DIETARY PATTERN-INDUCED GREENHOUSE GAS EMISSION AND WATER FOOTPRINT ESTIMATIONS IN TURKEY

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ABSTRACT

DIETARY PATTERN-INDUCED GREENHOUSE GAS EMISSION AND WATER FOOTPRINT ESTMATIONS IN TURKEY

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The recent studies in literature established a link between diets and several environmental impacts. As the environmental implications of commonly followed diets in Turkey have not been previously studied, the general aim of this study is to estimate the environmental impacts of the average dietary patterns in Turkey from 1960 to 2050 through quantification of water footprint and greenhouse gas emissions and to evaluate the health implications of those dietary patterns.

With this exploratory study, all dietary scenarios created were evaluated for their water footprint, using the water footprint assessment methodology and greenhouse gas emissions, using the average Mediterranean greenhouse gas emission factors; which were compiled from life cycle assessment studies in literature. The health implications of the dietary scenarios were qualitatively assessed by using the dietary guidelines and recent epidemiological studies, which provide causal relationships between nutrition and dietary indicators and health outcomes. Moreover, two healthy dietary scenarios were constructed based on the recent Turkey Dietary Guidelines and the Mediterranean recommendations in order to evaluate the environmental and health implications of all dietary scenarios for Turkey.

Results of this study showed that the environmental impact of food consumption in Turkey is lower than the environmental impact associated with average European and Mediterranean food consumption. In addition, the future diet-related GHG emissions and water footprint are not expected to exceed the average environmental impacts associated with average diets in Europe or other developed regions. However, the dietary scenarios for the current as well as future food consumption in Turkey did not reveal adherence to nutritional guidelines and resulted in lower health scores in comparison with the dietary guidelines and the Mediterranean Diet. The dietary scenario created based on the dietary guidelines performed best in terms of health implications whereas, it was the most environmentally burdensome dietary scenario. The Mediterranean-based dietary scenario, on the other hand, performed second in terms of health score and it performed best in terms of greenhouse gas emissions and water footprint. In line with other studies, the increasing share of animal-oriented foods in the dietary scenarios increase the associated greenhouse gas and water footprint emissions.

This study followed an interdisciplinary approach to combine nutritional and environmental research in order to provide an opportunity to formulate an environmentally friendly, healthy, socially and economically acceptable diet; which corresponds to the sustainable diet for Turkey. Despite all the outlined key limitations in this diet-related environmental study, it is expected to provide a useful basis for future studies in both environment and nutrition in Turkey.

Key Words: greenhouse gas emissions, water footprint assessment, life cycle assessment, health implications of diets, dietary guidelines, dietary patterns

ÖZ

TÜRKİYE'DE YAYGIN OLAN BESLENME ÖRÜNTÜLERİNE İLİŞKİN SERA GAZI EMİSYONLARI VE SU AYAK İZİ DEĞERLENDİRMESİ

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Çevresel etki analizi literatüründe gerçekleştirilen son çalışmalar, beslenme ve diyet örüntüleri ile çok çeşitli çevresel etkiler arasındaki ilişkiyi ortaya koymaktadır. Türkiye'de yaşayan ortalama bir kişinin, diyet örüntüsü ve beslenmesine ilişkin çevresel etkilerin henüz araştırılmamış olması nedeniyle; bu çalışma 1960 yılından günümüze ve daha sonar 2050'ye ortalama gıda tüketimin su ayak izi ve sera gazı emisyonlarını hesaplamayı hedeflemektedir. Beslenme ve diyet örüntülerinin sağlıkla yakın ilişkisi göz önünde bulundurulduğunda, çevresel etki ile birlikte sağlık üzerindeki etkilerin de değerlendirilmesi temel hedeflerden biri haline gelmiştir.

Bu çalışma dahilinde, oluşturulan tüm diyet senaryoları, su ayak izi yaklaşımı ve faktörleri ile, literatürde bulunan yaşam döngüsü analizi çalışmaları derlemesi sonucu elde edilen ortalama Akdeniz sera gazı emisyon faktörleri kullanılarak, çevresel etkileri bakımından değerlendirilmiştir. Diyet senaryolarının sağlık üzerindeki etkilerinin niteliksel olarak değerlendirilmesi için, Türkiye'ye özel hazırlanan diyet önerileri kılavuzu ve son zamanlarda gerçekleştirilen ve beslenme, diyet göstergeleri ile sağlık arasındaki nedensel ilişkiyi ortaya koyan epidemiyolojik araştırmalardan faydalanılmıştır. Bunun yanı sıra, Türkiye Beslenme Rehberi ve

Akdeniz Diyeti önerileri temel alınarak, iki farklı sağlıklı diyet senaryosu oluşturmak yoluyla, ortalama tüketimi yansıtan diğer diyet senaryoları hem sağlık hem de çevresel etki bakımından karşılaştırılmıştır.

Bu çalışmanın sonuçları, Türkiye'de gıda tüketiminin çevresel etkisinin, Avrupa ve Akdeniz ortalamalardan daha düşük olduğunu ortaya koymuştur. Buna ek olarak, 2050 yılı için öngörülen diyetle ilişkili sera gazı emisyonları ve su ayak izinin, Avrupa ya da diğer gelişmiş ülkelerdeki mevcut ortalama diyetle ilişkili çevresel etkileri aşmadığı tespit edilmiştir. Ancak, Türkiye'de mevcut gıda tüketimini gösterir diyet senaryoları, beslenme önerilerinden önemli ölçüde farklılaşmaktadır ve bu nedenle, diğer iki sağlıklı diyet senaryosu ile karşılaştırıldığında, daha düşük sağlık skorları elde edilmektedir. Türkiye Beslenme Rehberi’ne dayalı olarak oluşturulan diyet senaryosu, sağlık puanı açısından en iyi sonucu vermesine rağmen, en yüksek çevresel etkiye sahip diyet senaryosu olmuştur. Öte yandan, Akdeniz Diyeti önerileri temel alınarak hazırlanan diyet senaryosu ise sağlık puanı açısından ikinci sırada yer almış ve sera gazı emisyonları ile su ayak izi açısından en iyi performansı göstermiştir. Literatürde yer alan diğer çalışmalar ile uyumlu olarak, diyet senaryolarında hayvansal gıdaların artan payı ile sera gazı ve su ayak izi emisyonlarının arttığı gözlemlenmiştir.

Bu çalışma, disiplinler arası bir yaklaşım ile; beslenme ve çevresel etki araştırmalarını bilimsel yaklaşımlar yoluyla birleştirerek, Türkiye için sağlıklı, çevre dostu ve hem ekonomik hem de sosyal açıdan kabul edilebilir bir diyet önerisinin geliştirilmesine katkı sağlamaktadır. Bu ve daha sonar yapılacak olan çalışmalar ile Türkiye için bir sürdürülebilir diyet önerisi hazırlanması mümkündür. Araştırma süresince kullanılan yöntem ve araçlara ilişkin tüm kısıtlara rağmen, bu çalışmanın hem çevre hem de beslenme alanında gerçekleştirilecek diğer çalışmalara yararlı bir temel oluşturması beklenmektedir.

Anahtar Kelimeler: sera gazı emisyonları, su ayak izi değerlendirmesi, yaşam döngüsü değerlendirmesi (analizi), diyetlerin sağlık üzerindeki etkileri, beslenme önerileri, beslenme örüntüleri

To my precious family and my dear husband…

“Knowing is not enough; we must apply. Willing is not enough; we must do.” —
Goethe

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AFOLU	Agriculture, Forestry and Other Land Use
BMI	Body Mass Index
CH_4	Methane
CO_2	Carbon Dioxide
CVD	Cardiovascular Diseases
DALY	Disability adjusted life years
EIO-LCA	Economic Input-Output Life Cycle Assessment
EIPRO	The Environmental Impacts of Products
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
FAOSTAT	FAO Statistics
FBS	Food Balance Sheets
GDP	Gross Domestic Product
GEC	Global Environmental Change
GHG	Greenhouse Gas
GWP	Global Warming Potential
IOA	Input-Output Analysis
IPCC	Intergovernmental Panel on Climate Change
LC	Life Cycle
LCA	Life Cycle Assessment
LCI	Life Cycle Inventory
LUC	Land Use Change
MoH	Ministry of Health of Republic of Turkey
MRIO	Multi Regional Input-Output
N_2O	Nitrous Oxide
NCDs	Non-communicable Diseases
OECD	Organisation for Economic Co-operation and Development

PED	Primary Energy Demand
SCP	Sustainable Consumption and Production
SDG	Sustainable Development Goal
SFS	Sustainable Food Systems
SRES	Special Report on Emissions Scenarios
TBM	Triple burden of malnutrition
TDG	Turkey Dietary Guidelines
UNEP/SETAC	United Nations Environment Programme Society of Environmental Toxicology and Chemistry
US EPA	Unites States Environmental Protection Agency
USDA	United States Department of Agriculture
WCED	United Nations World Commission on Environment and Development
WFA	Water Footprint Assessment
WFN	Water Footprint Network
WHO	World Health Organization
WULCA	Water Use in Life Cycle Assessment

CHAPTER 1

INTRODUCTION

1.1 Sustainability in Food Systems and Diets

The concepts, sustainability and sustainable development, are in the middle of international debate since the United Nations World Commission on Environment and Development (WCED) in 1987, when the Brundtland Report or ‘Our Common Future’ was published. At the Oslo Symposium in 1994, the very first definition of Sustainable Consumption and Production (SCP) was formulated as “the use of services and related products, which respond to basic needs”, while ensuring life quality for people and diminishing the use of resources and emissions [1]. In the forthcoming years, SCP is accepted as one of the most important objectives and requirements to reach sustainable development, together with poverty eradication and natural resource management [2]. The importance of SCP for sustainable development is expressed in Sustainable Development Goals (SDGs), that are adopted in 2015 at the UN Sustainable Development Summit as the 2030 Sustainable Development Agenda, as a standalone goal. SDG 12, *Responsible Consumption and Production* is to “ensure sustainable consumption and production patterns” as more people are expected to “join the middle class” in the coming years and the demand for already limited natural resources are increasing [3]. Food consumption and food waste, energy use in households and water use and pollution are highlighted in Goal 12, as food-energy-water nexus. In addition to SDG 12, there are other goals and targets related to the sustainability of consumption and production of food. SDG 2, *Zero Hunger*; with the Target 2.4 which is to ensure sustainable food production systems with increased efficiency in production and resource use and maintained ecosystems, SDG 6, *Clean Water and Sanitation*; with the Target 6.4 which is to increase the water use efficiency, mostly during the agricultural production as it is the major consumer, SDG 8, *Decent Work and Economic Growth*; with the Target 8.4 which is to improve resource efficiency in consumption and production of domestic products while ensuring economic development and decoupling of it from environmental degradation and SDG 13, *Climate Action*; with the Target 13.2 which is to integrate climate change measures into national strategies in order to minimize the impacts of food production, are the other goals that are closely related to decreasing the unsustainability in the global food production and consumption [4].

Food consumption is one of the problematic issues discussed under SCP, with water and energy [5]. SCP studies claim that more than 70% of the environmental deterioration can be allocated to the consumption and production of food, energy, transportation and housing ([6]–[10]). Food and getting the sufficient nutrition is one of the basic needs of people. The current global food systems can provide the sufficient amount of food. However, the food security and sufficient nutrients are not provided equally at global and local scale. Accordingly, the life quality of every person is not ensured.

Moreover, the current global food system, including the food consumption, has a significant contribution to the climate and global environmental change (GEC) through resource use and emissions ([11]–[13]). Food systems contribute to GEC especially through strengthening the change in climate and increasing the demand from the natural resources, such as the freshwater and land. Accordingly, the food systems are also affected by the changes in natural resource levels as well as the climate and ecosystem services [14]. The feedbacks occurring in between the food systems and the environmental change engender the challenge of feeding a growing population in the future and their food security [15]. Approximately, 30% of greenhouse gas emissions (GHG) and 37% of land use are associated with the food systems ([16], [17], [18]). The agricultural activities account for at least 70% of total water withdrawal globally [19]. In addition to drain on water quantity, quality of freshwater resources also decreases with increasing agricultural chemical use. The environmental implications will be worsened under the effect of climate change, which will naturally limit the use of resources for the food system.

The term, sustainable diet, was firstly proposed by Gussow and Clancy in 1986 to consider the “resource cost of dietary recommendations” [20, p. 2]. Two decades later, Food and Agriculture Organization of the United Nations (FAO) and Bioversity International organized an international symposium ‘Biodiversity and Sustainable Diets: United Against Hunger’ in Rome in 2010 to discuss the sustainability in diets. The participants reached to a consensus on a definition for sustainable diets, which is “diets with low environmental impacts which contribute to food and nutrition security and to healthy life for present and future generations” [21, p. 83]. There is enough scientific evidence showing the unsustainability of current local, regional or global diets ([16], [22]–[25]) and the unsustainable shift of the dietary patterns with increasing income and globalization ([17], [26]). Considering the growing world population, which was 7.3 billion in 2015 and is expected to become 8.5 billion and 9.7 billion in 2030 and 2050, respectively [27], who are also expected to be richer and more urbanized, agri-food sector is under the pressure of providing qualitatively and quantitatively enough food to meet the nutritional needs while ensuring the sustainability in the three pillars. FAO estimates at least 70% increase in the food production, necessary to feed every one in 2050, which especially consists of the increase in the annual cereal and meat production levels [28]. The increase in production, borne from the consumption, will increase the burden of food and diets on environment and natural resources. The environmental impact of production in the agri-food sector can be reduced by technological development and diminishing the food losses [29] however, the production-side improvements are limited to a maximum 20% decrease in environmental impacts ([30], [31]). That’s why the consumption side is important for the mitigation of elevated environmental degradation associated with food.

Furthermore, the outcome of the rise in food consumption is not only environmental but also in close relation to health globally. “*Nutrition transition*” term and the historical model, proposed by Barry M. Popkin in 1993 [26], stands for the dietary transition, driven by increasing income and urbanization. The current nutrition transition occurs in between the stages of the third and the fourth dietary patterns, especially in developing regions of the world, which is from a traditional diet to a

"Western Diet" [26, p. 138] (which can also be defined as "Westernization" of the diet [32, p. 31]). Nutrition transition taking place have both health and environmentally burdensome outcomes. The occurrence of overweight, obesity and diet-related disease risks have increased mainly because of the dietary shifts [33], [34]. Triple burden of malnutrition (TBM), the occurrence of deficiency in calorie intake, nutrient deficiency and obesity or overweight co-existing together in several countries or regions ([35], [36]) is another outcome of the changing dietary patterns.

From the environmental perspective, dietary shift-originated increase in food production create extra environmental impact, that are not associated with the growing population [37]. The per capita food consumption for specific products is increasing proportionally with income especially in developing regions of the world. The daily calorie intake per person on average is expected to rise to 3130 Calories daily [38]. Health implications of this dietary shift, combined with the environmental impact, will be a challenge to provide food and nutrition sustainably in future. The need for studies on the potential environmental impacts of dietary choices and initiations to reduce the food consumption, which is unhealthy for both human and environment, for efficient mitigation in both areas is increasing.

Food system activities contribute directly to the emissions of greenhouse gases including carbon dioxide (CO_2) from fossil fuel use and land use change, nitrous oxide (N_2O) from fertilizer use and methane (CH_4) from livestock and rice production. The Global Warming Potential (GWP) of the food systems, which is determined based on the carbon and equivalent emissions associated with the studied system and expressed in terms of GHG emissions in CO_2 equivalents (CO_2eq), are the most commonly studied aspect of the global food production from an environmental perspective. Table 1 summarizes some of the results of the studies in literature on the magnitude of global GHG emission associated with food production. In the 5th assessment report of Intergovernmental Panel on Climate Change (IPCC), the ratio of global GHG emissions attributed to Agriculture, Forestry and Other Land Use (AFOLU) sector was calculated as 24% of total GHG emissions [39]. In the report, the pre- and post-production stages and associated GHG emissions are not accounted under the AFOLU sector category. It is claimed by FAO that including the GHG emissions from the stages mentioned above, the total magnitude of emissions associated to AFOLU would increase by 30% [13].

Table 1. Yearly average GHG emissions associated with global food production

The Process	GHG Emissions (MtCO2eq)	Year	Reference
Fertilizer Production	284 – 575	2007	[40]
Pesticide Production	3 – 140	2007	[40]
Feed Production	60	2005	[38]
Agriculture, Forestry and Other Land Use sector (AFOLU)	10000 – 12000	Per year	[39]
Fossil fuel-related agricultural CO_2 emissions	400 – 600	2010	[39]
Non-CO_2 GHG emissions linked to the agriculture	5200 – 5800	2010	[39]
Food Waste (including land use change (LUC))	4400	2011	[41]
The Global Food System	9800–16900	2008	[12]

The impacts of agricultural production on GHG emissions in coming decades are expected to increase globally and regionally. According to the report published by Unites States Environmental Protection Agency (US EPA) and Climate Change Division [42], emissions from the agricultural soils are estimated to increase by 35%, from 1840 to 2483 $MtCO_2eq$ in between 2005–2030. CH_4 emissions born from enteric fermentation are also estimated to increase by 22%, equal to an increase of 426 $MtCO_2eq$ in between 2005–2030. By 2030, it is important to state that the largest increase in fertilizer use among the countries from Organisation for Economic Co-operation and Development (OECD) are expected to become in United States, Canada, Turkey, New Zealand and Australia.

Not only the global climate but also the global freshwater resources face with the risk of deterioration because of the irrigated crop production and associated pollution. Agriculture is the major consumer of water resources and the demand is expected to grow in future, challenging the countries, which are especially facing with water scarcity problems. Agricultural production accounted for minimum 70%, though it may be as high as 90%, of total water withdrawal globally [19]. Since 1974, total area equipped for irrigation infrastructure to provide the crops sufficient water, have increased more than 65% and it is expected to grow 11% by 2050 globally [43]. This growth is estimated to take place especially in developing countries [43]. Not only quantity, but also quality of freshwater resources faces the risk of deterioration. As there are numerous studies showing the global and regional eutrophication and chemical pollution potential of diets, associated with ascending fertilizer and pesticide use ([44]–[46]), degradation and salinization of soils ([21], [47]), which are expected to be worsen under climate change conditions ([39]).

There are many other large impacts of agriculture and food consumption on environmental change along with water use and GHG emissions such as land use change, biodiversity loss, alteration of the nutrient cycles, desertification, emission of other acidifying pollutants and cumulative energy demand (CED) ([39], [48]–[50]). The effects and consequences of land use change is more than the transformed land and climate change. Land use change is claimed to have the largest impact on the biodiversity loss especially for the terrestrial ecosystems [51]. Land use change and related biodiversity loss, are mostly associated with the food systems, especially the agricultural production stage. According to Tilman and Clark [17], “half of the ice free land area of Earth” is used for agricultural purposes and food production. The latest estimations of FAO reveal that the agriculture covers 37% of terrestrial land all around the world [18]. By 2050, the increase in the demand for food is estimated to be satisfied especially by intensifying the agricultural practices for more yields. 90% in developed world and 80% in developing regions of the increase in supply will be associated with increased yields [43]. The rest is estimated to provide through land expansion for agricultural production. The land is estimated to be expanded by 5% and 12% in developed and developing regions respectively [43].

1.2 Greenhouse Gas Emission Estimates with Life Cycle Approaches

Life Cycle Assessment (LCA) is used commonly to quantify the potential environmental impacts of the food products as well as related activities, such as global warming potential (GWP), acidification and eutrophication potential [52]. LCA was developed as a decision-support tool to compile and evaluate the environmental impacts associated with the studied products or processes by considering the inputs and outputs of the system throughout the life cycle [53]. ISO 14040:2006 [53] provided the standards for practicing a Life Cycle Inventory or Life Cycle Assessment study. ISO 14040:2006 defined 4 phases for a LCA study that included goal and scope definition, life cycle inventory analysis, life cycle impact assessment, and interpretation. The studies with a proper goal and scope definition and which can be satisfied with only an inventory analyses, are called Life Cycle Inventory (LCI) studies. Functional Unit is the quantitative reference flow that is related to other flows, inputs and outputs in the product system under study, which is determined at the goal and scope definition stage of an LCA study [53]. The selection of functional unit for the specific subject in LCA should be the quantification of the function of that subject ([54], [52]). In an LCA study, the processes included in the assessment are defined by system boundaries, which are also determined at the goal and scope stage of the study [53]. LCA studies should include a total life cycle of the studied product or service and so, the system boundaries should be from cradle-to-grave [53]. However, most of the LCA studies on food products and diets only include the agricultural production processes as the environmental impact associated with it is the largest of all processes [55]. Those system boundaries for such studies are defined as cradle-to-farm gate. There are now several studies on food products, production methods, food system sustainability, food processing and food consumption as well as methodological studies using Life Cycle Assessment (LCA) ([12], [55], [56]).

