water Footprints of Nations: Water Use by People As A Function of Their Consumption Pattern". *Water Resources Management* (2007): 35-48.

92. N Saygın and Ö Demirbaş. "Red Meat Consumption in Turkey: Problems and Suggestions". *Selcuk Journal of Agriculture and Food Sciences* 3.32 (2018): 567-574.

93. N Alexandratos and J Bruinsma. "World Agriculture Towards 2030/2050: The 2012 Revision". Food and Agriculture Organization of the United Nations (FAO), Rome (2012).

94. MW Rosegrant and PK Thornton. "Do Higher Meat and Milk Prices Adversely Affect Poor People?". Id21 insights (2008): 72-74.

95. T Searchinger., *et al*. "Creating a Sustainable Food Future: Interim Findings of the 2013–14 World Resources Report". World Resources Institute., Washington (2013).

96. S Wirsenius., *et al*. "How Much Land Is Needed For Global Food Production Under Scenarios of Dietary Changes and Livestock Productivity Increases in 2030?". *Agricultural Systems* 9.103 (2010): 621-638.

97. R Waite., *et al*. "Improving Productivity and Environmental Performance of Aquaculture". Washington DC (2014).

98. FAO, IFAD, WFP (Food and Agriculture Organization of the United Nations, International Fund for Agricultural Development, World Food Programme, "The State of Food Insecurity in the World 2015". Rome (2015).

99. G Eshel., *et al*. "Land, Irrigation Water,Greenhouse Gas, and Reactive Nitrogen Burdens of Meat, Eggs, and Dairyproduction in the United States". *Proceedings of the National Academy of Sciences of the United States of America* 33 (2014): 11996-12001.

100. FAO (Food and Agriculture Organization of the United Nations), "The State of the World's Land and Water Resources for Food and Agriculture". Rome (2011).

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