The potential environmental impacts of single food products and their consumption have been assessed prior to diets. In current literature, there are extensive amount of studies carried out to quantify the environmental impacts of single food products with LC approaches. Red meat ([57]–[62]), dairy ([57], [59], [61], [63]), sea foods ([58], [59]), rice ([60], [63]), white meat ([60], [64]), fruits, and vegetables ([23], [60]) grains ([60]) and legumes ([58], [60], [62], [65]) are some of the examples using LC approaches in assessment. The studies on potential environmental impacts of meat and dairy products become prominent in between those and are emphasized as emission intensive compared to plant-based food products by many international organizations ([11], [38], [66]–[68]) and in peer-reviewed papers ([56], [60], [69]–[74]). Including the impacts born as a result of land use change (LUC) attributed to meat and dairy production, the contribution from animal-based food consumption rises ([38], [11]). The environmental impacts associated with food products differ according to the geographic location and production methods followed. Figure 1 below demonstrates the GHG emission contributions of some food products sold in Sweden, which can provide a basis to compare the environmental impacts of animal and plant-based products [60].

Apart from the environmental burden of agriculture and food production processes, food consumption and dietary choices have been evaluated in relation to their environmental impacts since the middle of 1980s. Gussow and Clancy (1986) firstly pointed out the importance of studying the natural resource use in food consumption by proposing the nutrition education to be enhanced with not only human health-related information but also include education on agricultural practices, environmental science and economics [20]. Then, Gussow [75] proposed to assess and compare different dietary patterns around the globe based on their efficiency in land, water and energy use.

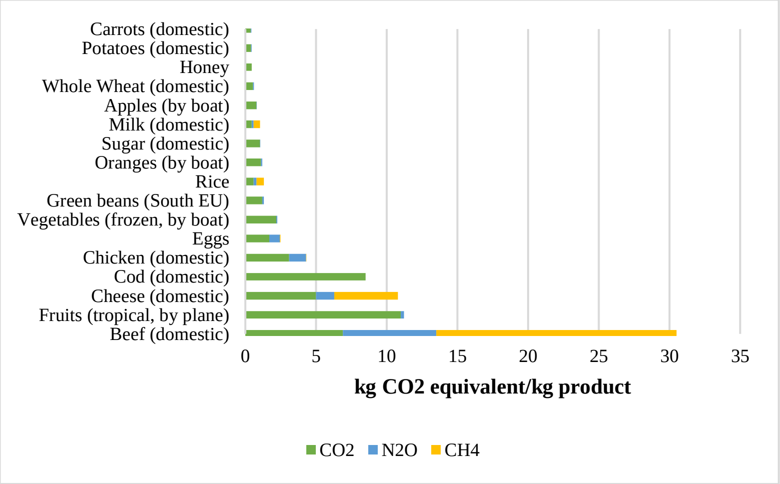

Figure 1. CO2, N2O and CH4 (CO2eq) GHG emissions per kg-product (Visualized from [59])

The studies evaluating the relationship between food consumption and environment started to appear in the literature firstly in Europe. Pioneering studies can be grouped according to their study boundaries, the countries. The outstanding and recent studies in the Europe region are carried out in Austria ([76]–[78]), Brazil [79], Denmark, ([25], [80], [81], [82]), Finland ([83]–[86], France ([87]–[91]), Germany ([29], [48], [92], [93]), Greece [94], Ireland [95], Italy ([59], [96]–[99]), Norway [100], Spain ([65], [61]), Sweden ([58], [65], [101]–[105]), Switzerland ([64], [44]), The Netherlands ([16], [57], [106]–[108]) and United Kingdom ([11], [23], [24], [45], [109]). The Environmental Impacts of Products (EIPRO) study started in 2004 by the Joint Research Center (JRC) Institute for Prospective Technical Studies (IPTS) revealed that food is one of the main drivers of environmental impacts born from consumption in Europe [6]. Following that, a study targeting to quantify the environmental impacts associated with food consumption and widespread dietary patterns in the EU-27 countries was published in 2009 ([49], [110]). In the EU, the consumption of food and beverages generates 22-31% of total GHG emissions from overall consumption ([110],[31]) revealing that the consumer choices on what to eat and drink have a significant impact on the amount of GHG emissions.

Apart from Europe, there are some outstanding studies, evaluating the relationship between food consumption and environment carried out in Australia ([62], [111], [112]), Canada [113], China ([114]–[116]), India [63], New Zealand [117], Qatar [118] and USA ([119]–[124]). Recently, studies on environmental life cycle impacts associated with global food consumption in 2007 have been carried out [125]. However, there is lack of research in environmental impacts of food consumption (the average dietary pattern) in Turkey.

The prominent environmental impact categories selected to quantify the environmental impacts of food consumption are GHG emissions, water use, land use and cumulative energy demand (CED). GHG emissions and GWP calculation were chosen as the main impact to be studied in most of the studies ([19], [20], [22], [86], [90], [103], [108], [125], [132], [145]). The prominent studies that follow a LC approach in assessing the GHG emissions as well as other impacts of food consumption are provided in Appendix A in details.

1.3 Water Footprint Assessment of Food Consumption

There are numerous studies quantifying the agricultural demand of water. The methodology developed by the Water Footprint Network (WFN), the Water Footprint Assessment, is one of the quantification methods of water use. The water footprint (WF) concept was firstly proposed by Hoekstra in 2002 as to measure the water use along the supply chains of the products and processes [126]. Since then, WF is used as an indicator for the freshwater use of products or services [127]. WF of production and WF of consumption differ when assessing the water use of products and services. The first one is the total amount of direct and indirect water use from the regional water sources. The latter one is, on the other hand, the total amount of direct and indirect water use of both regional and foreign water resources [128]. The WF of consumption is calculated by summing the WF of production and the virtual water import; the total amount of water virtually used in foreign waters, and subtracting the virtual water export; the total amount of water used by foreign consumers [127].

According to Hoekstra (2011), the water consumption is accounted as the sum of demand for and pollution of water [127]. In that sense, WFA lets the researcher to assess the water use over three main components, green, blue and grey water. Green water use is the amount of water made available for plants by precipitation and stored in the unsaturated zone of the soil until it evaporates or transpires through plants [128], [129]. Blue water use is the amount of water used from freshwater resources. The irrigated agricultural areas use both blue and green water whereas, rainfed agricultural areas use only green water resources. The grey water use, on the other hand, is the total amount of water polluted as a result of production or consumption [127].

The WF concept has been employed widespread in the literature to measure the magnitude of agricultural water use [128]. The global WF of anthropogenic activities for the period 1996 – 2005 was calculated as 9087 Gm^3/year by Hoekstra and

Mekonnen [130]. They also calculated the total WF of agricultural production as 92% of the total WF, which equals 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 [131]. Following that, Hoekstra and others [127] developed a guide to standardize the WF assessment. The green, blue and grey WFs of many crops and livestock products were calculated based on the published manual ([132], [73]). When global estimations on water consumption of food products are considered, animal-oriented food products are more water intensive than plant-based ones [133] (Figure 2). In between animal-oriented food products, there is still a variation of water consumption, especially due to the farming system and the region of the farming (Table 2).

Table 2. Amount of water needed to produce 1 kg of animal-oriented food product (Tabularized from [132] and [133])

Animal Products	Water Required (liters/kg) [a]	Water Footprint (m^3/ton) [a]
Chicken Meat	3500	4325
Pig	6000	5988
Beef	43000	15415
Sheep	51000	10412
[a] m^3/ton ≡ l/kg		

The WFs calculated were used in numerous diet-related water use studies, of which, the outstanding ones are [129], [134]–[137]. The study design and the main outcomes of those studies are provided in Appendix A in details.

Additively, 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 [138].

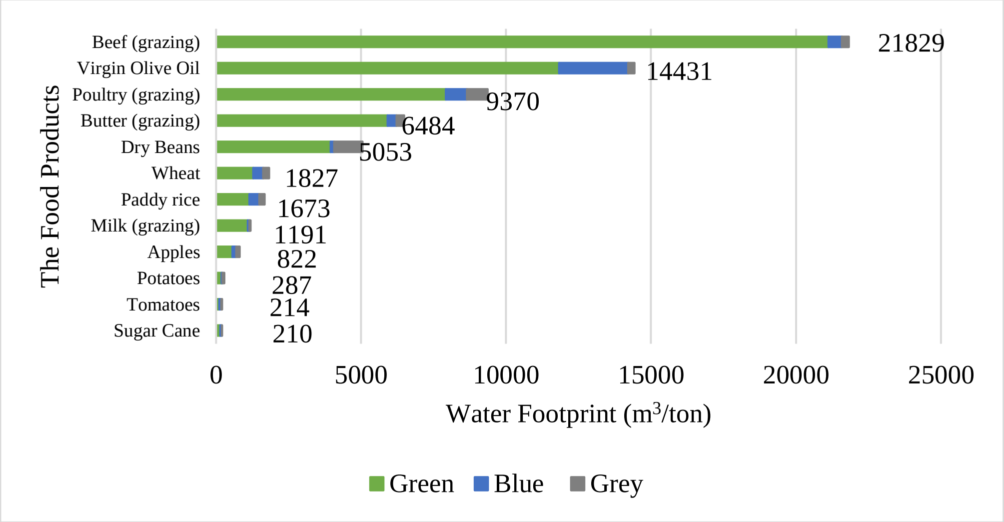

Figure 2. The Green, Blue and Grey Water Footprints associated with selected food products (compiled from [65] and [132])

1.4 The Construction of Dietary Scenarios to Assess the Environmental Impacts

The dietary consumption is assessed environmentally over dietary scenarios, which can be constructed based on actual consumption data or hypothetical data on food consumption. The actual consumption data contains average consumption amounts for a selected population or can be aggregated from self-selected diets. Hypothetical dietary scenarios, on the other hand, are constructed to represent the associated environmental impacts related to food consumption or to measure the change in impact in case there is a shift from actual to hypothetical dietary scenarios. Food balance sheets (FBS), constructed by FAO from the national accounts to represent the food supply pattern of a country for a specific period [139] are used commonly to develop basic dietary scenarios for a specific time and region [52]. The average availability of food products, as provided in FBSs, is the amount of food produced and imported minus the food exported, fed to animals and the ones that are not available for human consumption, divided by the population size of the specific nation for the period and named as food supply per capita.

There are studies constructing hypothetical dietary scenarios to project the future food demand and the potential environmental and health impact associated with the demand [17]. Total food demand in terms of total calorie intake per person, total demand for meat in terms weight and calories, demand for other animal-oriented food products such as dairy and eggs, and demand for unhealthy or empty calories are modelled to create future food demand and consumption scenarios. There are numerous studies showing a positive relationship between income and food demand in environmental ([17], [140]–[142]) as well as in nutrition and health field ([26], [34]). Engel's Law, which is an economic law for demand prediction, claims that the increase in food demand is less than proportional to the increase in income [143]. Another economic approach, Bennet's Law claims that the impact of income on the food demand depends on the type of the food and the demand for starchy foods decrease with increasing income. However, the demand for meat products is expected to grow more than other food groups. Distinct from economic approaches, there are studies modelling the relationship of food demand in relation to income for analyzing the environmental and health outcomes of changing dietary patterns ([17], [144], [145]). The other determinants affecting the food demand are the degree of urbanization, demographical features of a society, food industry including the food prices, the level of globalization and climate change ([26], [32]).

Bodirsky and others (2015) employed "time-dependent regression models" to define the relationship between income and food demand, based on the economic approaches mentioned above [140, p. 1]. On the other hand, Tilman and Clark (2014) [17] employed a nonlinear, logistic-like regression model with a Gompertz 4P function to predict the composition of the global diet in 2050. Vranken and colleagues (2014) [146] studied the relationship between meat consumption and income in 120 countries and found the evidence that meat consumption and income has an inverted U-shape curve, which is very similar to Environmental Kuznets Curve (EKC), named after Kuznets [147] and emerged in 1990s following the attempt by Grossman and Krueger [148]. Kuznets hypothesized that the economic inequality will rise first with rising income until a tipping point where the inequality in between a population would start to decrease [147]. Grossman and Krueger applied the Kuznets Curve approach to claim a relationship between environmental degradation and income, which would rise and fall after some income level when the economic growth continues [148]. Meat consumption, which is hypothesized as having an inverted-U shape curve with income, was also studied with an EKC. Cole and McCoskey [142] applied a regression model based on the EKC formulation and tried to find a similar relationship, with a tipping point in income that the meat consumption would decrease. Their results showed that, an EKC was possible in case the studied countries' income levels are upper-middle or high.

1.5 Assessment of Environmental Outcomes of Diets together with Health Implications

The main function of a diet is to provide nutrition to human beings. Following a healthy diet is an important determinant of good health and has the potential to prevent NCDs in addition to any type of malnutrition, including both insufficient nourishment and over-consumption ([149], [150]). Accordingly, assessment of diets from an environmental perspective cannot eliminate the health perspective. Tilman and Clark (2014) entitled the problem of feeding a growing population under the constraints of health and environment as "diet – environment – health trilemma" [17, p. 521]. The recent studies in the field generally assess the environmental and health implications together as to achieve sustainability in diets ([87]–[89], [106], [109], [151]).

The health implications of the diets are under debate and they are not easily quantified directly [16]. Assessing the health implications; adherence to regional or local guidelines and food pyramids, protein content and the nutritional quality of diets are some of the approaches used in environmental studies. The dietary guidelines and food pyramids are used commonly in literature to construct healthy dietary scenarios to quantify the associated environmental impact (See [48], [50]). Those dietary scenarios are used as benchmark for healthy nutrition. Quantifying the nutritional quality of the dietary patterns has already been assessed with diverse approaches among environmental studies (See [23], [24], [59], [64], [86]–[88]). Nutrient profiling, nutrition quality indices and qualitative analysis using the epidemiological studies are the most commonly used approaches [52]. The first two approaches assume that the high nutritional quality is associated with improved health. The epidemiological studies as well as the recommendations by WHO [152], World Cancer Research Fund [153] and national guidelines are used to qualitatively assess the nutritional and health implications of diets over the health indicators ([16], [17], [52], [108], [122], [154]).

The commonly used nutritional indicators are low intake of fruits, vegetables and fish; type and amount of fatty acids; low fiber and high salt consumption, which have probable or convincing causal relationship with obesity, coronary heart disease (CHD) and cancer ([149], [152], [155]–[158]). Fruit and vegetable intake at least at recommended levels decrease the risk of obesity and cardiovascular diseases (CVDs) ([149], [152], [156], [159]). In addition, fruit and vegetables are linked to decreased risk of occurrence of type II diabetes and some type of cancers with probable evidence [152]. Fish consumption is linked to the decreased risk of CHD when consumed at optimal intake levels [156]. The type of fatty acids consumed (monounsaturated fatty acids-MUFA, polyunsaturated fatty acids-PUFA, saturated fatty acids-SFA) is also a determinant on the health implications of diets [152]. PUFA are abundant in vegetable oils such as soybean and sunflower whereas MUFA are abundant in olive and canola oil [152]. Nuts are also high in unsaturated fatty acids and low in saturated ones. Saturated fats are abundant in animal-based food products and some vegetable-based oils such as coconut, palm and palm kernel oils [152]. The intake of unsaturated fatty acids is favored over SFAs and carbohydrates as the latter ones are associated with increasing incidence of NCDs with convincing evidence ([152], [156]–[158]). The SFA intake in high levels increase the risk of CVDs whereas the shift to unsaturated fatty acids from SFA and carbohydrates are associated with lower risk of coronary heart diseases (CHD) ([152], [156], [158]).

Healthy Eating Index (HEI), a concept proposed for assessing the adherence to the dietary guidelines for United States by Kennedy and others (1995) [160] is also used to examine relationships between diet and health implications in environmental studies ([16], [108]). It is not directly applicable but a health score for diets can be calculated based on the concept as described in [15].

FAO, when proposing the sustainable diet concept, selected the Mediterranean Diet as an example dietary pattern for the concept [21]. Several epidemiological studies showed the link between adherence to the Mediterranean Diet and better health ([161]–[165]). In addition, the Mediterranean-type dietary pattern was assessed from an environmental perspective and those studies concluded that adherence to such dietary patterns are also better for environment ([17], [75], [166]). The Mediterranean Diet scenario is included in a substantial majority of studies as a benchmark for a sustainable diet ([16], [17], [96], [99], [154], [167]).

1.6 Turkish Food Consumption, Health and Environmental Implications

1.6.1 The Average Dietary Pattern and the Dietary Guidelines in Turkey

The nutritional habits of Turkish people change spatially, temporally and socio-economically [168]. However; it is right to state that Turkish people's main food comes from cereals and grains. According to the statistics provided by the Ministry of Health (MoH), 44% of daily calorie intake in Turkey is from bread. When the other grains and cereals are considered, the ratio rises to 58% [168]. The most recent nutrition and health survey in Turkey was completed in 2010 [169]. The main results of the Survey related to the average daily consumption of main food groups, for the adults older than 19 years old, are presented in Table 3.

The very first food-based dietary guidelines in Turkey was published in 2004. The last dietary guidelines was published in 2016 [170] by Ministry of Health (MoH). Turkey Dietary Guidelines (TDG), provided the healthy food plate for Turkish people. The guidelines categorize the foods under 5 main food groups [170], as provided in Table 4.

Table 3. Average Daily Intake per Food Group in 2010 (Tabularized from [169])

Food Groups	Average Daily Intake (adults > 19 years old) (g/day)
Meat	69,3
Egg	24,4
Legumes	9,1
Nuts, seeds, oil crops	6,9
Dairy and products	188,9
Fruits and Vegetables	548,3
Bread and other grains	277,2
Total fat and oil	32,8
Sugar-added food products	33
Water and other beverages	1682,3

Table 4. The key food groups and the recommended consumption amounts in Turkey Dietary Guidelines (Tabularized from [170])

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	3 – 4 portion/day	-150 gr cooked green leafy vegetables	Fruits and Vegetables ≥ 5 portions/day Green leafy vegetables ≥2,5 – 3 portion/day Fruits ≥ 2 – 3 portion/day
Fresh Fruits	2 – 3 portion/day	-(50 – 100 kcal)	
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

The TDG provided the recommended levels of energy and macronutrients based on gender and per each age group. The daily recommended levels of energy and macronutrients for healthy men and women in the age group 19-49, is presented in Table 5.

Table 5. The daily energy and macronutrient intake recommended for a healthy adult in Turkey

	Age Group	**Men**	**Women**	**Average Recommendations**
Total Calorie Intake (kcal/day)	19-29	2558[1]	2041[2]	-
	30-39	2452[1]	1977[2]	
	40-49	2429[1]	1934[2]	
Carbohydrates (%E)	18-50	45-60[3]	45-60[4]	45-60 %E
Fat (%E)	18-50	20-35[3]	20-35[4]	20-35 %E
Protein (g/day)	19-29	74.8[5]	62.4[6]	10-20 %E
	30-39	82.1[5]	70.3[6]	
	40-49	82.2[5]	77[6]	

[1] The recommendations for an adult healthy man who is assumed to be moderately active, with a height of 171 - 173 cm and BMI of 22 kg/m^2 in the 50% percentile are provided in the table.
[2] The recommendations for an adult healthy woman who is assumed to be moderately active, with a height of 156 – 159 cm and BMI of 22 kg/m^2 in the 50% percentile are provided in the table.
[3] For a healthy adult man
[4] For a healthy adult woman
[5] For a healthy adult man with a weight range in 72 – 79 kg.
[6] For a healthy adult woman with a weight range in 60 – 74 kg.

The occurrence of diet and weight-related diseases in Turkey was also reviewed to understand the trend in health outcomes of the dietary patterns. In 2008, obesity became the third most important risk factor for NCDs for adults in Turkey [171]. According to an estimation by WHO EU [172], 84% of all deaths during 2014 in Turkey were accounted to NCDs, 47% of which was associated with cardiovascular diseases. A detailed analysis of death-related demographic information can be found in Figure 3.

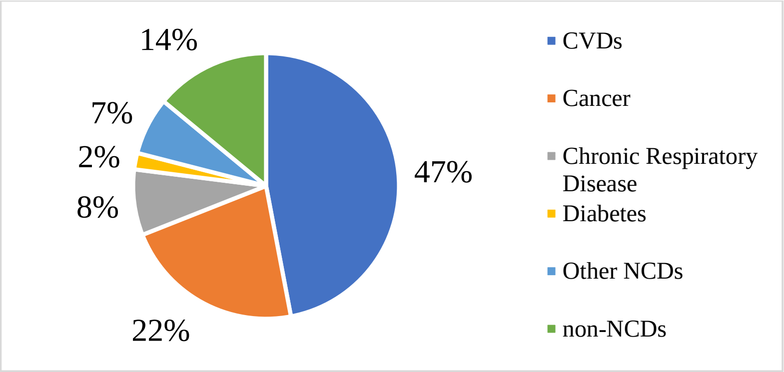

Figure 3. Main Causes of Deaths in Turkey in 2014 (Visualized from [171])

1.6.2 Diet and Food-related Environmental Outcomes in Turkey

Based on the planetary boundaries approach, proposed by Rockström and others [173], the selected issues; climate change, land system change, freshwater use and biogeochemical flows are examined based on the impacts associated with agricultural production. As an indicator for climate change, the percentage of agricultural global GHG emissions for Turkey and EU28 are calculated from the data provided by FAO for the year 2010 [18]. The world average ratio for agricultural GHG emissions is 10%. Agricultural GHG emissions ratio for EU28 (8.5%) and Turkey (9%) is lower than the world average. Land system change is assessed with the indicator; percentage of agricultural area to land area, calculated from the data provided by FAO [18]. Approximately 40% of global lands are used for agriculture. The ratio of agricultural land use is higher for EU28 (44%). The ratio of agricultural land use in Turkey is higher than the world and EU28 average and equal to 50%. Freshwater use is assessed based on the percentage of agricultural water withdrawal to total water withdrawal gathered from the AQUASTAT database [174]. The global ratio of agricultural water withdrawal is approximately 70%. The agricultural water withdrawal for EU28 countries are calculated excluding Bulgaria, Finland, Greece, Ireland, Italy and Portugal as there were not enough data to assess the countries mentioned. Agricultural production accounted for nearly 70% of total water withdrawal globally and more than 80% for Turkey in 2010 ([18] and [174]). From 1974, total area equipped for irrigation infrastructure to provide the crops sufficient water, have increased more than 65% globally and more than doubled (145% increase) in Turkey (Calculated from [18]). The change in biogeochemical flows that can be attributed to the agricultural production, is assessed with the indicator, percentage of synthetic fertilizer emissions in total agricultural emissions, calculated from the data provided by FAO for the year 2014 [18]. GHG emissions associated with synthetic fertilizers are the total emissions of N_2O expressed in CO_2 equivalent. The global GHG emissions associated with the use of synthetic fertilizers is 13%, which is lower than the EU28 and Turkey average. Approximately one third of agricultural emissions are associated with the use of synthetic fertilizers in Turkey (28%), which is higher than the EU28 average (19%). Figure 4 summarizes the selected indicators' ratio for the World, EU28 and Turkey to highlight the impact of agricultural production on the issues having planetary boundaries.

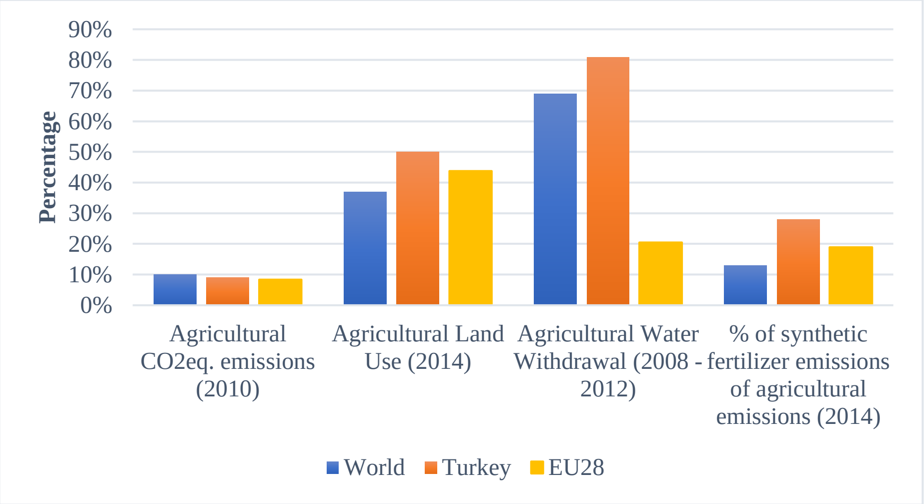

Figure 4. The proportion of a) Agricultural CO2 and equivalent emissions, b) Agricultural Land Use, c) Agricultural Water Withdrawal and d) Emissions from Fertilizer Use, globally, in EU28 and Turkey (Calculated from [17] and [174])

Related to agricultural production, main contributor activities to greenhouse gas emissions in Turkey are livestock production, nitrogenous manure use, stubble burning; which is the burning of residual crops following the harvest of cereals, and paddy rice production [175]. Most of the contribution to emissions are from CH_4 and N_2O, which are non-CO_2 greenhouse gases. Livestock production is responsible for the emission of CH_4 due to digestion of animals. Moreover, nitrogenous manure use is responsible for the emission of N_2O due to the storage of animal-oriented manure under oxygen-free environments. The stubble burning as a waste management activity in agricultural production is responsible for both CH_4 and N_2O emissions due to the burning process.

Based on the compiled results, GHG emissions and water footprint associated with food consumption in Turkey is selected as environmental impact categories that will be assessed over dietary scenarios. The study design and the main outcomes of other food-related environmental impact studies carried out in Turkey are provided in Appendix B in details.

1.7 Thesis Objectives

The general purpose of this thesis is to understand the nature of Turkish dietary pattern and the potential nutrition transition from 1960 to the future (2050), to assess the environmental impacts through quantification of water footprint and GHG emissions, and to evaluate the health implications of the dietary patterns. The special purposes of this thesis are to:

- Construct dietary scenarios for the years 1961, 2013 representing the food consumption,
- Develop the income-dependent 2050 dietary scenarios for Turkey,
- Estimate the GHG emissions and water footprint of those dietary scenarios, identify the main contributors to environmental impacts, compare the results with other hypothetical diets; the Mediterranean Diet and the Turkey Dietary Guidelines (considering the importance of the two impact categories for Turkey and the data accessibility (availability of the data for a wide range of food products, which is also significant for other researchers), other impact categories are not included),

- Evaluate the health implications of the dietary scenarios in relation with the environmental implications,
- Highlight the improvement potentials of the dietary pattern into a more sustainable diet.

The main hypotheses of this study are:

1) The environmental impacts associated with the food consumption of an average person in Turkey is expected to be lower than the European averages.

2) The environmental impacts associated with the food consumption of an average person in Turkey in 2050 is anticipated to be higher than present due to the increasing consumption of meat and other energy-dense foods.

3) The shift to a healthy diet is expected to have better health and environment implications than the current average diets followed in Turkey.

CHAPTER 2

MATERIALS AND METHODOLOGY

2.1 The Dietary Scenarios

FAO food balance sheets (FBSs) provide yearly supply levels of the food products for a specific country or region. Use of FBSs as a resource to construct dietary scenarios is widespread in the literature ([94], [134], [166]). Based on the data provided for the years 1961 and 2013, the change in food supply levels in Turkey were examined and the probable nutrition transition in Turkey was evaluated over the dietary scenarios representing the Turkish food consumption from 1961 to 2013. 1961 was the first and 2013 was the last years that the yearly food supply levels were provided by FAO for Turkey at the time of this study. The 1960s and 2010s have distinct properties economically, socially and environmentally in relation to agricultural production and consumption. The intensification of agriculture, use of fertilizers and pesticides, greenhouse cultivation and import of agricultural technology; which are associated with increasing environmental impact of agriculture, were limited until the mid-1960s in Turkey [175]. In addition, both protection and conservation acts, such as wetland protection practices, were also firstly initiated in the same period. From 1960 to 2000; the average agricultural enterprise-owned land increased by 10% [175] and the agricultural land use expanded by 6% from 1961 to 2013 [18]. Moreover, the total population more than doubled approaching to 2010 while the share of rural population shrank from 68% to 32% in total population [175].

The food groups that were examined to understand the nutritional transition in Turkey were meat products, fruits, vegetables, cereals and the hypothetical group of empty calories, which was constructed to describe the change in food supply to a more calorie and fat-dense foods (sum of total intake of sugar and sweeteners, animal fats, vegetable oils and alcoholic beverages in terms of kg capita^{-1} year^{-1} and kcal capita^{-1} day^{-1}) in addition to the total caloric intake. For benchmarking, EU28 average values provided by FAOSTAT for the same period were used in examination. In addition, the change in environmental impact associated with the food consumption in Turkey, in terms of GHG emissions and water footprint were evaluated.

For the environmental and nutritional assessment, the 1961 and 2013 dietary scenarios, the hypothetical income-dependent 2050 dietary scenarios (ID 2050 (A1) and ID 2050 (A2)), the Mediterranean diet scenario (MED) and a healthy dietary scenario with 2000 Calories daily, provided by Turkey Dietary Guidelines [170] (TDG-H) were developed. Using the suggested daily intake levels provided in [16], [165], [176], a hypothetical 2000 kcal/day Mediterranean diet for this study was constructed. The proportions within the food groups were kept identical to 2013 levels. The ratio of each food product supply in the 2013 diet was used to determine the daily intake levels of the same food products in the simulated Mediterranean diet. Turkey Dietary Guidelines (TDG) provided the recommended daily and weekly portions of the key food groups for a 2000 kcal day^{-1} diet [170]. The average daily calorie requirements of low active men and moderately active women aged between 18-49 years in Turkey, which were calculated due the 50th percentile height and BMI = 22 kg/m^2, were calculated as 2057 kcal day^{-1} [170][1]. Accordingly, the 2000 kcal day^{-1} diet was selected as a reference healthy diet for the population. In order to determine the daily consumption of food products in grams, the reference values per one portion of a food product provided in TDG were used in calculations (Table 6).

Table 6. The factors used in converting serving sizes to grams [170]

Food Products	Fruits	Vege-tables	Milk	Eggs	Poultry	Red Meat	Fish	Legumes	Nuts & Seeds	Starchy Roots
g/portion	150	150 [a]	240	100	100 [a]	100 [a]	250 [a]	50 [a]	30	90 [a]

[a] Portion size of uncooked food products

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[1] The writer discussed about it with one of the co-writers of TDG; Prof. Dr. Sevil Başoğlu.

The recommendations of TDG for the food groups, were converted into daily recommended intake in grams, are summarized in Table 7, with the methodology followed in constructing the 2000 kcal day^{-1} healthy diet (TDG-H). Bread was converted to wheat equivalent, using the conversion factors applied as in FBS calculations by FAO [177]. The calories associated with foods and the diet in TDG-H were calculated based on the nutrition facts applied in FBS calculations by FAO [139].

For the environmental assessment, all dietary scenarios were adjusted to 2000 Calories daily (isocaloric). Thus, the environmental impact of the dietary scenarios was compared on a caloric-equivalent basis. In addition, the change in environmental impact in case a shift from one dietary scenario to another was possible without changing the energy intake. In addition, as the MED and TDG-H only included the recommended intake per food products, the food loss and waste rates per food products were incorporated into the indicated scenarios. Prior to assessment, all dietary scenarios were equivalent over total calories per day and for food loss and waste. On the other hand, for the nutritional assessment and to point out the health implications, all dietary scenarios were adjusted to loss and waste and then the total calories associated with them were adjusted to 2000 Calories daily. As the main dietary scenarios for Turkish Food Consumption was developed using FBSs, the amount of food supply or food calories were the food/calorie available for human consumption. The terms, food consumption or intake (when used especially in assessing the dietary scenarios) stand for the availability of food and calories in Turkey for the indicated period of time.

Table 7.Total Recommended Intake Amounts from TDG for a 2000 kcal-day healthy diet and assumptions used to simulate the TDG-based Healthy Diet (TDG-H)

The Food Groups	Total (g/cap/day)	NOTES AND ASSUMPTIONS
Meat, poultry, fish, eggs, legumes	218.2	Proportions within the food group, as recommended in TDG [170], were used to calculate the sub-food products.
Red Meat	35.5	Daily Recommendation = 0,60 portion a day
Poultry	35.5	Daily Recommendation = 0,60 portion a day
Fish	71.5	Daily Recommendation = 0,29 portion a day
Eggs	35.7	Daily Recommendation = 0,35 portion a day
Legumes	25	Daily Recommendation = 0,50 portion a day
Nuts and Seeds	15	Daily Recommendation = 0,50 portion a day
Fresh Vegetables	410	Proportions within the food groups were kept identical to 2013 levels.
Fresh Fruits	375	Proportions within the food groups were kept identical to 2013 levels.
Starchy Vegetables	38,5	Potatoes are selected as to represent the starchy vegetables. Proportions within the food groups were kept identical to 2013 levels.
Milk, yoghurt and cheese	720	All is assumed to be taken from milk. No conversion factors were used.
Oil	30	Olive Oil is recommended only. Other oils and fats are excluded from this dietary scenario.
Bread and Cereals Group	225	Wheat Equivalent is calculated: The world average of getting wheat flour from wheat = 79% [177]. The bread has 100 -130% more weight than the wheat flour (115% in average) [177]. 225 g of bread = (225/1,15) = 195,7 g wheat flour; (195,7/0,79) = 247,67 g of wheat per day
Total Energy (kcal)	2002	The calculated amounts in TDG [170]
Total Protein (g)	95	The calculated amounts in TDG [170]
Protein, (% kcal)	19%	The calculated amounts in TDG [170]
Total Fat (g)	78 – 80	The calculated amounts in TDG [170]
Fat (% kcal)	34 - 35%	The calculated amounts in TDG [170]

The food loss and waste ratios were compiled from the FAO-supported report [178] prepared for Turkey. To the best of the writer's knowledge, it is the possible best approach that is available to adjust the FBS data for food loss and waste. The food waste and loss rate estimates for the key food groups at each supply chain stage, that were used to calculate the percentage of mass that is lost or wasted within each group are provided in Table 8.

Table 8. The Food Loss and Waste Rates in Turkey (Tabularized from [178])

		THE SUPPLY CHAIN STAGES				
FOOD GROUPS	PRIMARY FOOD PRODUCTS	Postharvest handling and storage (%)	Processing & Packaging (%)	Distribution (%)	Consumption at household (%)	Food Waste & Loss (%) (Calculated Average)
Cereals	Wheat, barley, corn	4	2	1	5	11.52
Roots and Tubers	Sugar beet, Potatoes	6	2	3	2	12.43
Oilseeds	Sunflower seeds and sesame seeds, Oil crops, Vegetable Oils (excl. Olive oil)	5	7	1	4	16.03
Pulses	Chickpeas, lentils and dry beans	5	7	1	4	16.03
Vegetables	Tomatoes, peppers and cucumbers	8	10	10	5	29.21
Fruits	Grapes, olives and apples; Olive oils	8	10	10	5	29.21
Meat	Meat (beef, chicken, mutton and goat)	0,2	5	0,5	1	6.61
Fish and Seafood	All	0,02	0,04	0,01	2	2.07
Milk	Milk (cattle, sheep, goat and buffalo)	1	1,5	6	1,5	9.71
Eggs	Eggs	1	2	1	0,01	3.96

The waste and loss rates at the agricultural production stage were excluded from calculations as the FBS data are assumed to be compiled from the official statistics, recorded after the agricultural production is complete. The average food loss and waste rates were the average of rates at the supply chain stages indicated in the Table above.

2.1.1 Statistical Analysis: Extrapolation of the Food Consumption Data to Project the Income-dependent 2050 Dietary Scenarios for Turkey

FAO FBS data were used to construct the income-dependent 2050 dietary scenarios for Turkey. The historical food demand data was put together from the FAOSTAT database for the years 1980 to 2010. The historical demand for the selected food groups in EU28 was also gathered as a benchmark for Turkish consumption.

Historical data on per-capita income were gathered from an open-source study, carried out in 2015 to project the global food demand in the coming century [140]. They also provided the per capita income projections for more than 160 countries, which were in constant US$$_{2005}$ based on market exchange [140]. The EU28 weighted average income per capita was calculated using the same data. The historical population data were multiplied with the per capita GDP to calculate the EU28 total GDP for each year. Then, the total GDP of EU28 was divided by the total population of EU28 to obtain weighted average income per capita in EU28.

Bodirsky and others (2015) [140] calculated the income projections based on the Special Report on Emissions Scenarios (SRES) storylines, which are developed by IPCC to describe the relationship of the drivers of GHG emissions and climate change as well as to predict the future relationships to develop mitigation strategies. There are 4 storylines developed by IPCC [179]. A1 and A2 scenarios describe a world where the main emphasis is on the economic and technological growth. A1 scenario describes a globalized world with globalized economic growth whereas, A2 describes a regional one. For this study, A1 and A2-based income scenarios, gathered from [140], were used to statistically model the relationship between the income and meat demand, total calorie supply and empty calorie supply as the intake of meat and empty calories are claimed to increase with rising income [17], increasing the total calories daily. Then, the A1 and A2 income scenarios-based projections were used to predict the income-dependent food demand in 2050.

Different linear or non-linear regression models can be applied to formulate the relationship between food demand and income (See [17], [140], [142], [146]). For this study, the food demand was assumed to be in relation with income only as the data on other regressors are not available for use. Following the approach by Cole and McCoskey [142], EKC in a quadratic shape was applied to extrapolate and forecast the income-dependent 2050 diet. The data was prepared and analyzed using the statistical software JMP by SAS [180]. The linear and nonlinear regressions were carried out to compare the accordance of them to the data points based on the main statistical approaches.

The meat demand and total calories were plotted against the historical data on per-capita income for the years 1980 to 2010. The Figure 5 (A and B) presents the scatterplot drawn to see the potential relationship between income and meat demand in Turkey and in EU28.

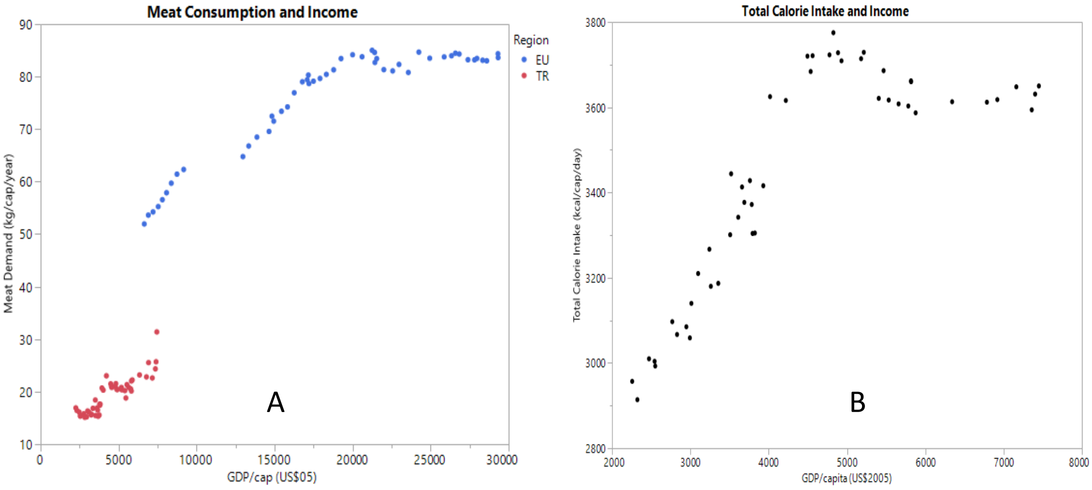

Figure 5. The relationship between meat demand and income (Turkey and EU28). EU: European Union, TR: Turkey. (A: The relationship between meat demand by weight and the income in GDP/capita; B: The relationship between total calories and the income in GDP/capita)

The linear relationships, which are curvilinear as shown above, between income (GDP capita^{-1} year^{-1}), meat demand (kg capita^{-1} year^{-1}) and total calorie demand (kcal capita^{-1} day^{-1}) were ensured by plotting a scatter diagram. Then, the possibility of an Environmental Kuznets relationship was examined and a quadratic relationship was tested for the formulation below:

$$Meat = \alpha + \beta_1 x\ Income + \beta_2\ x\ Income^2 + \varepsilon \qquad (1)$$

The empty calories are the total caloric demand for the animal fats, oils, sugars and alcohol [17]. The assumption of Environmental Kuznets Curve was also applied to the total empty calories demand. The total empty calories demand per capita in Turkey was plotted against the historical data on per-capita income for the years 1980 to 2010 to test any relationship. The scatterplot of this relationship is given in Figure 6 (A and B). The scatter plot reveals a linear relationship between income (GDP capita^{-1} year^{-1}) and empty calories demand (kcal capita^{-1} day^{-1}). In order to make sure that the empty calories supply and income has a similarity to EKC, the EU28 data for empty calories supply and income was also settled into the graph (as EU28 is selected as a benchmark because of their higher income levels). The Figure 6-B provides both empty calories supply for EU28 and Turkey versus the average income levels per capita. When the EU28 data for empty calories were added to the scatter plot, the linear relationship between the income and empty calories turned into a quadratic polynomial. Based on this result, it was assumed that, the Turkish empty calories supply would follow a trend similar to the EU28.

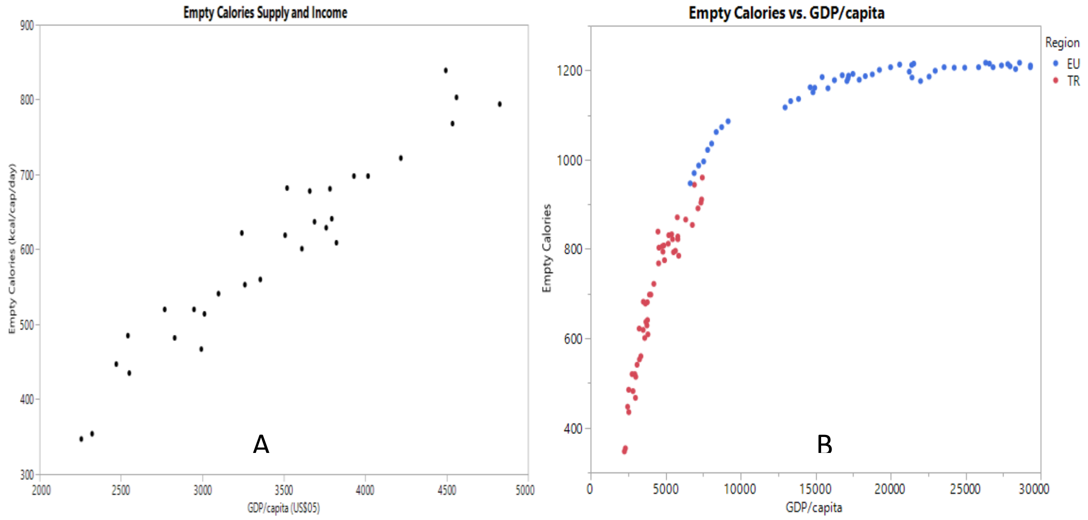

Figure 6. The relationship between total energy and empty calories with income (Turkey and EU28). EU: European Union, TR: Turkey

The projected meat supply/demand in kg capita^{-1} year^{-1}, total calorie supply and empty calories supply in kcal capita^{-1} day^{-1} values for 2050 were used to construct two income-dependent 2050 diets (ID 2050 A1 and A2), as the projections were made based on two income scenarios. The daily meat calorie supply levels were calculated from meat supply in kg capita^{-1} year^{-1}. The sum of projected meat calories and empty calories per day were extracted from the projected total calorie supply. The rest of the calories were compared with the 2013 diet and a ratio of change was calculated. The ratio was applied to the rest of the food groups and without changing the food pattern in the groups, the calorie and kg per year supply levels for all food products were determined.

All dietary scenarios that were constructed to be used in environmental and nutritional assessment are provided in Appendix C.

2.2 Water Footprint Assessment to Quantify the Dietary Water Consumption

There are two main approaches for the assessment of Water Footprint (WF) in scientific literature. The first one is the approach developed by the Water Footprint Network [127] and the second one is developed for the Life Cycle Approaches by the LCA community [181]. As the WF methodology is more detailed and employed by numerous studies to assess the WF related to the dietary consumption (See: [129], [134], [137]), the same approach is used in this study.

Mekonnen and Hoekstra [182] calculated the water footprint of consumption for food products for regions, countries and the basins of a specific country. In addition, weighted averages for the countries were also calculated for the time period 1996 to 2005. The average water footprint of consumption data for the food products in Turkey were gathered from the data set as provided in [182]. The WF of consumption for fish and other seafood are not included in the data set so they were excluded from the WF assessment of the dietary scenarios. The weighted average water footprint of consumption of the food products in Turkey was multiplied by the food supply amounts constituting the dietary scenarios. All three components of the WF (green, blue and grey) were calculated for the Turkish dietary scenarios constructed.

2.3 Life Cycle Approaches to Quantify the Dietary GHG emissions

The GHG emissions associated with food products are generally calculated by using life cycle methodologies in the literature. To find the GHG emissions for the food products, a meta-analysis was conducted as there is not enough country-specific life cycle or carbon footprint data in Turkey to calculate the actual GHG emissions of food supply. The meta-analysis conducted in the life cycle assessment studies that were carried out in the Mediterranean Region were used to compile the Mediterranean average life cycle GHG emission factors per kg of each food product. The life cycle assessment studies carried out in Mediterranean countries including France, Greece, Italy, Spain and if possible, Turkey, Portugal and Cyprus were used to compile the Mediterranean average GHG emission factors for food products and groups. The food life cycle databases, AGRIBALYSE [183] and Agri-Footprint [184] were also examined to find additional GHG emission factors on food products. The emission factors found for each food product in literature were selected kg-product as the functional unit. They were classified according to the system boundaries selected by the scientific study for life cycle assessment. Then, the data with same system boundaries (and mostly cradle-to-gate) were chosen to calculate the Mediterranean average for that specific food product. Due to the differences in climate, production methods and technologies as well as the use of chemicals, applied among the Mediterranean countries in agricultural production; the maximum, minimum and average life cycle GHG emission factors found for most of the food products were incorporated in estimating the GHG emissions of the dietary scenarios. The minimum and maximum emission factors were used to provide a range of GHG intensity for each food product.

GHG emission factors for 64 food products were compiled. Based on the country-specific GHG emissions, a Mediterranean average was calculated for more than 50% of the food products in the food supply list provided by FAOSTAT (38 food products). For some of the products, there was only one scientific publication or data provided for one of the countries in the selected research region. For that reason, that single GHG emission factor was used as the Mediterranean average in calculations (13 food products). For the food products that did not have any LCA studies carried out in the research region, the GHG emissions calculated with a Life Cycle approach in other countries (US, The Netherlands, Sweden, Brazil, Philippines, Ecuador) were used as emission factors (13 food products). The Mediterranean Average GHG emission factors of food products were used in quantifying the GHG emissions associating with food consumption given in the dietary scenarios. The minimum and maximum GHG emission estimates were also included to create ranges of emission for each food product. The Appendix D includes the detailed results of the meta-analysis carried out in literature as well as the Mediterranean average GHG emission factors for foods.

To quantify the total GHG emissions of the dietary scenarios, the Mediterranean average GHG emissions associated with food products were multiplied with the food supply per capita per day in the dietary scenarios. Then, the daily GHG emissions associated with the dietary scenario as well as the GHG emission per kcal of diet were calculated to carry out comparisons in between the dietary scenarios.

2.4 Assessment of Health Implications of the Dietary Patterns

For the nutrition and health assessment, all dietary scenarios were adjusted to probable food loss and waste, then the total calories were degraded to 2000 kcal-day basis. The total energy of the Mediterranean and healthy dietary scenarios (TDG-H) was calculated using the nutritional information provided in FAOSTAT [18] to make those scenarios compatible with other diets. The energy associated with TDG-H was found to be 7% higher than the energy level calculated for the same diet in the guidelines, [170]. The total calories associated with the Mediterranean Diet was calculated as 2579 kcal capita^{-1} day^{-1}; which was 29% more than the calculated calories in [16].

Secondly, the dietary scenarios developed were assessed due to their health implications. The adherence to the dietary guidelines was selected as the first indicator to qualitatively assess the nutritional quality of the dietary scenarios. In addition, the epidemiological studies were referred in discussing the health implications of the dietary scenarios. For this study, coronary heart disease (CHD) was selected as the indicator of health gain and the dietary indicators were determined based on the probable or convincing causal relationships they have on CHD. The following causal relationships were considered in qualitatively assessing the diets in terms of health:

1) Higher consumption of fruits and vegetables lower the risk of obesity and cardiovascular diseases (especially CHD) with evidence ([149], [156]).

2) Increase in the consumption of fish is associated with lower risk of coronary heart disease (CHD) ([156]).

3) The limited saturated fatty acid (SFA) intake is associated with lower risk of CHD ([149], [158]).

4) Replacing calories from carbohydrates or SFA with PUFA have significant benefits on CHD ([156], [158]).

5) Increased consumption of pulses, nuts and seeds will lower the risk of CHD [156].

Risk relationships of fruits, vegetables, pulses, nuts and seeds and fish intake as well as share of PUFA calories in total energy with coronary heart disease (CHD) were compiled from recently published epidemiological studies. The indicated food groups and PUFA content were selected as the indicator for assessing the health implications of diets as they were the most frequently studied dietary and nutritional factors in relation to health as there is causal relationships between them and CHD with probable or convincing evidence [156]. The optimal intake levels in [156], that were determined considering the lowest disease risk-associated amounts in meta-analyses, feasibility and consistency with global extensive dietary guidelines, were assumed to be another healthy eating indicator. The risk relationships for the intake levels of the indicated food groups and the share of PUFA in total energy are summarized in Table 9.

Table 9. Estimates of causal relationships of dietary factors with probable or convincing evidence and risk of CHD (Tabularized from [156])

DIETARY FACTORS			**Relative Risk (a)**				
Food Group	**Optimal Intake (b)**	**Health Outcome**	**MIN**	**MAX**	**AVG**	**Unit of Relative Risk in case of increase**	**Reference**
Fruits	300	Lower CHD	0,91	0,98	0,94	per 100 g/day intake	[156]
Vegetables	400	Lower CHD	0,92	0,98	0,95	per 100 g/day intake	[156]
Pulses	100	Lower CHD	0,65	0,9	0,77	per 100 g/day intake	[156]
Nuts and Seeds	20	Lower CHD	0,67	0,84	0,78	per 4 servings/week	[156]
Fish and Seafood	50	Lower CHD (fatal)	0,9	0,98	0,94	per 15 g/day intake	[156]
NUTRIENT-RELATED FACTORS			**Relative Risk (a)**				
Nutrients	**Optimal Intake (b)**	**Health Outcome**	**MIN**	**MAX**	**AVG**	**Unit of Relative Risk in case of increase**	**Reference**
PUFA replacing carbohydrates	11%E	Lower CHD	0,85	0,94	0,9	per 5%E/day intake	[156]
PUFA replacing SFA	11%E	Lower CHD	0,87	0,96	0,96	per 5%E/day intake	[156]
PUFA replacing SFA or carbohydrates	12%E ± 1.2%E	Lower CHD			0,87	per 5%E/day intake	[158]

(a) increased consumption of each dietary target per unit of relative risk and respective change in disease risk
(b) Calculated For 2000 kcal per day diet

In addition, using the approach in Healthy Eating Index by Kennedy and others (1995) [160] and the optimal intake levels, as indicated in Table 9, the health scores for the dietary scenarios were calculated based on the 5 nutritional indicators; the intake of fruits, vegetables, pulses, nuts and seeds and fish, using the following formula:

$$Health\ Score_{DS_i} = \left(\frac{gram\ vegetables_{DS_i}}{400} + \frac{gram\ fruits_{DS_i}}{300} + \frac{gram\ pulses_{DS_i}}{100} + \frac{gram\ nuts_{DS_i}}{20} + \frac{gram\ fish_{DS_i}}{50}\right) \div 5 \times 100 \text{ (DS: dietary scenario)}$$

All the indicators were weighted equally in estimating the health score of the dietary scenarios. The associated MUFA, PUFA and SFA with single food products were calculated for each dietary scenario, based on the fatty acid content per 100 gram of food products, as provided in TURKKOMP ([185]) and USDA Food Composition Database ([186]).

CHAPTER 3

RESULTS

3.1 The Dietary Scenarios for 1961, 2013 and 2050

The dietary scenarios for the years 1961 and 2013 were created based on the FBS data, which can be examined in details in Appendix C. In the 1961 dietary scenario, most of the calorie intake (58% of total energy, %E) was associated with cereals food group. It was followed by milk (10%E) and fruits (6%E). In the 2013 dietary scenario, the cereals also constituted most of the calorie intake (44%E). Different from 1961 it was followed by vegetable oils (14%E), milk (9%E) and sugar and sweeteners (8%E). The composition of the dietary scenarios was depicted in Appendix I Figure I1.

3.1.1 The Income-Dependent Dietary Scenarios

To extrapolate the meat demand into the year 2050, a regression model was applied. The regression function for EU28 and Turkey revealed statistically meaningful results. The results for the quadratic polynomial regression, best fitted to the data points are provided in Table 10.

Table 10. The Regression Results for the Meat Demand and Income Relationship

Parameters	Results	The Function
Intercept (α)	-13.74	$Meat = -13,74 +$
Income (β_1)	0.00778	$0,00778\ x\ Income -$
Income squared (β_2)	$-1.595244e^{-7}$	$1,595244e -$
Error (ε)	4.78118	$7\ x\ (Income)2 + 4,78118$

Using the regression equation with income scenarios A1 and A2, the following results were gathered for meat consumption in 2050 in Turkey (Figure 7).

Using the quadratic polynomial function, the tipping point (the income level) where the meat demand would reduce with the increasing income was found as approximately US$24385 per capita-year. This regression function gives statistically significant results in between the income levels, US$1176 and US$47574 as the quadratic polynomial can result in negative values for meat demand for higher GDP/capita.

Figure 7. The historical and forecasted meat demand. MC: meat consumption. The red circles are the historical meat consumption per capita per year; gathered from FAOSTAT [17]. The green plus signs and the blue circles indicate the trend in meat consumption to the year 2050 with respect to the change in income.

Quadratic polynomial regression model was also applied to extrapolate the total energy and empty calories associated with the income dependent 2050 diets. The parameters and the fitted quadratic polynomial function for both total and empty calories in relation with income were provided in Table 12. Using the quadratic polynomial function, the tipping point (the income level) where the total energy and empty calories would reduce with the increasing income was found as approximately US$6000 and US$20965 per capita-year, respectively. The regression functions gave statistically significant results in between the income levels up to US$13711 for total energy up to US$46000 for empty calories.

Using the regression equation with income scenarios A1 and A2, the following results were gathered for total energy and empty calories in 2050 in Turkey (Figure 8).

Table 11. The Regression Results for the Total and Empty Calorie Demand in relation with income

Total Calorie and Income Regression Results		
Parameters	Results	The Function
Intercept (α)	2754.52	$Total\ Calories\ = 2754{,}517431 + 0{,}741527897\ x\ Income - 0{,}000062504\ x\ (Income)2 - 1244{,}95258$
Income (β_1)	0.74	
Income squared (β_2)	-0.000062504	
Error (ε)	-1244.95	
Rsquare	…	
Total Empty Calories and Income Regression Results		
Parameters	Results	The Function
Intercept (α)	639.69	$Tot.Empty\ Calories = 639{,}69062139 + 0{,}085054072\ x\ Income - 0{,}0000020271497285696\ x\ (Income)2 - 272{,}5866365$
Income (β_1)	0.085	
Income squared (β_2)	-0.0000020271497285696	
Error (ε)	-272.59	
Rsquare	……	

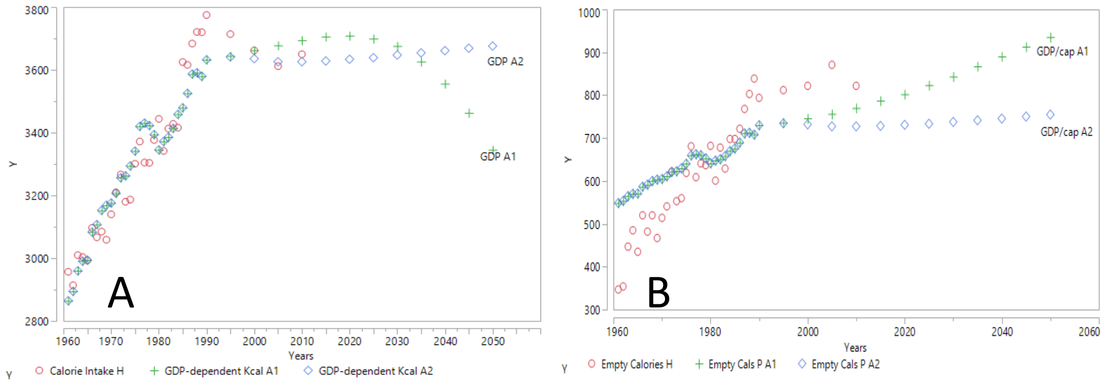

Figure 8. The historical and forecasted total energy and empty calories. The red circles are the historical total energy and energy from empty calories per capita daily, gathered from FAOSTAT [18]. The green plus signs and the blue circles indicate the trend in calories extrapolated to the year 2050 with respect to change in income.

In the income dependent diet scenarios for the year 2050 with A1 and A2 development scenarios, the two main calorie suppliers were identical with the ones in 2013 diet. Cereals constituted 42%E and 48%E in the 2050 A1 and A2 diets respectively, followed by the vegetable oils; which constituted 15%E and 11%E in the diets. In ID2050 A1 scenario, the proportion of calories from sugar and sweeteners increased and reached to 9%E whereas the proportion of calories from dairy decreased to 8%E. The amount of sugar and sweeteners in the 2050 A1 dietary scenario was 126% higher than the recommended level in the dietary guidelines by weight. Differently, in ID2050 A2, the proportion of calories associated sugar and sweeteners decreased to 7%E; which was still more than 60% higher than the recommended intake. The proportion of calories from dairy increased to 9.4%E, which was higher than the 2013 levels. The ID 2050 A1 dietary scenario was high in poultry, animal fats, red meat, vegetable oils and cereals.

3.2 Change in Environmental Impact due to Nutritional Transition in Turkey from 1961 to 2013

In Turkey, the total calorie supply per capita increased approximately 25% from 1961 to 2013, and had been higher than the EU28 averages since the mid-1970s (Figure 9-A). The main contribution to the increase in calorie supply per capita was associated with empty calories food group (175% increase) (Figure 9-B).

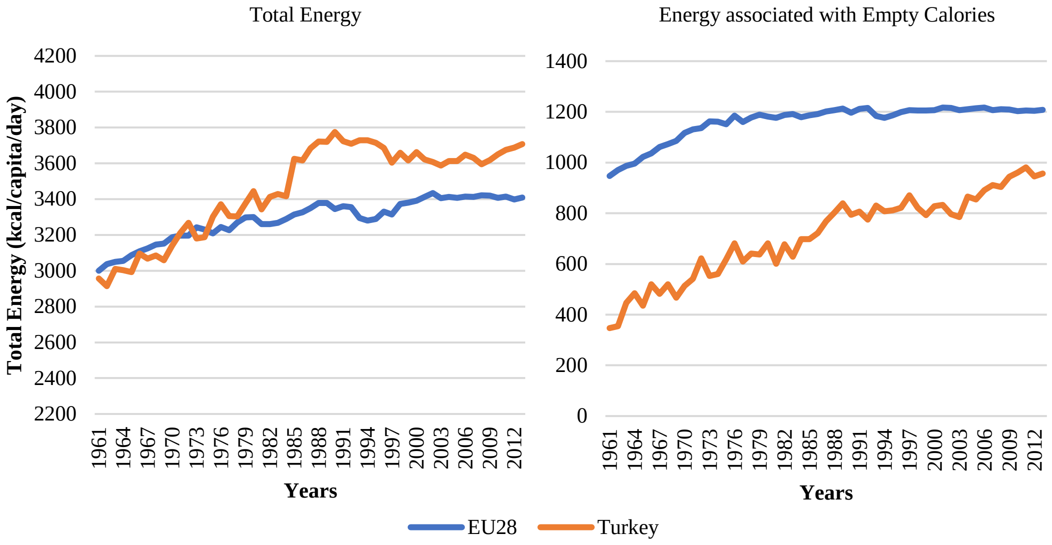

Figure 9. The trend in total energy and empty calories supply for Turkey and EU28 (1961 - 2013) (Visualized using the FBSs, [17])

For the indicated period, the proportion of calories from fat was in the recommended range (20-35%E) (Figure 18). The main fat supplier food group in Turkey was the vegetable oils, followed by animal fats, nuts, oil crops and meat. The proportion of protein calories in Turkey remained stable around 12% in the same period, which was closer to the lower end of the recommended level (10 – 20%E) in TDG [170] (Figure 10). In 1961, 12.6% of total energy supply was from protein, which was equivalent to 90 grams per capita daily. The amount increased to 108 grams per capita (20% increase daily) however, the percentage of protein calories decreased to 11.8% in 2013. Cereals were the main protein suppliers in Turkey (App. H, Fig. H1).

However, the proportion of plant-oriented protein supply decreased from 72% in 1961 to 66% in 2013. Animal-oriented protein supply followed an increasing trend from 1961 (20%), with a higher rate since 2002 (App. H, Fig. H1).

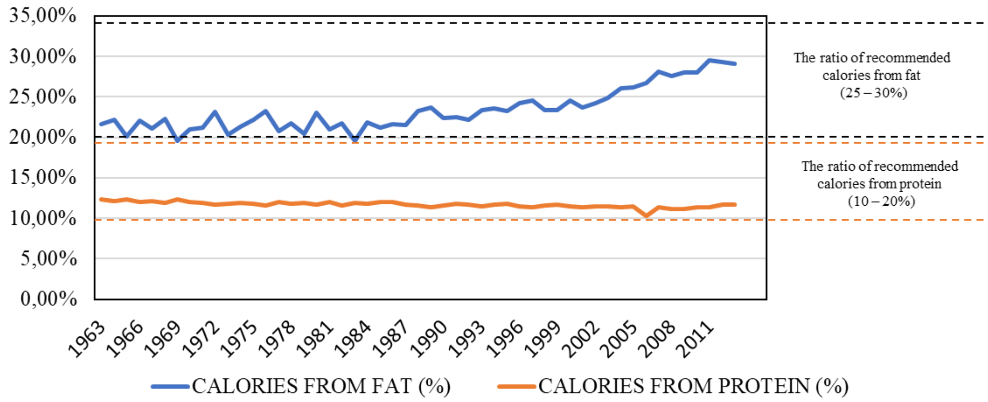

Figure 10. The proportion of fat and protein calories in total energy supply (%E) (Visualized using the FBS data for Turkey, [18])

Table 12 provides the relative change in the amount of food products (by weight and calories) in the diets with the relative change in environmental impact in terms of GHG emissions and water footprint from 1961 to 2013. The supply of poultry, eggs, sugar, vegetable oils and alcoholic beverages increased considerably from 1961 to 2013. In the vegetable oil food group, the calories from sunflower seed oil rose approximately 980% and constituted more than 200 kcal/capita in 2013 diet. In addition, the calorie supply from maize germ oil rose more than 300%, constituting the daily 31 kcal/capita in 2013 diet. Palm and palm kernel oil were not the part of the diet in 1961 whereas, for the 2013 diet, more than 20% of vegetable oil calories were from those oils. The only type of vegetable oil whose consumption considerably decreased was the olive oil. There has been 67% decrease in olive oil calories supply per capita, which was more than 40% of total vegetable oil calories in 1961 and decreased to 5% in 2013. In animal fats group, the raw animal fat (lard and other meat-oriented fats) calories supply increased 650% whereas the butter calories decreased approximately 6% in 2013 compared to 1961. Considering the origin of food products, both animal and plant-based food consumption per capita increased more than 20%. Beneath the animal-based calories, the energy supply from eggs increased 313%, constituting the highest rate of increase. The ratio of beef calories in total meat calories rose from approximately 15% to 30%, whereas the ratio of poultry calories in total meat rose from 8% in 1961 to 47% in 2013. Plant-oriented calories, on the other hand, increased 26%. The increase in the proportion of plant-based calories was mostly associated with vegetable oils. Despite the decrease in fruit and cereal calories, the supply of vegetable and fruit calories in Turkey was always higher than the EU28. The trend of food supply for the main food groups is visualized in Figures G1-G7 in Appendix G for Turkey in comparison with EU28 averages.

Table 12. Relative change in food consumption (% by weight and by calories), GHG emissions and water footprint (%) between 1961 to 2013. Positive values indicate an increase and negative values indicate a decrease.

	% by weight	% by associated calories	GHG emissions	Water Footprint
MEAT	107	45		
Red Meat	*14*	*17*	15	112
Poultry	*713*	*684*		
FISH	154	120	124	-
DAIRY	8	8	8	8
EGGS	312	313	312	312
EMPTY CALORIES	216	175	101	82
Sugar	*350*	*348*	*237*	*368*
Vegetable Oils	*168*	*168*	*205*	*65*
Animal Fats	*15*	*15*	*15*	*13*
Alcoholic Beverages	*247*	*200*	*203*	*150*
CEREALS	-3	-3	0.45	6
FRUITS	-2	-24	16	-19
VEGETABLES	62	53	98	48
TOTAL			**30.7**	**29.4**

The WF associated with food supply increased from 3233 liters capita^{-1} day^{-1} in 1961 to 4184 l capita^{-1} day^{-1} in 2013 (29.4% increase). The green WF constituted more than 80% of all WF since 1961, ranging between 80.3 to 82.3%, whereas the proportions of blue and grey WF in total did not change much. Blue WF was 304 liters per capita in 1961 daily; constituting the 9.4%; and rose to 458 liters in 2013; constituting 11% of total WF. The Grey WF was 267 l capita^{-1} day^{-1} in 1961 and increased to 330 liters capita^{-1} day^{-1} in 2013. The increase in WF from 1961 to 2013 was mostly associated with the increase in meat (60% of all increase), vegetable oils (13%) and sugar (9.3%). When the average Mediterranean emission factors were considered, the GHG emissions associated with food supply (including the food loss and waste in all supply chain stages) increased from 2.6 to 3.3 kg CO2eq capita^{-1} day^{-1} (30.7% increase). GHG emissions associated with food supply in Turkey did not change much until 2010, ranging in between 2.5 to 2.9 kg CO2eq capita^{-1} day^{-1}. The increase in emissions accelerated in between 2010 to 2013 (14% increase) (Figure 11). The increase in GHG emissions from 1961 to 2013 was mostly due to the increase in vegetables (42% of increase), poultry (20%), meat (12%) and dairy (8%) supply.

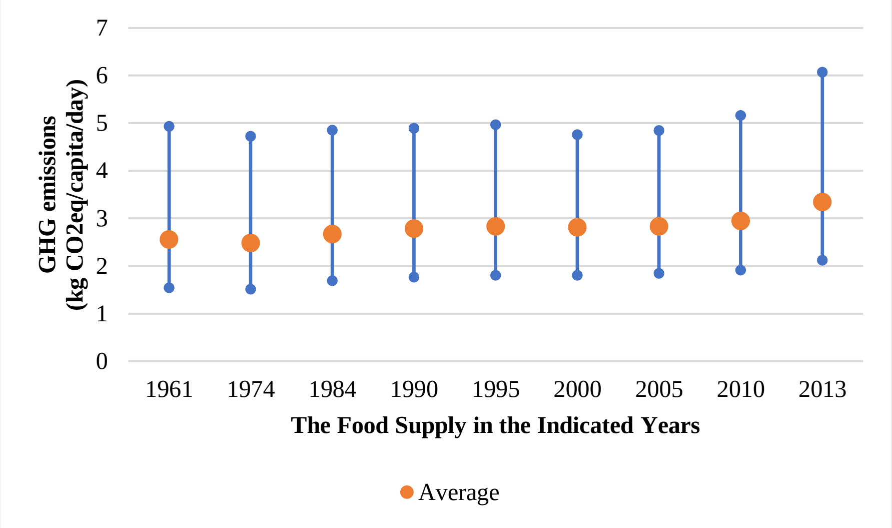

Figure 11. The GHG emissions associated with the food supply in Turkey (1961 - 2013). The GHG emission estimations were calculated based on the minimum, average and maximum Mediterranean life-cycle GHG emission factors per kg of each food product.

3.3 Environmental Assessment of the Turkish Dietary Consumption

3.3.1 Water Footprint Assessment of the Dietary Scenarios for the years 1961, 2013 and 2050, in comparison with the Mediterranean and Healthy Dietary Scenarios

Regarding the WF associated with the dietary scenarios, which were adjusted to 2000 Calories (isocaloric), the total WF ranged between 1943 to 2984 liters per capita daily. The TDG-H dietary scenario had the highest WF whereas the Mediterranean Diet had the lowest (Figure 12).

For all the dietary scenarios, cereals, milk and meat constituted more than 55% WF associated with the diets; with changing order, according to their amount. Cereals were responsible for more than 25% of WF in the dietary scenarios except the TDG-H; in which, the WF associated with cereal consumption decreased to 18% of all footprint. Fruits and vegetables contributed approximately 10% to the WF of daily diets. Table 13 provides the contributions of the food groups to the total water footprint of the dietary scenarios in decreasing order. In Appendix F, the contributions of the food groups to total WF of the dietary scenarios were demonstrated in Figure F1.

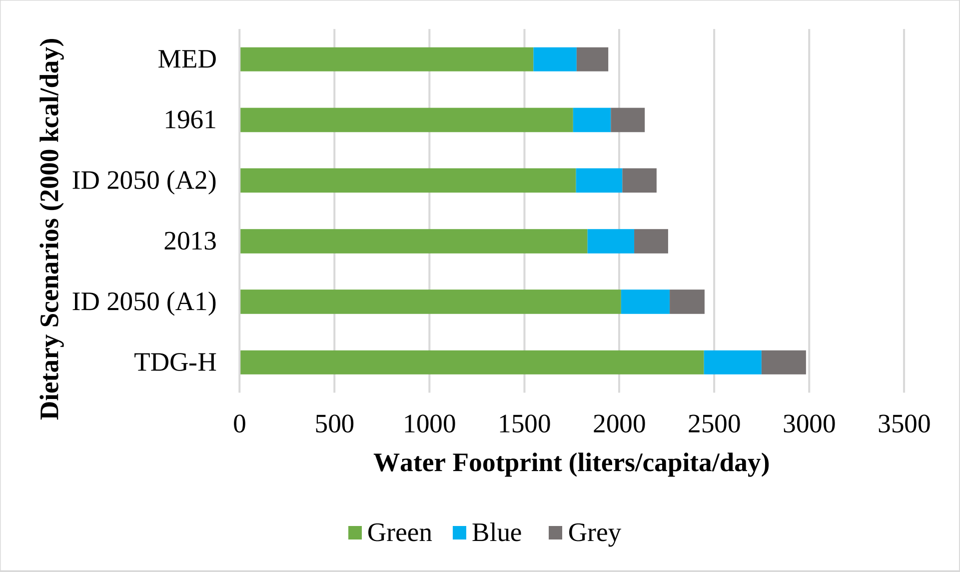

Figure 12. The green, blue and grey water footprint associated with isocaloric dietary scenarios (at 2000 kcal/day). MED: The hypothetical Mediterranean Diet; 1961, 2013: The dietary scenarios representing the food consumption in 1961 and 2013; ID 2050 (A1), (A2): The dietary scenario forecasting the food consumption in 2050 based on A1 and A2 income projections; TDG-H: The healthy dietary scenario constructed based on Turkey Dietary Guidelines.

The WF associated with the dietary scenarios varied depending on the choice of comparison basis; per kcal or mass. Both calorie per capita and kg per capita units are compared in the scenarios as the calorie-based assessments can present the calorie-dense foods in a more favorable position [123]. In Figure 13, the WF intensity of the diets per kcal and per gram is provided. The least water intensive diet was the Mediterranean Diet for both kcal and mass. However, TDG-H was found to be the most water intensive per kcal but ranked third in terms of WF per grams. When assessed over mass, the income dependent 2050 diet with A1 income scenario was associated with the highest water footprint, which was followed by the 2013 dietary scenario.

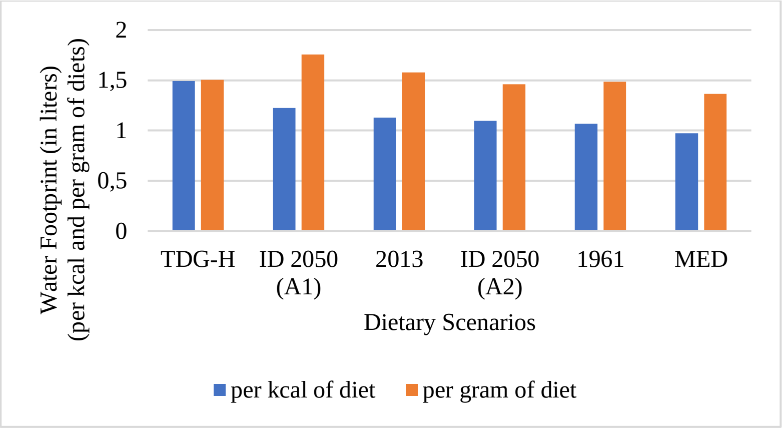

Figure 13. The water footprint of the dietary scenarios, per kcal and per gram

Table 13. The Ratio of water footprint contributions of the food groups to the dietary water footprint, in decreasing order

1961		2013		ID 2050 (A1)		ID 2050 (A2)		MED		TDG-H	
Food Group	**% TWF**	**Food Group**	**% TWF**	**Food Group**	**% TWF**	**Food Group**	**% TWF**	**Food Group**	**% TWF**	**Food Group**	**% TWF**
Cereals	39,40 %	Cereals	29,66 %	Meat	33,20 %	Cereals	33,10 %	Cereals	26,66 %	Milk	24,43 %
Milk	17,60 %	Meat	25,61 %	Cereals	25,89 %	Meat	20,90 %	Milk	17,18 %	Meat	23,84 %
Meat	16,13 %	Milk	14,39 %	Milk	12,57 %	Milk	16,06 %	Meat	12,20 %	Cereals	17,86 %
Fruits	7,11%	Veg. Oils	7,37%	Veg. Oils	7,37%	Veg. Oils	6,04%	Veg. Oils	9,35%	Veg. Oils	13,47 %
Veg. Oils	5,85%	Fruits	4,30%	Fruits	3,75%	Fruits	4,79%	Pulses	7,33%	Fruits	6,82%
Vegetables	2,78%	Vegetables	2,95%	Sugar	2,67%	Vegetables	3,29%	Nuts & Seeds	6,93%	Eggs	4,25%
Pulses	1,83%	Sugar	2,67%	Vegetables	2,57%	Eggs	2,52%	Fruits	5,90%	Vegetables	2,70%
A. Fats	1,81%	Eggs	2,26%	Eggs	1,97%	Pulses	2,26%	Eggs	4,49%	Nuts & Seeds	2,67%
Nuts & Seeds	1,64%	Pulses	2,02%	Pulses	1,77%	Sugar	2,19%	Sugar	2,89%	Pulses	1,88%
Edible Offals	1,39%	Nuts & Seeds	1,93%	Nuts & Seeds	1,68%	Nuts & Seeds	2,15%	Vegetables	2,56%	Sugar	0,98%
Oilcrops	0,98%	Oilcrops	1,84%	Oilcrops	1,60%	Oilcrops	2,05%	Oilcrops	2,24%	A. Fats	0,92%
Spices	0,88%	Stimulants	1,70%	Stimulants	1,56%	Stimulants	1,74%	Alcoholic Beverages	1,83%	Starchy Roots	0,17%
Sugar	0,75%	A. Fats	1,55%	A. Fats	1,55%	A. Fats	1,27%	Edible Offals	0,28%	Oilcrops	0,00%
Eggs	0,72%	Edible Offals	0,60%	Edible Offals	0,77%	Edible Offals	0,49%	Starchy Roots	0,15%	Stimulants	0,00%
Starchy Roots	0,48%	Spices	0,45%	Spices	0,42%	Spices	0,47%	Stimulants	0,00%	Spices	0,00%
Stimulants	0,48%	Starchy Roots	0,39%	Starchy Roots	0,34%	Starchy Roots	0,43%	Spices	0,00%	Alcoholic Beverages	0,00%
Alcoholic Beverages	0,15%	Alcoholic Beverages	0,31%	Alcoholic Beverages	0,31%	Alcoholic Beverages	0,26%	A. Fats	0,00%	Edible Offals	0,00%

TWF: Total water footprint
1961, 2013: The dietary scenarios representing the food consumption in 1961 and 2013
ID 2050 (A1), (A2): The dietary scenario forecasting the food consumption in 2050 based on A1 and A2 income projections.
MED: The hypothetical Mediterranean Diet; TDG-H: The healthy dietary scenario constructed based on Turkey Dietary Guidelines

3.3.2 GHG Emission Estimates of the Dietary Scenarios for the years 1961, 2013 and 2050, in comparison with the Mediterranean and Healthy Dietary Scenarios

For the dietary scenarios constructed, the average estimated GHG emissions at 2000 kcal diet basis (isocaloric) were in between 1.6 to 2.7 kg CO2eq capita^{-1} day^{-1} (Figure 14). The Mediterranean Diet had the lowest GHG emissions whereas the diet constructed based on the dietary guidelines (TDG-H) was associated with the highest amount of GHG emissions per 2000 kcal-day diet.

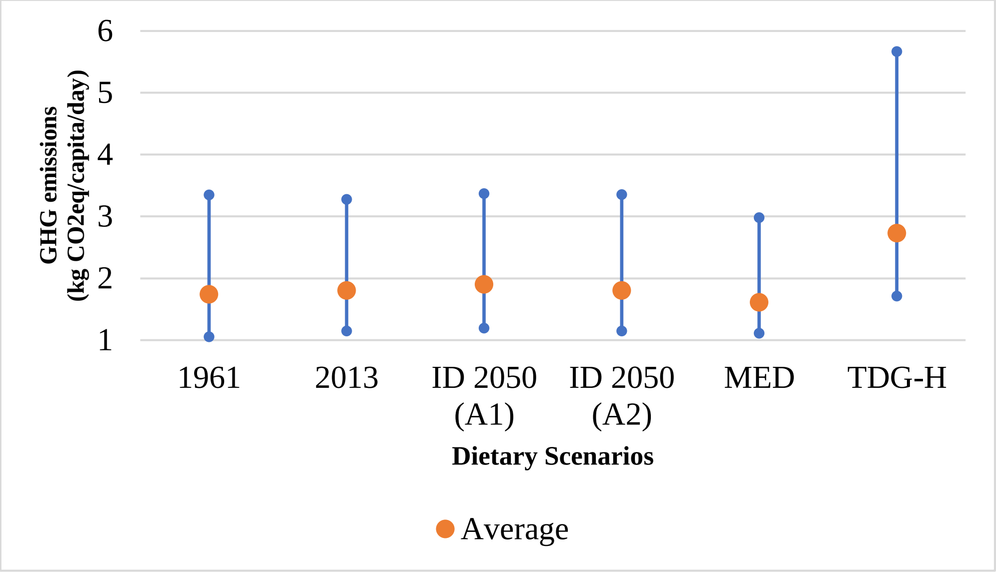

Figure 14. Total GHG emissions associated with Isocaloric Dietary Scenarios at 2000 kcal/day. MED: The hypothetical Mediterranean Diet; 1961, 2013: The dietary scenarios representing the food consumption in 1961 and 2013; ID 2050 (A1), (A2): The dietary scenario forecasting the food consumption in 2050 based on A1 and A2 income projections; TDG-H: The healthy dietary scenario constructed based on Turkey Dietary Guidelines.

For all the dietary scenarios, milk, meat, vegetable and fruits dominated the GHG emissions associated with the diets (more than 70%). Milk was responsible for more than 20% of GHG emissions in all of the dietary scenarios. Meat food group were associated with more than 20% of GHG emissions in the dietary scenarios 1961, 2013 and 2050 whereas in the Mediterranean Diet and TDG-H; the ratio of meat-associated GHG emissions decreased. In the Mediterranean Diet, fruits had the third largest contribution to GHG emissions following milk and vegetables. Table 19 provides the contributions of the food groups to the total GHG emissions of the dietary scenarios in decreasing order. In Appendix G, the contributions of the food groups to total GHG emissions of the dietary scenarios were demonstrated in Figure G1.

The GHG emissions associated with the dietary scenarios were also assessed for their GHG intensity over the mass of them per day. Both calorie per capita and kg per capita units are compared in the scenarios as the calorie-based assessments can present the calorie-dense foods in a more favorable position [123]. In Figure 15, the GHG intensity of the diets per kcal and per gram is provided. The least GHG intense diet was the Mediterranean Diet for both kcal and mass. In addition, TDG-H was found to be the most GHG intensive for both kcal and mass. When assessed over mass, the income dependent 2050 diet with A2 income scenario was associated with the lowest GHG emissions, following the Mediterranean Diet.

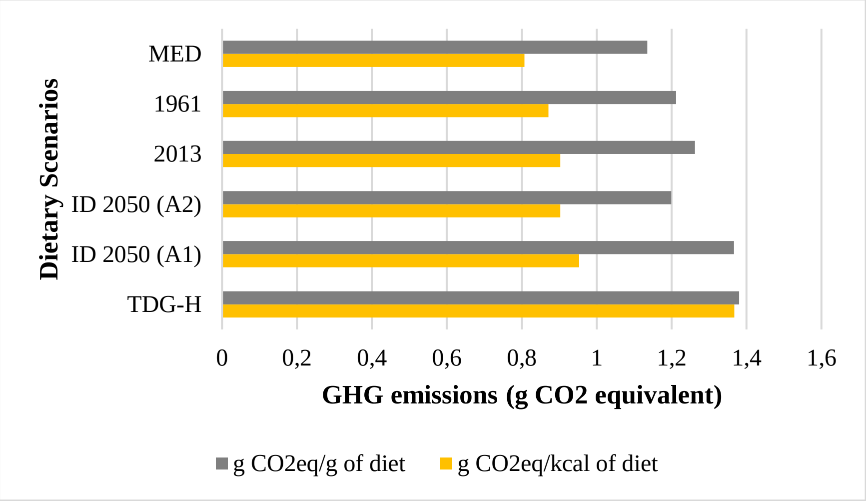

Figure 15. The greenhouse gas emissions of the dietary scenarios, per kcal and gram

The Mediterranean Average GHG emission factors used in calculations are provided in Table D1 in Appendix D of this thesis, with minimum, maximum and average values and references.

Table 14. The Ratio of Contributions of the Food Groups to the Dietary GHG emissions, in decreasing order

GHG INTENSIVE FOOD PRODUCTS IN DIETARY SCENARIOS											
1961		**2013**		**ID 2050 (A1)**		**ID 2050 (A2)**		**MED**		**TDG-H**	
Food Group	% GHGe	**Food Group**	% GHGe	**Food Group**	% GHGe	**Food Group**	% GHGe	**Food Group**	% GHGe	**Food Group**	% GHGe
Milk	30,6%	Milk	25,5%	Meat	27,6%	Milk	27,7%	Milk	29,33%	Milk	37,8%
Meat	23,9%	Meat	20,7%	Milk	22,9%	Vegetables	22,0%	Vegetables	16,92%	Meat	16,9%
Vegetables	13,8%	Vegetables	20,2%	Vegetables	18,1%	Meat	16,5%	Fruits	11,50%	Vegetables	16,1%
Cereals	13,7%	Cereals	11,1%	Cereals	9,9%	Cereals	12,0%	Cereals	9,60%	Fruits	12,0%
Fruits	10,5%	Fruits	8,7%	Fruits	7,8%	Fruits	9,4%	Meat	9,51%	Fish & Seafood	6,0%
Animal Fats	2,8%	Veg. Oils	4,6%	Veg. Oils	4,7%	Veg. Oils	3,7%	Fish & Seafood	8,57%	Cereals	5,1%
Veg. Oils	1,9%	Animal Fats	2,5%	Animal Fats	2,5%	Stimulants	2,1%	Veg. Oils	5,54%	Veg. Oils	2,2%
Edible Offals	0,5%	Stimulants	2,1%	Stimulants	2,0%	Animal Fats	2,0%	Alcoholic Bev.	4,42%	Eggs	1,9%
Fish & Seafood	0,5%	Fish & Seafood	1,3%	Fish & Seafood	1,1%	Fish & Seafood	1,4%	Eggs	2,26%	Animal Fats	1,3%
Eggs	0,4%	Eggs	1,2%	Eggs	1,1%	Eggs	1,3%	Pulses	0,85%	Nuts & Seeds	0,3%
Starchy Roots	0,3%	Alcoholic Bev.	0,8%	Alcoholic Bev.	0,8%	Alcoholic Bev.	0,6%	Nuts & Seeds	0,81%	Pulses	0,2%
Alcoholic Beverages	0,3%	Oilcrops	0,3%	Edible Offals	0,3%	Oilcrops	0,3%	Oilcrops	0,37%	Starchy Roots	0,1%
Pulses	0,2%	Starchy Roots	0,3%	Oilcrops	0,3%	Starchy Roots	0,3%	Sugars	0,13%	Sugars	0,0%
Nuts & Seeds	0,2%	Pulses	0,2%	Starchy Roots	0,2%	Pulses	0,3%	Edible Offals	0,10%	Oilcrops	0,0%
Oilcrops	0,1%	Nuts & Seeds	0,2%	Pulses	0,2%	Nuts & Seeds	0,3%	Starchy Roots	0,09%	Stimulants	0,0%
Stimulants	0,1%	Edible Offals	0,2%	Nuts & Seeds	0,2%	Edible Offals	0,2%	Stimulants	0,00%	Spices	0,0%
Sugars	0,0%	Sugars	0,1%	Sugars	0,1%	Sugars	0,1%	Spices	0,00%	Alcoholic Bev.	0,0%
Spices	0,0%	Spices	0,0%	Spices	0,0%	Spices	0,0%	Animal Fats	0,00%	Edible Offals	0,0%

GHGe: Greenhouse Gas Emissions
1961, 2013: The dietary scenarios representing the food consumption in 1961 and 2013
ID 2050 (A1), (A2): The dietary scenario forecasting the food consumption in 2050 based on A1 and A2 income projections.
MED: The hypothetical Mediterranean Diet; **TDG-H:** The healthy dietary scenario constructed based on Turkey Dietary Guidelines

3.3.3 The Food Loss and Waste

The GHG emissions and WF associated with the lost or wasted food in the dietary scenarios were shown in Figure 16. About 17-18% by weight was lost or wasted through spoilage or squandering, in the dietary scenarios. In addition, approximately 14-15% of all GHG emissions and 11-12.5% of all water footprint was associated with the food loss and waste. The food loss and waste constituted the highest rate in both GHG emissions and water footprint in the income dependent A2 dietary scenario (Table 15).

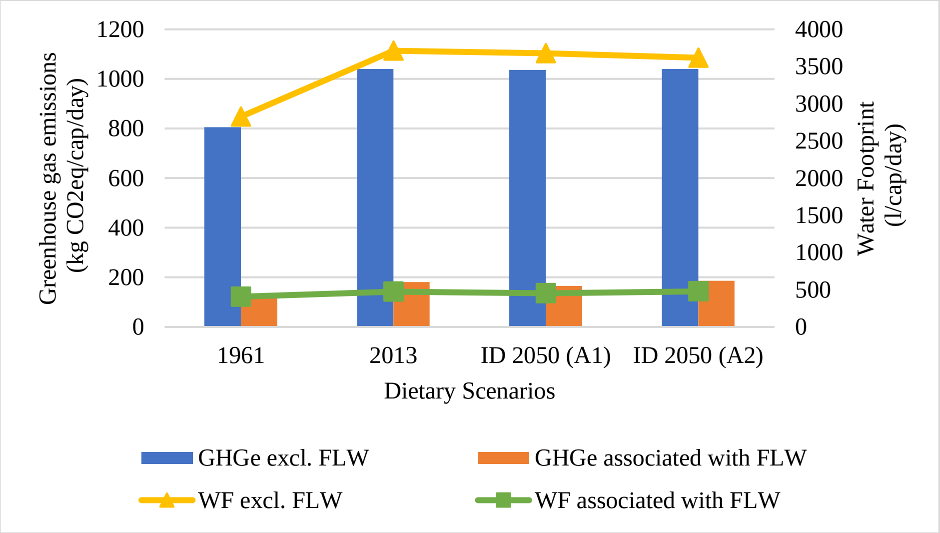

Figure 16. Greenhouse gas emissions and water footprint associated with the food loss and waste in the Dietary Scenarios; 1961, 2013 and 2050 (A1 and A2)

Table 15. The calculated rate of food loss and waste in the dietary scenarios and the GHG emissions and water footprint associated with food loss or waste

Dietary Scenarios	Food loss or waste by weight	GHGe of FLW (kg CO2eq/capita/year)[a]	WF of FLW (liters/capita/year)[a]
1961	17%	129 (14%)	407 (12.5%)
2013	18%	181 (15%)	474 (11.3%)
ID 2050 (A1)	17%	165 (14%)	451 (11%)
ID 2050 (A2)	18%	186 (15%)	478 (12%)

[a] The proportion of FLW-associated impact in total impact were given in parentheses.
FLW: Food loss and waste
GHGe: Greenhouse gas emissions, **WF:** Water footprint

3.4 Overall Assessment of the Dietary Scenarios with Health Implications

3.4.1 Comparison of the Dietary Scenarios over GHG emissions, Water Footprint and Health Implications

The environmental assessment of the healthy dietary scenario (TDG-H) resulted in the highest GHG emissions and WF whereas the Mediterranean diet was associated with the lowest scores for both. The dietary scenarios representing food consumption in Turkey ranged in between two for both environmental outcomes (Figure 17). The per capita GHG emissions associated with the TDG-H were equivalent to 2.7 Kg CO2eq capita $^{-1}$ day $^{-1}$; ranging in between 1.7 to 5.7 Kg CO2eq. capita $^{-1}$ day $^{-1}$ when minimum and maximum emission factors are considered. The daily WF per 2000 Calories TDG-H dietary scenario was 2984 liters. The per capita GHG emissions associated with MED diet were equivalent to 1.60 Kg CO2eq capita $^{-1}$ day $^{-1}$; ranging in between 1.11 to 2.98 Kg CO2eq. capita $^{-1}$ day $^{-1}$ when minimum and maximum emission factors are considered. The WF of the MED scenario was also the lowest and the daily WF per 2000 Calories MED dietary scenario was 1943 liters. Cereals, milk and meat contributed to the WF at most, and GHG emissions were dominated by milk, vegetables and fruits.

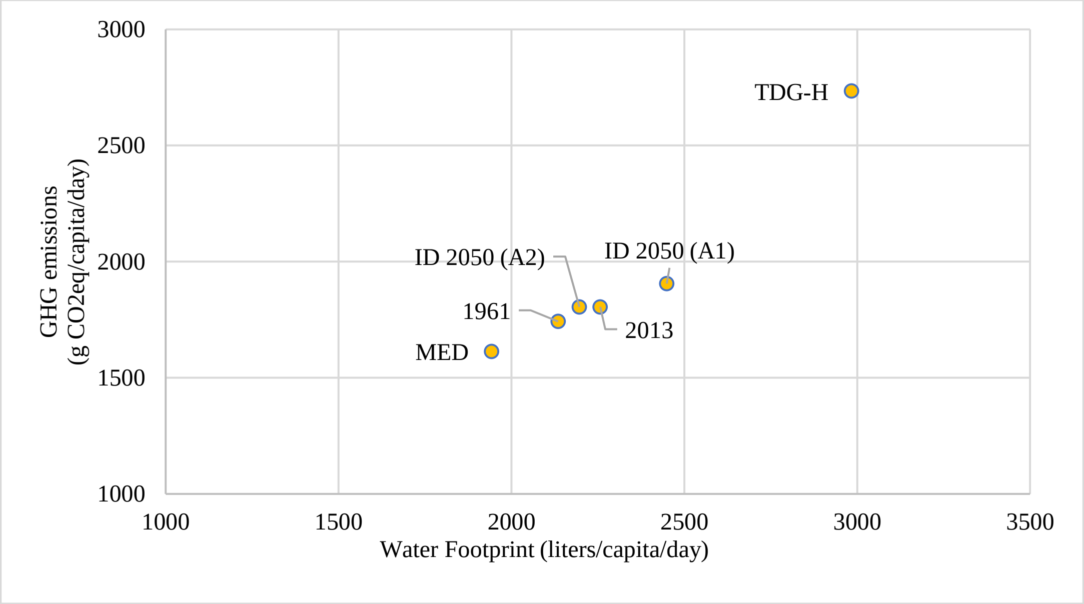

Figure 17. The GHG emissions and water footprint associated with the dietary scenarios

The per capita GHG emissions associated with 1961 food supply levels in Turkey is calculated as 1.75 Kg CO2eq capita $^{-1}$ day $^{-1}$; ranging in between 1.05 to 3.34 Kg CO2eq. capita^{-1} day^{-1} when minimum and maximum emission factors are considered. On the other hand, daily WF per 1961 dietary scenario at 2000 Calorie basis was 2135 liters per day, more than of which 80% was due to the green water footprint. It was the second environmentally sound dietary scenario after the Mediterranean Diet (Figure 17). Cereals had the highest contribution to WF while milk had the highest contribution to GHG emissions as most of the calorie intake was associated with cereals (58%E) and milk (10%E). The main reason that cereals having the highest water footprint is that they were consumed in substantial amounts per capita even if they are associated with lower water footprint compared to any other animal-oriented food product. Milk, having a large contribution to GHG emissions per kg, was responsible for more than 30% of all food-related GHG emissions even if milk group accounted for less than 25% by weight in this dietary scenario.

The per capita GHG emissions associated with 2013 food supply levels in Turkey was slightly higher than the 1961 levels; which were equivalent to 1.80 Kg CO2eq capita $^{-1}$ day $^{-1}$; ranging in between 1.15 to 3.27 Kg CO2eq. capita $^{-1}$ day $^{-1}$ when minimum and maximum emission factors are considered. On the other hand, daily

WF per 2013 dietary scenario at 2000 Calorie basis was 2257 liters per day, 5.7% higher than the 1961 diet. Cereals had the highest contribution to WF while milk had the highest contribution to GHG emissions, even if their contribution decreased from 40% in 1961 to 30% in 2013. For the water footprint, the cereals were followed by meat food group. The meat contributed to water footprint in 1961 by 17% whereas in 2013, the contribution rose to 26%. The main contribution to the rise in water footprint in 2013, in comparison with 1961 was due to the 60% increase in meat consumption by weight. Milk, having a large contribution to GHG emissions per kg, was responsible for more than 25% of all food-related GHG emissions. It was followed by meat and vegetables. The contribution of vegetables to GHG emissions in 2013 rose, when compared to the 1961 diet, since the vegetables accounted for 23% more by weight in the 2013 diet.

The per capita GHG emissions associated with the hypothetical dietary scenario A1 were 5.7% higher than the 2013 levels. On the other hand, the GHG emissions associated with A2 scenario did not change much compared to the 2013 dietary scenario (0.004% increase). The GHG emissions for the dietary scenarios were equivalent to 1.90 and 1.80 Kg CO2eq capita $^{-1}$ day $^{-1}$ respectively. Moreover, daily WF per ID 2050 A1 dietary scenario at 2000 Calorie basis was 2449 liters per day, 8.5% higher than the 2013 diet. On the other hand, the ID 2050 A2 dietary scenario had 2.7% less water footprint (2196 liters per day) than the 2013 dietary scenario. In A1 dietary scenario, the meat food group had the largest contribution to both water footprint and GHG emissions. More than 33% of the water footprint and more than 27% of the GHG emissions were associated with meat consumption even if meats accounted for approximately 5% by weight in this dietary scenario. Meat was followed by cereals and milk in WF and cereals and vegetables in GHG emissions. The largest contribution to WF in ID 2050 A2 dietary scenario was from cereals, followed by meat and milk. The GHG emissions associated with this scenario were dominated by milk, vegetables and meat; owing to high GHG intensity of animal-based food products.

The health implications of the dietary scenarios were assessed qualitatively based on the macronutrients and the relative intake of food products in the dietary scenarios in comparison with TDG-H and optimal intake levels in recent epidemiological studies.

The dietary scenarios differed both on the mass and energy basis. The total calories ranged from 2140 to over 3700 kcal cap^{-1} day^{-1}. The total mass of the diets ranged from 1.7 to over 2.7 kg cap^{-1} day^{-1}. Figure 18 shows the differences in macronutrients compared with the healthy dietary scenario. Total protein and fat associated calories in all dietary scenarios were significantly lower than the recommendations. The protein content of the dietary scenarios ranged between 11.8-12.5%E whereas the optimal protein intake for a 2000 kcal diet is 95 grams daily; constituting 18%E [170]. The 2013 dietary scenario had the lowest content of protein (59 grams daily), which was 38% lower than the recommended amount in TDG. The protein content was higher than the others in the 1961 dietary scenario (63 grams daily); which was still 34% lower than the recommended levels. The fat intake composition differed in between the dietary scenarios. In TDG-H, the recommended 2000 kcal-day diet constituted of 11.7% and 10% of total calories from SFA and PUFA respectively. SFA content of the other dietary scenarios ranged from 9 to 10.4%E. The 1961 dietary scenario had the lowest SFA and PUFA calories in total energy whereas the Mediterranean diet, high in nuts and seeds, had PUFA content equivalent to 12% of total energy. On the other hand, carbohydrate calories in all dietary scenarios were at least 15% more than the recommendations, ranging between 54%E to 66%E. TDG recommended that the ratio of calories from carbohydrates in total energy to be in between 45-60% [170].

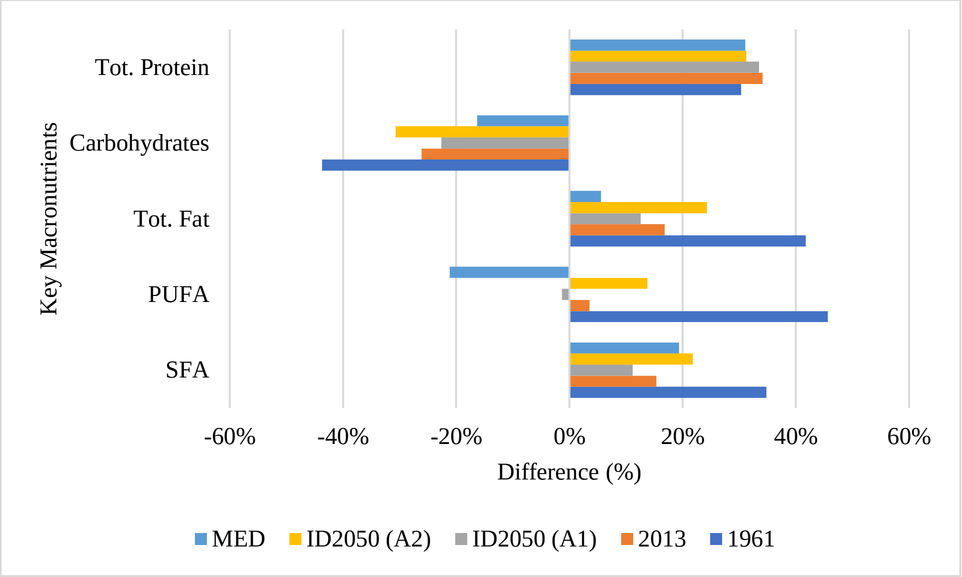

Figure 18. Difference in macronutrient intake (in percentage of total energy intake, %E) within the dietary scenarios 1961, 2013, 2050 and the Mediterranean, in comparison with the healthy (TDG-H). (PUFA: Polyunsaturated fatty acids, SFA: saturated fatty acids).

In terms of macronutrients, TDG-H and the MED diet satisfied the optimal intakes for total fat, PUFA and SFA. The 1961 dietary scenario performed worse in all assessments as it was generally high in carbohydrate intake and low in both fat and protein intake. The income-dependent 2050 A2 dietary scenario had the second largest variation from the recommendations as well as the optimal intake levels for PUFA and SFA. 2013 and ID 2050 (A1) scenarios had similar results in terms of macronutrient content. When only macronutrient levels were considered, the MED scenario is expected to bring better health implications, as well as the TDG-H, compared to other dietary scenarios. The Mediterranean Diet satisfied the recommended range for fat calories (33.5%E). As the nuts and vegetable oils were one of the leading food groups in the diet, the PUFA levels were higher than the recommended, which is still in the range for good health outcomes (12%E). The proportion of calories from carbohydrates were the lowest in between the dietary scenarios. SFA content of the Mediterranean dietary scenario was lower because animal-oriented food sources were less than recommended in the dietary guidelines

(9.4%E). Still, the proportion of calories from protein was the second largest in between the dietary scenarios.

In Figure 20, the differences in quantity of food products consumed (in % variation from TDG-H), GHG emissions and water footprint associated with the food groups when consumed at TDG-H (% variation) were depicted.

The quantitative nutritional assessment, conducted on a 2000 kcal-day basis, revealed that most of the food groups (fish and seafood, eggs, milk, vegetables and fruits) were consumed inadequately when TDG-H was accepted as a healthy scenario. Cereals, on the other hand, were overconsumed and starchy roots were also higher than the recommended levels for each scenario, except the Mediterranean Diet (Figure 20 - A).

Fish, fruit and vegetables, pulses, nuts and seeds were closely related to better health implications with probable or convincing evidence [156]. When the 2000 kcal-day composition of the dietary scenarios were considered as consumption, the variation from optimal intake levels can be used to calculate health scores of diets. The health scores of the dietary scenarios with the associated environmental outcomes were depicted in Figure 19. Meat is generally under-consumed in all dietary scenarios (except ID 2050 (A1)) and mainly, not assessed as a health indicator in this study.

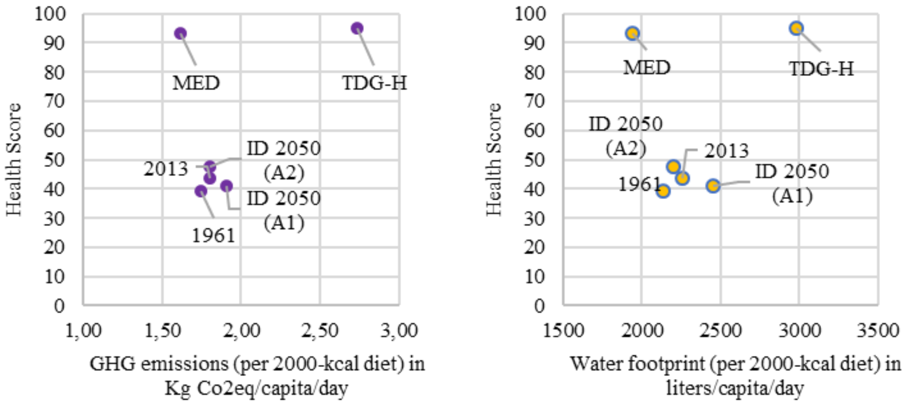

Figure 19. Comparison of the health and environmental implications (GHG emissions and water footprint) of the dietary scenarios. Health score of 100 indicates a full adherence to optimal intake levels given in [156].

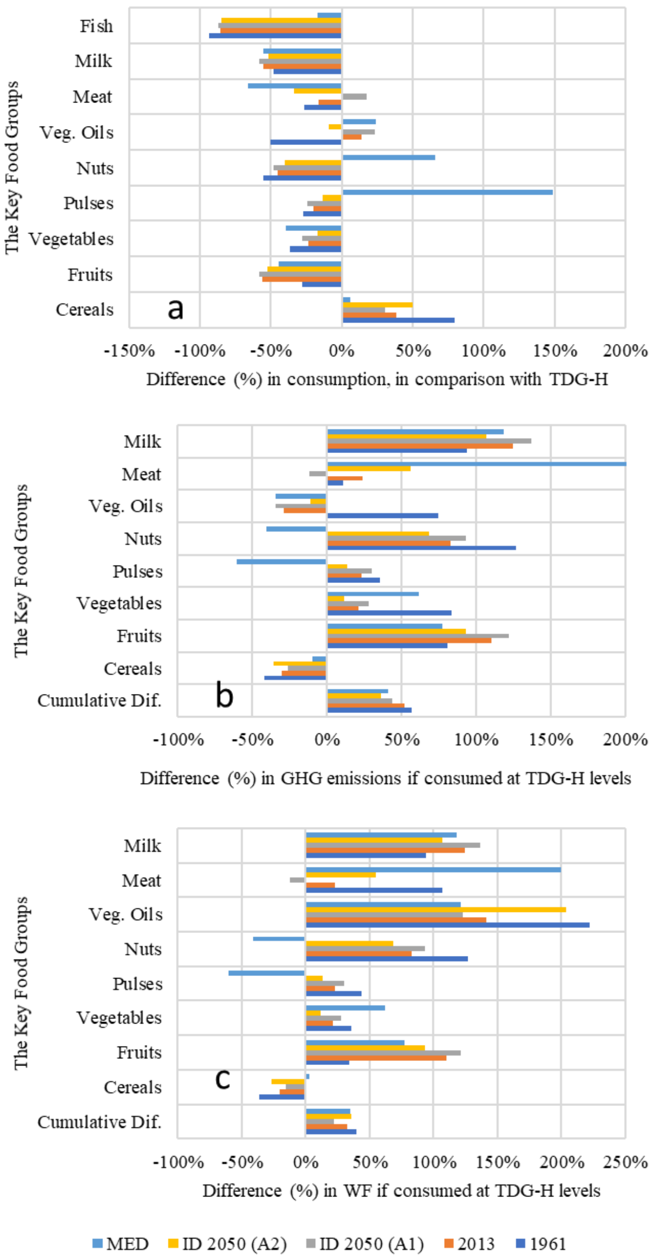

Figure 20. Differences in (a) Quantity of food products consumed (in % variation from TDG-H), (b) GHG emissions consumption if consumed at recommended levels (%) an (C) water footprint of consumption if consumed at recommended levels (%). (Fish is excluded from the graph b as the increase in GHG emissions would be larger than 500% for the dietary scenarios, except the Mediterranean diet (18%)). Cumulative Difference is the difference in environmental impact if the dietary scenario is shifted to TDG-H.

The optimal intake of fruits and vegetables for a 2000 kcal diet was at least 300 and 400 grams per day respectively and the lack or insufficient intake of fruits and vegetables are associated with lower health performance for the diets. The optimal intake of pulses for better health outcomes was calculated as 100 grams daily [156]. The TDG-H diet, containing at least 350 grams of fruits and vegetables intake per day, was associated with lower CHD risk when compared to other diets. The Mediterranean dietary scenario had the closest intake levels for pulses; which was still 40% lower than the optimal levels. In terms of nuts and seeds, TDG-H and the Mediterranean Diet had higher intake than the calculated optimal, which was 20 grams a day [156]. As a result, the two dietary scenarios were associated with lower risk for CHD whereas the risk would be higher in the other dietary scenarios. The fish and seafood consumption in the dietary scenarios representing the food consumption in 1961, 2013 as well as 2050, were far too less than the recommended intake in TDG-H as well as the optimal intake calculated in [156], as 50 grams daily. The MED dietary scenario constituted fish and seafood in a slightly higher level than the optimal intake whereas the TDG-H had the advantage to lower the risk of CHD by associating with 50% higher intake for fish and seafood. As a result, TDG-H and MED dietary scenarios were expected to bring better health implications when compared to the dietary scenarios representing the food consumption in Turkey in the past and the future.

3.4.2 Environmental Outcomes of shift to Healthier Diets

A shift from 1961 to the Mediterranean diet resulted in 9% decrease in WF, 8% decrease in GHG emissions. On the other hand, a shift to TDG-H resulted in approximately 40% increase in WF and more than 50% increase in GHG emissions. A total shift from the dietary scenario representing the food consumption in Turkey in 2013 to the Mediterranean diet would reduce the WF by 13% and GHG emissions by 11%. A shift to TDG-H, on the other hand, would increase the WF by 32% and GHG emissions by at least 50%. Even if, the TDG-H recommended to decrease the consumption of sugars, cereals, starchy roots for a healthier diet, the environmental impacts grew as those foods are associated with less WF and GHG emissions. A shift to the Mediterranean dietary scenario on a 2000 kcal basis would reduce the WF associated with ID 2050 (A1) by 21% and GHG emissions by 15%. The WF associated with ID 2050 (A2), on the other hand, decreased by 12% and GHG emissions by 11%. Shifting to the TDG-H, would increase the WF by 22 and 36% for the A1 dietary scenario. The increase in WF and GHG emissions would be 36% and 51% if A2 dietary scenario were shifted to TDG-H. When compared to TDG-H, the Mediterranean Diet had 35% lower WF and 41% lower GHG emissions associated with the diet (Figure 21). The increase in WF and GHG emissions as the result of the shift to TDG-H were mostly dominated by the increase in the consumption of animal-oriented food products, milk and meat (Figure 20- B and C). Differences in cereal consumption did not translate into a large difference in environmental load in terms of GHG emissions and water footprint as both water footprint and emission factors per kg of cereals were lower than the animal-oriented food products.

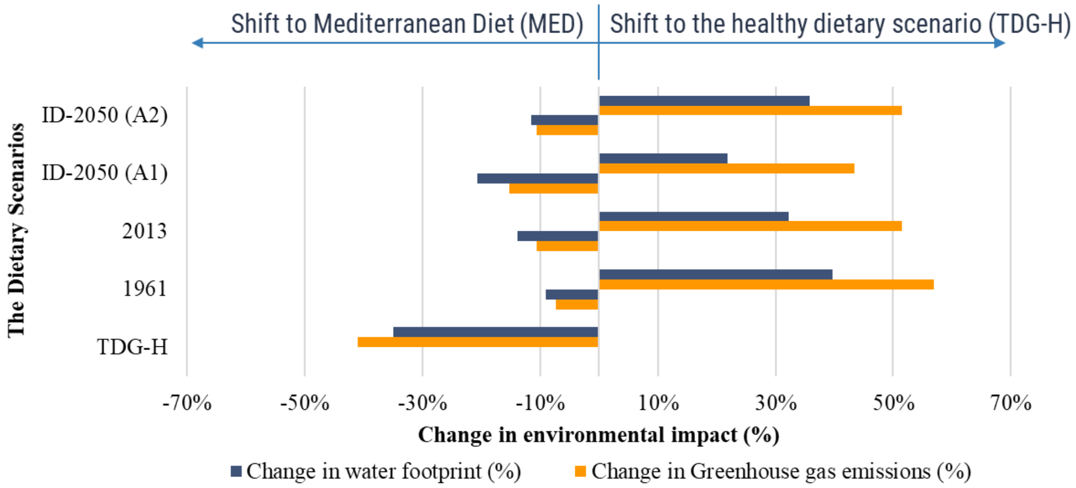

Figure 21. Environmental outcomes of a probable shift to healthier diets

CHAPTER 4

DISCUSSION AND CONCLUSIONS

Different methods were used to test the hypotheses determined for this study. First, dietary scenarios were created to represent the food consumption in Turkey in 1961 and 2013 based on FAO Food Balance Sheets. In order to test the second hypothesis, two 2050 dietary scenarios projecting the then food consumption in Turkey were constructed with two income scenarios. Then, applying the water footprint and GHG emission factors; which were compiled from several life-cycle based environmental studies, the environmental impact associated with the food consumption in different dietary scenarios were estimated. The third hypothesis was tested by comparing the estimated environmental impacts associated with food consumption, with two healthy dietary scenarios; which were constructed based on the Mediterranean dietary recommendations and Turkey Dietary Recommendations.

The water footprint associated with the food consumption of an average person in Turkey in 2013 is 1526 m^3/capita, which is equivalent to 1.13 liters per kcal of diet. The water footprint of the diet per kcal is lower than the EU averages by at least 20% (See Table 17). Moreover, the GHG emissions associated with the 2013 diet is estimated to be in between 0.6 – 1.6 g CO2eq per kcal of the diet (See Table 18). The GHG emissions associated with the 2013 diet in Turkey is associated with 20% of all emissions in Turkey. The GHG emissions of food in EU is associated with 20 – 30% and Turkey would be the one of the lowest in the region. In both environmental impact categories, the 2013 diet representing the food consumption in Turkey performed better than European as well as other Mediterranean countries, validating the first hypothesis of this study.

The environmental impacts (GHG emissions & water footprint) associated with the food consumption of an average person in Turkey in 2050 is higher than the associated environmental impact in the 2013 diet. However, the results for the water footprint is not significant. The water footprint is expected to change in between 1.11 – 1.21 liters per kcal of diet for the 2050 dietary scenario; which is only equivalent to 0.7% increase in the water use. Moreover, the change in GHG emissions associated with the income-dependent 2050 diets are limited to 1% increase. The meat and empty calories consumption increased in the A1 dietary scenario however, due to the decrease in other calorie suppliers, the environmental impact associated with kilocalories of diet did not change much. Accordingly, the second hypothesis is rejected.

The dietary scenarios created to represent the food consumption in Turkey failed to meet the recommendations provided by the Ministry of Health in 2016. In addition, the dietary scenarios failed to meet the optimal intake levels, calculated based on meta-analyses in epidemiological studies. The TDG-H dietary scenario, on the other hand, met the optimal intake levels for fruits, vegetables, nuts and seeds, fish and as well as for the share of PUFA in total calories. Not only the TDG-H but also the MED dietary scenario, met the optimal intake levels for nuts and seeds and fish. In addition, the share of PUFA in the MED dietary scenario met the optimal intake level and they both performed best in terms of health score.

A total shift from the dietary scenario representing the food consumption in Turkey in 2013 to the Mediterranean diet would reduce the WF by 13% and GHG emissions by 11%. A shift to TDG-H, on the other hand, would increase the WF by 32% and GHG emissions by at least 50%. The increase can be attributed to the recommendations for higher consumption of meat, fish and seafood, fruits and vegetables in the recommendations. The last three would bring health advantages with convincing evidence. Even if, the TDG-H recommended to decrease the consumption of sugars, cereals, starchy roots for a healthier diet, the environmental impacts grew as those foods are associated with less WF and GHG emissions. When compared to TDG-H, the Mediterranean Diet had 35% lower WF and 41% lower GHG emissions associated with the diet. The increase in WF and GHG emissions as the result of the shift to TDG-H were mostly dominated by the increase in the consumption of animal-oriented food products, milk and meat. In addition, TDG-H recommended the intake of olive oil rather than any other sources of vegetable oils; which had higher WF intensity than other oils. Differences in cereal consumption did not translate into a large difference in environmental load in terms of GHG emissions and water footprint as both water footprint and emission factors per kg of cereals were lower than the animal-oriented food products. Accordingly, the third hypothesis of this study neither validated nor rejected. The recommendations-based dietary scenario provide evident positive health outcomes. However, the diet is also associated with more environmental impact, in terms of GHG emissions and water footprint. The Mediterranean recommendations-based dietary scenario, on the other hand, is both associated with better health and environmental outcomes in comparison with other diets in Turkey. It can be deducted that there are options to create both environmentally friendly and healthy dietary scenarios. In addition, there is a strong need to assess the dietary scenarios from a deeper health and environmental perspective to create a sustainable diet option for Turkey.

The results of the present study coincide with the findings of other diet-related environmental impact studies in literature. As expected, animal-oriented food products (milk and meat) are associated with higher GHG emissions and WF than other food products even if their consumption is lower than the recommended levels for most of the dietary scenarios. For GHG emissions, vegetables also constitute a high share and cereals are the most water intensive plant-oriented products.

4.1 Environmental Assessment of Food Consumption

4.1.1 The Nutrition Transition in Turkey and the Related Change in Environmental Impact

The supply of calories for all food groups, except cereals and fruits, increased considerably from 1961 to 2013 in Turkey. The increase in supply of vegetable oil calories was mostly associated with the developments in edible oil production. The new methods proposed in the middle of the 20th century provided the removal of oil from seeds of corn, soy, cotton an palm cheaply [33]. As a result, the use of such oils increased considerably both in the developed and developing world. The vegetable oils are both used in home cooking and in industrial food production. Therefore, the increase in the supply of vegetable oils is an indicator of an increase in the supply of industrialized food calories. The increase in sugar calories also support the same argument. The global average diet is sweeter than the past and the average national data on sugar calories supply in Turkey has increased, suggesting that the consumption of sugar; especially through industrialized foods, have increased. It can be deducted that, the calories from cereals and fruits are exchanged with the calories from sugar. The increase in such energy-dense food products in the diet is an indicator for the nutrition transition in Turkey.

The increase in animal-oriented calories in the average 2013 diet has both positive and negative indications for health in Turkey. On one hand, the people who consume animal protein lower than the sufficient levels to satisfy the micronutrient intake, can reach more animal-oriented calories. On the other hand, some of the increase can be associated with overconsumption, as well as consumption of raw and saturated animal fats, increasing the risk of obesity, NCDs and other related health problems. Either way, the increase in animal-oriented calories is another indicator for nutrition transition taking place in Turkey to a more Westernized diet.

Gill and others (2015) [37] quantified the increase in supply of food calories per capita in Brazil, China and India from 2001 to 2011; which are the developing countries with high development rates, in order to estimate the environmental impacts associated with the probable nutrition transition. The change in supply of food calories per capita in Turkey as well as the study results for Brazil, China and India for the indicated period were provided in Table 16.

Table 16. Comparison of the change in supply of calories (per capita per food group) from 2001 to 2011

	Cereals	Meat	Fruits	Sugar	Dairy	Empty Calories
Brazil [37]	955	422	149	13	254	-
China [37]	1440	433	90	0	57	-
India [37]	1394	14	66	8	124	-
Turkey	-279	40	28	1	74	148

When the results were compared, the transition in Turkey seemed not as strong as the nutrition transition in Brazil and China in terms of the increase in meat calories. The nutrition transition took place in Turkey was mostly dominated by the shift of calories from cereals to vegetable oils, animal fats and to animal-based food products, in decreasing order. The increase in total calories from animal-oriented products (meat + dairy) was less in Turkey than all three countries. However, the cereal calories decreased and the total calories from vegetable oils, animal fats and sugars increased 148 kcal capita^{-1}day^{-1} for the same period, even if the total supply of calories slightly decreased from 3219 in 2001 to 3145 in 2011. As a result, the share of supply of empty calories in total energy increased.

For the same period, meat and milk had the highest contribution to the increase in both GHG emissions and water footprint in Turkey, as the supply of cereals decreased by 15% by weight. Gill and others (2015) [37] also found that, the increase in water footprint and GHG emissions in Brazil and in China were mostly associated with the increase in supply of animal-oriented food products. On the other hand, in India the rise in both water footprint and GHG emissions was dominated by cereals due to the lower share of the animal-oriented food products in their diet.

4.1.2 Water Footprint Assessment of the Dietary Scenarios

The water footprint assessment carried out in this study for the dietary scenario representing the food consumption in 2013 resulted in 4182 liters of water consumption per capita daily. Yearly, this amount translates into 1526 m^3 per capita. Cereals (30%), meat (26%) and milk (14%) products constituted the largest share in the WF of consumption in Turkey. The total water footprint associated with food consumption in Turkey for the 2013 dietary scenario was found as 117 billion m^3 based on the population in 2013 [187], including food losses and wastes. The green WF constituted the largest share in total WF (%81) followed by the blue (11% and the grey water footprint (8%).

The global water footprint calculated by Hoekstra and Chapagain (2007) was 7450 Gm^3/year, which corresponded to an average of 1240 m^3 of WF per capita per year [188] for an average global person. The highest contribution to the global water footprint were from the production and consumption of cereals, meat and milk products, constituting 27%, 22% and 7% of global WF respectively [130]. The average water footprint in Turkey was also calculated as 1615 m^3 per year for the period 1997 – 2001 in the same study. In another report by WWF, the water footprint associated with production and consumption in Turkey was assessed [189]. The total water footprint of consumption in Turkey was equivalent to 140 billion m^3/year; 89% of which was associated with the consumption of agricultural products (125 billion m^3/year). Green water footprint constituted the largest part in total water footprint of consumption (66%) [189]. The WF per capita was equivalent to 1642 m^3/year, with the water footprint factors as given in Hoekstra [182] for the years 1996 – 2005, and 1977 m^3/year with the updated WF factors for the years 2006 - 2011 [189]. The reasons behind the 20% rise in water footprint were attributed to the rise in the production capacity and changing consumption patterns.

The results of this study are well in line with the WF calculated for consumption in Turkey. Firstly, the water footprint associated with food consumption in Turkey per capita per year was found to be 5% and 7% less than the results in [188] and [189] respectively for the 2013 dietary scenario. If compared with the results calculated with updated water footprint factors in [189], the difference increases to 23%. The variation was due to the use of updated water footprint factors for the years 2006 – 2011, which were not available in literature. The total water footprint attributed to agricultural consumption in [189] was also more than 6% higher than the results found in this study. On the other hand, the 2013 diet is 23% more water-intensive than the global averages. The most water-intensive food products were similar to global averages however, their contribution to water footprint was determined due to their share in the dietary scenarios.

In another study, Vanham and others (2016) [129] quantified the water consumption of different diets followed in the Mediterranean cities which included Ankara and İstanbul. The sum of green and blue water footprint in liters per capita were calculated for both provinces. In this study, the total of green and blue water footprint of an average person living in Turkey was calculated as 3855 l $capita^{-1}$ day^{-1}. The sum of green and blue water footprint was approximately 11% lower than the results of [129]. The variation in between two studies are mainly due to the use of different dietary scenarios. Vanham and others (2016) [129] calculated the average food consumption in Ankara and İstanbul based on both Food Balance Sheets and on an additional dietary survey carried out in the indicated provinces; which was not published. The average meat consumption in Ankara and İstanbul were found to exceed the national averages by 42% [127]. As a result, the WF associated with meat consumption in this study for the 2013 dietary scenario was found to be 32% less than the water footprint calculated in the given study. Other food products with outstanding WF deviations from the results in [129] were, cereals (6% more), milk and milk products (12% more) and eggs (32.5% less). Table 17 incorporates the water footprint results of the diets followed in different regions of the world. In comparison with EU28 averages, the 2013 Turkish Diet performed better in terms of water footprint per kcal of diet (20% less). When compared to EU28, the average diet in Turkey is less water intensive in terms of Calories. The magnitude of the water footprint in EU28 was associated with the animal-oriented food consumption [134]. Turkey is advantageous as the consumption of such food are generally lower. In addition, 2013 diet is associated with 4 – 8% lower water footprint per kcal of diet than the average diets in Italy and Austria. The healthy dietary scenario (TDG-H) was with the highest WF per kcal. Even so, the WF associated with TDG-H was only 0.2% higher than the EU28 averages and 0.4% higher compared to another healthy dietary scenario in Germany. The shift from the average EU28 diet to the recommended diet would bring 0.2% decrease in WF per kcal of diet. On the other hand, a shift from the 2013 dietary scenario to TDG-H would increase the associated water footprint by 32%.

Table 17. Comparison of the total water footprint associated with the dietary scenarios in this study with the studies carried out in indicated regions

The Study Region	Total Water Footprint (m^3/capita/year)	Total Energy of the Dietary Scenarios (kcal/day)	Water Footprint per kcal of diet (liters/kcal)	References
EU28 (Average)	1556	2929	1.46	[134]
EU28 (Healthy diet based on German Dietary Guidelines)	1201	2308	1.43	[134]
Italian (Average)	1638	3649	1.23	[96]
Italian (the Mediterranean Dietary Scenario	965	-	-	[96]
Austria (Average)	1334	3104	1.18	[136]
Turkey (2013)	1526	3706	1.13	THE RESULTS OF THIS THESIS
Turkey (2050) (A1 and A2)	1473 - 1495	3346 – 3674	1.11 – 1.21	
Turkey (Healthy diet based on the Turkey Dietary Guidelines)	1165	2140	1.49	
Turkey (the Mediterranean Dietary Scenario)	915	2579	0.97	

4.1.2.1 The Importance of Blue Water Footprint

Green water is the amount of water made available for plants by precipitation and stored in the unsaturated zone of the soil until it evaporates or transpires through plants [128], [129]. Blue water footprint, on the other hand, is the total volume of freshwater used from the surface or ground water resources to produce or consume one unit of product. In agriculture, more than 60% of water use is from green water resources as rain is an important input to crop production and, blue water constitute approximately 20% of all water use [189]. Increase in blue water footprint is an indicator of vulnerability of production or consumption to irrigation and freshwater resources. Blue water footprint per capita in Turkey is larger than the global averages, meaning that the food consumption in Turkey is more blue water footprint-intensive [189]. In the report of WWF [189], the blue/green water footprint ratio was selected as an indicator to assess vulnerability of food products to rainfall and irrigation. As the ratio increases, the food products are more dependent on irrigation. Based on that approach, the blue/green water footprint associated with the food products were assessed. As in Figure 21, blue water footprint associated with rice, sugar and potatoes are higher than the green water footprint (the ratio is greater than 1). They are the most irrigation-intensive food products, produced and consumed in Turkey.

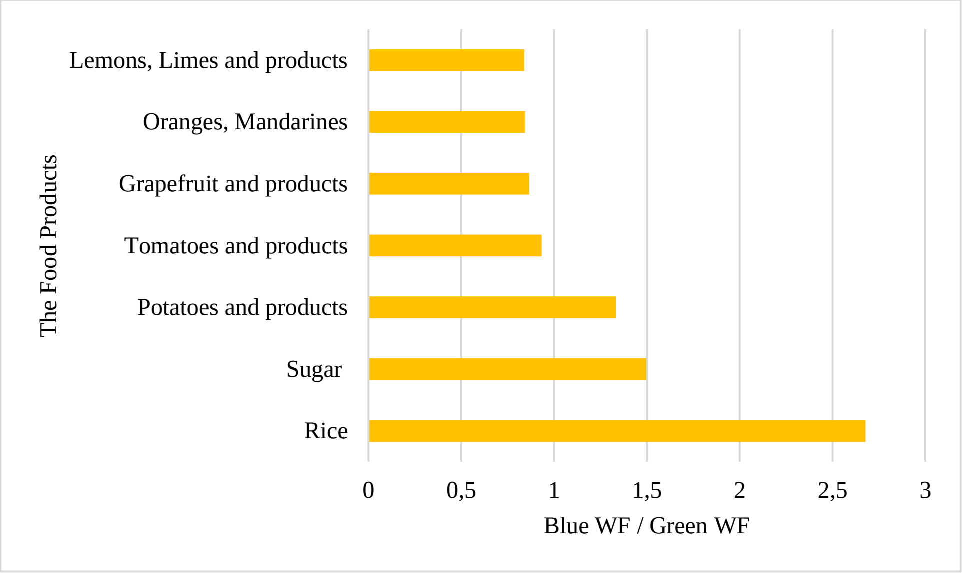

Figure 22.The highest blue-green water footprint ratios associated with the food products, produced and consumed in Turkey

4.1.2.2 The Importance of Water Footprint for Turkey

High water footprint in a basin or a region with water scarcity problems, such as Turkey, can result in decrease in access to adequate and healthy drinking water, loss of biodiversity or intensive droughts and destruction of the water resources. Future water availability in Turkey is at notable risk due to climate change-induced decreasing run off, decreasing trend in precipitations and increasing trend in temperatures ([190]–[193]). Especially, in the regions with current water stress, such as Southern and Eastern Mediterranean Region, the runoff is expected to be minimized according to the changing precipitation and evaporation patterns [191]. It is scientifically identified that the annual precipitation in Turkey have had a decreasing trend and the average summer temperatures have increased approximately 1.5°C since the very beginning of 1960s ([192], [193]).

The water availability in the beginning of 2000 was determined as 112 km^3, which translates into 1735 m^3 of water available for use per capita [175]. Based on those calculations, it is expected that the average water availability per capita will decrease by 25%, and will be equivalent to around 1300 m^3; under the impact of both environmental change and increase in population [175]. Moreover, approaching to the 2050s, a decrease around 50-70% in water availability especially around Southern Turkey is also expected ([190], [191]).

Accordingly, a decrease in current water use is of great interest for Turkey. Higher efficiency in irrigation systems as well as selection of crops which are less water-intensive for agricultural production are two of the measures that can be taken currently. It has been claimed that conventional irrigation methods, applied in Turkey, is associated with lower efficiency; which was claimed to be around 50% [175]. Expansion of the use of more efficient irrigation methods like irrigation by sprinkling or dripping, 80-90% efficiency can be expected, which translates into a 20-30% savings from water use per each irrigated area [175]. As already been discussed in WWF [189], river basin-oriented water footprint assessments for agricultural production should be carried out, especially in the basins with obvious water scarcity problems such as Konya closed basin and less water-intensive crops should be cultivated in those regions.

4.1.3 Greenhouse Gas Emission Estimations of the Dietary Scenarios

Total GHG emissions associated with the food consumption in 2013, calculated based on the dietary scenario for the actual calories constituting the diet (3706 Calories daily), is equivalent to 3.3 kg CO2eq per capita daily, including food loss and waste. Based on the population in 2013 [187], the total GHG emissions associated with food was calculated as 93.1 million tonnes $CO2_{eq}$ for the year 2013. According to the statistics provided by TURKSTAT, the GHG emissions were 5.9 and 6.04 tonnes per capita in the years 2012 and 2014, respectively [187]. The GHG emissions per capita translates into 16.16-16.66 kg CO2eq daily. Accordingly, the GHG emissions associated with producing the 2013 diet constituted approximately

20% of all emissions generated per capita. The share of food consumption in total GHG emissions are similar to Turkey. In UK, one fifth all GHG emissions are attributed food consumption [23], [109]. In addition, food production and consumption was associated with 20 – 30% of all European GHG emissions [49].

The population of Turkey was forecasted to reach more than 90 million (93.475.575 – 110.546.401) in 2050 [187]. Using the forecasted population, the total GHG emissions associated with foods in 2050 were also calculated. For the A1 dietary scenario, the total GHG emissions of food consumption can be expected to reach more than 108 million tonnes per year (16% increase when compared to the 2013). For the A2 dietary scenario, the GHG emissions can be expected to grow at least to 112 million tonnes, as daily energy for the A2 scenario is greater than the A1 (20% increase). The global average diet, projected for the year 2050, is expected to be associated with 4.1 Gt CO2eq per year [17] and if the current income-dependent 2050 projections are considered, food consumption in Turkey will be responsible for approximately 2.7% of the emissions.

In the Mediterranean Region, there are numerous studies estimating the GHG emissions associated with the food consumption. The studies that estimated the GHG emissions of diets using the life cycle approaches, that were carried out in the Mediterranean countries and from other developed regions of the World whose results are in line with the results of this study are given in Table 21. In comparison with the other Mediterranean countries, the GHG emissions of all dietary scenarios created for Turkey are lower than the benchmarking countries for the average emission factors. Compared to France, the 2013 diet is associated with 25 – 70% lower GHG emissions. The GHG emission of the healthy dietary pattern, TDG-H is the highest on in the dietary scenarios. Even so, it is similar to the average Greek diet and performs better than average French, Italian and Spanish diets. Moreover, TDG-H is associated with approximately 40% less GHG emissions per day compared to other dietary guidelines in Germany, Denmark and US with average emission factors. The GHG emissions associated with the A1 and A2-oriented dietary scenarios for the year 2050 is estimated to be in between 0.6 – 1.7 g CO2eq per kcal of diet; which is approximately 30% lower than the GHG emissions in other Mediterranean countries.

The GHG emissions of the diets differ across countries due to various reasons. The components of the diets, cultural preferences for food, food availability and affordability are some of the determinants for an average diet in a country. On the other hand, the differences in climate, production practices, economic and social development have an impact on the magnitude of emissions of GHG in countries. Accordingly, the differences in environmental impact calculations could occur due to the average diet definition, the incorporated food loss or waste and the emission factors used in estimations. In order to minimize the differences, the results of the studies that estimated the GHG emissions of diets using the life cycle approaches from the Mediterranean countries and from other developed regions of the World were given. The difference is largely due to the fact that the meat consumption in Turkey is lower than the consumption in stated countries.

The strategies widely proposed in literature to diminish the GHG emissions mostly cover reducing the consumption of high-impact foods while increasing the consumption of their alternatives in terms of nutritional quality. GHG emission intensive animal-oriented food products (meat and dairy) are consumed lower than recommended in the dietary scenarios in this study. For that reason, replacement of those with other plant-oriented food sources may lead to lower nutritional quality. However, the substitution can be done among the food groups. As shown in Figure 22, per gram of protein in poultry are associated with less GHG emissions than red meat, and substituting all red meat with poultry would result in 10% decrease in GHG emissions (12% decrease in water footprint). However, one should note that the only environmental impact that is considered is the GHG emissions and its relation to protein content. Increasing intensive poultry production may be associated with more harmful environmental impacts such as land use clearing, waste disposal problems, triggering the surface and ground water and soil quality problems and ecosystem contamination [194]. Another option is to increase the intake of high protein sources with low GHG intensity. For instance, peas and beans provide the largest amount of protein per gram of product and they are less GHG intensive than other protein sources (Figure 22). The dietary guidelines can also consider diminishing the consumption of vegetables grown in greenhouses, which are associated with high GHG intensity, and promote the consumption of seasonally and spatially local food products.

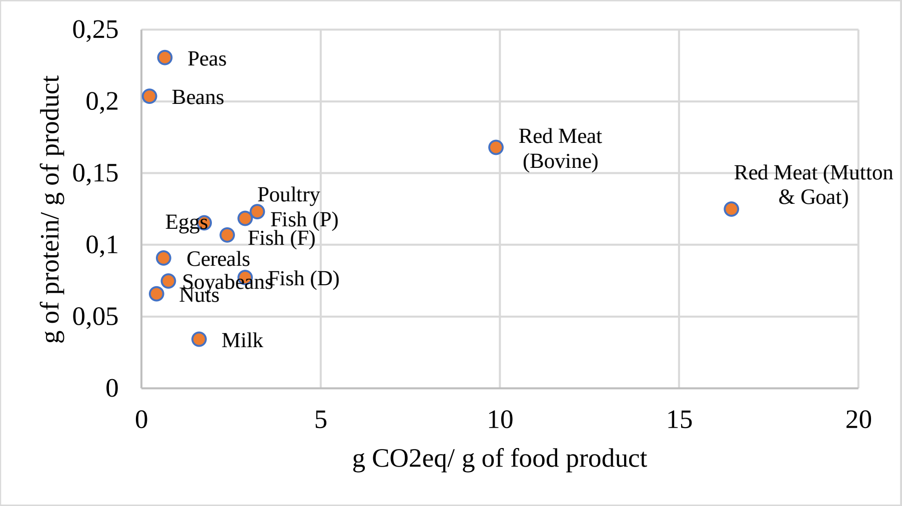

Figure 23. Common protein sources and the corresponding GHG emissions per gram of those food products.

4.4 Food Waste and Loss

In general, the GHG emissions associated with producing the food products that was lost or wasted at all supply chain stages amounts approximately 14-15% of all emissions associated with food consumption in Turkey. Based on the given FLW ratios for Turkey, an average person was supplied 3706 kcal-day in 2013; however, at least 500 calories of which was lost or wasted. Total GHG emission associated with food loss or waste in 2013 was 13.9 million tonnes CO2 equivalent per year. In addition, the WF of food waste and loss was equivalent to 13.2 billion cubic meters in total. The shift from the diet in 2013, or shift from the 2050 dietary scenarios to the Mediterranean diet would result in at least 11% less GHG emissions and 12-21% less WF. The same reduction in GHG emissions would be achieved if most of the food loss and waste throughout the supply chain could be eliminated. In addition, 85% reduction in food waste and loss for the 2013 diet would result in the same amount of GHG emissions elimination, by eliminating 50% of milk intake from the same diet. Even if it is not possible to eliminate the food loss and waste majorly, efforts to decrease the food loss and waste should be combined with the efforts to mitigate production or consumption-oriented environmental impact for food products. Without any sanctions or improvements in the food loss or waste, the GHG emissions associated with food loss is expected to grow 15.1 – 16.8 million tonnes CO2eq and the WF to 15.4 – 16.56 billion cubic meters per year in Turkey.

Table 18. Comparison of the greenhouse gas emissions associated with the dietary scenarios in this study with the studies carried out in indicated regions

The Study Region	GHG emission per year (kgCO2eq/cap)	GHG emission per day (kgCO2eq/cap)	Energy of an average diet (kcal/cap/day)	Mass of an average diet (g/cap/day)	GHG emission per kcal (gCO2eq)	GHG emissions per gram (gCO2eq)	Source
France	-	4.2	2025 - 2118	-	1.98 – 2.07	-	[87]
Italy	-	5.4	2600	2270	2.08	2.4	[195]
Italy (MED)	-	4.7	-	-	-	-	[195]
Spain		4.8	-	2367	-	2.02	[61]
Greece	1800	4.93	-	-	1.5	-	[94]
Germany	1533 – 2201	4.2 – 6.03	-	-	-	-	[48]
Germany (DG-GE)	1820	4.98	-	-	-	-	[48]
Denmark	2030	5.6	-	2493	-	2.25	[25]
Denmark (NNR)	1900	5.2	-	-	-	-	[25]
Denmark (NND)	1720	4.7	-	-	-		[25]
UK		3.34 – 4.58	-		1.97 – 2.05		[196]
USA	-	5	2000	-	2.5	-	[121]
USA (DG-US)	-	4.95	2000	-	2.48	-	[121]
USA (DG-US)	-	5.6	2534	-	2.2	-	[121]
2013	416 - 1197	1.14 - 3.28	2000	1430	0.6 - 1.6	0.80-2.29	THE RESULTS OF THIS THESIS
ID 2050 (A1)	434 - 1230	1.19 - 3.37	2000	1394	0.6 - 1.7	0.85 – 2.40	
ID 2050 (A2)	420 – 1223	1.15 - 3.35	2000	1506	0.6 - 1.7	0.78 – 2.09	
TDG-H	628 - 2070	1.72 - 5.67	2000	1981	0.85 - 2.8	0.85 - 2.90	

MED: The Mediterranean Dietary Scenario in the indicated study.

DG-GE: German Dietary Guidelines

NNR: Nordic Nutrition Recommendations

NND: New Nordic Diet, designed to be both healthy and environment-friendly

DG: Dietary Guidelines for US adults

4.5 Environmental Impact together with Health Implications

The dietary scenarios created to represent the food consumption in Turkey failed to meet the recommendations provided by the Ministry of Health in 2016, [170]. The estimated intake levels for fruits, vegetables, pulses, nuts, meat, milk and fish fell behind the minimum recommended intake at 2000 kcal basis daily diet. In addition, the dietary scenarios failed to meet the optimal intake levels, calculated based on meta-analyses in epidemiological studies. According to the FAOSTAT Food Balance Sheets (FBS) for Turkey, the fruit and vegetable supply (which equals to an average supply of 990 gr/capita/day) is one of the highest in the EU region ([172]) however, actual consumption of fruits and vegetables are considerably lower than the supply amount, according to Turkey Demographic and Health Survey carried out in 2013 [197].

The results of nutritional assessment suggested overconsumption of carbohydrates whereas the consumption of protein was lower than recommended. The increase of plant-based protein sources in the diet can be both a nutritionally adequate and environmentally sound solution to increase the ratio of protein in total calories though it might bring risk in inadequate of providing all essential amino acids. Overconsumption of carbohydrates (from cereals, sugars) is neither healthy nor environment-friendly. Cereals were consumed 30 – 80% more than recommended and constituted more than 25% of the WF in the dietary scenarios, except the healthy diet. The WF associated with the over consumption of cereals generate 136 liters per day of WF (6% of total WF) and 60 g CO2eq daily GHG emissions (3.5% of total GHG emissions) in 2013. Regards to the health implications, overconsumption of carbohydrates are shown to be linked to CHD and other NCDs ([156]).

The TDG-H dietary scenario, on the other hand, met the optimal intake levels for fruits, vegetables, nuts and seeds, fish and as well as for the share of PUFA in total calories. However, a shift to the recommended diet did not result in decrease in GHG emissions nor in WF even if the shift would result in better health outcomes. This is largely due to the recommended increase in protein intake from animal-oriented food products. The MED dietary scenario, met the optimal intake levels for nuts and seeds and fish. In addition, the share of PUFA in the MED dietary scenario met the optimal intake level. When compared to the TDG-H, the MED dietary scenario varied significantly for the intake of animal-oriented protein supplies. However, the Mediterranean dietary scenario was associated with 35% less WF and 41% less GHG emissions when compared to the TDG-H at 2000 Calories daily. In short, both dietary scenarios had the highest health scores and the one with higher animal-oriented foods (TDG-H) are associated with higher environmental impacts.

Recently, studies analyzing the GHG emissions and WF for hypothetical or actual dietary scenarios in comparison with dietary guidelines found that lower diet-related GHG emissions or WF may not be associated with nutritionally sufficient diets, with better health implications ([48], [88], [89], [108], [109], [121], [123], [151], [166]). In most of the studies, plant-based diets were expected to perform better than the omnivorous diets in terms of environmental sustainability and health. However, the diets that were assumed to be healthy and nutritious were not always linked to decreased environmental impact. The underlying cause was explained by the shift in food composition of diets. In addition, when the meat products were eliminated from the diets, the calorie requirements were mostly met by increasing the amount of other food products with lower environmental impact. Even if the per food product impact was lower, the total of quantified environmental impact of the diet increased due to elevated levels. Still, those studies revealed that, it is achievable to construct diets that are both environmentally sustainable, nutritionally adequate and healthy; whether they are plant-based or omnivorous.

Similarly, it is found that the healthy diet constructed based on dietary guidelines (TDG-H), which constitutes higher animal-oriented food is associated with higher GHG emissions and water footprint. The Mediterranean Diet, on the other hand, which is associated with quite similar health implications as TDG-H, resulted in the lowest GHG emissions and water footprint. The main difference in both environmental impact categories (GHG emissions and water footprint) was mostly associated with the difference in the recommendations related to meat and milk consumption.

4.6 Limitations of the Thesis and Recommendations for Future Studies

4.6.1 Constructing Dietary Scenarios

As also stated by FAO [198], Food Balance Sheets have problems related to coverage, representativeness, incompleteness and inaccuracy. Food Balance Sheets (FBSs) provide statistics from the national accounts to represent the food supply pattern of a country for a specific period (average food availability per capita per year), which do not show what people exactly consume or how the consumption differs among the society. Moreover, they do not provide data on the food that is produced for self-consumption. For instance, all meat produced in Turkey may not be included in the FBSs as home produce, hunting, gathering or fishing for self-consumption cannot be recorded by the national institutes. In short, they are only a general picture of food consumption in Turkey.

In addition, FBSs usually provide raw, unprocessed, semi-processed food commodities, rather than foods consumed as final products. As a result, FBS data incorporated more food products than edible amounts, which is expected to exceed the actual consumption amounts. In order to adjust the per capita daily food supply given in FBSs, food loss and waste rates were employed. It is assumed that losses at consumer level included the losses from non-edible parts of the food products and no other further adjustment was carried out related to non-edible losses.

There are two main consequences of using FBSs. Firstly, the amount of food supply in Turkey can be larger than estimated by FAO in FBSs. Secondly, as the food supply is not equal to the consumption exactly, the environmental impact results found in this study can be greater or lesser than the environmental impact associated with food actual consumption. Despite all, FBSs are the best data set to be used for constructing diet scenarios to represent the food consumption in Turkey as there is not enough actual dietary consumption data to be used in environmental impact assessment studies. Therefore, future studies with a similar objective should try to construct dietary scenarios based on self-selected diets or dietary surveys carried out in Turkey to estimate the environmental impacts and health implications of food consumption with less uncertainties.

4.6.2 Quantifying the Environmental Impact associated with Food Consumption

In this study, the environmental impact categories are limited to GHG emissions and water footprint. Future studies should include other environmental impacts such as land use, cumulative energy demand, eutrophication, acidification as well as biodiversity loss in their analyses.

One should note that, the calculated GHG emissions and the water footprint of the historical and forecasted Turkish diet is not equal to the environmental impact of the Turkish food system. Rather, the results show the trends of contribution of food consumption in Turkey to the global environmental and climate change and one of the indicators of sustainability in the Turkish food system.

Moreover, both the GHG emission and water footprint factors were compiled from previous studies in the field. The lack of consistent and reliable life cycle inventories for food products to quantify the associated GHG emissions in Turkey, as well as other environmental outcomes was a key obstacle for this study. A meta-analysis was conducted to construct a data set for GHG emission factors of single food products in the Mediterranean Region by gathering the life cycle emission results published. This approach has limitations. For instance, the GHG emission factors provided in literature have different system boundaries or allocation procedures. In addition, there may be differences in emission factors in different geographical regions due to common production practices followed, the use of fertilizers and pesticides and the electricity mix in comparison with Turkey. Those differences may influence the results. To eliminate such problems, minimum and maximum emission factors were gathered and used to estimate a range for total GHG emissions of the dietary scenarios and the emission factors with the same system boundaries were incorporated in the Mediterranean average GHG emission factors. Moreover, the water footprint assessment data was for the period, 1996 – 2005; which may not be convenient to quantify the footprint in the years 1961, 2013 and 2050. As no data were available for the indicated years in the time of this study, the given water footprint data for Turkey were used. Notwithstanding, they were still useful to make comparisons and detect relative changes in WF over time and in between dietary scenarios. There is a need to develop a detailed country-specific life cycle inventory data for food products. In addition, water footprint factors of the food products should be updated for future studies in the field.

4.6.3 Assessment of Health Implications of the Dietary Scenarios

What contributes to better health implications in dietary choices is still an open question and developing area. Due to the limitations of using Food Balance Sheet data, generalizations about nutritional adherence to recommendations, health implications and environmental outcomes of a dietary scenario should be made with caution. Even so, the average consumption data provided a sufficient basis as the main purpose of this study was to understand the nature of food consumption in Turkey from 1960s to the future (2050) and to assess the environmental impacts in terms of GHG emissions and water footprint, in relation with health implications.

In addition, health score is an imperfect measure of the healthiness of the dietary scenarios. The health assessment in this study was limited to the qualitative analysis of the causal relationships between some food groups and coronary heart disease (CHD). In future studies, one should include additional assessment of nutritional quality through intake of macro and micronutrients and vitamins and extend the health assessment through nutrition-related health indicators.

4.7 Conclusions

Sustainable Consumption and Production (SCP) approach recognizes the important part the consumers have in promoting sustainability through consumption choices, that will promote sustainability in production. Nowadays, providing the consumer the ability to decide responsibly to choose what to consume (through labels, social media etc.), consumers are more important drivers of the production compared to prior decades. Therefore, increasing the sustainability throughout the food systems involves the consideration of production and consumption altogether. In order to provide sufficient nutrition needs of a growing population, who are expected to be richer and more urbanized, current food systems should undergo a transition globally to become more protective to natural resources, resource-efficient, caring for equity in consumption and promoting sustainability in diets.

This study showed that the environmental impact of food consumption in Turkey is lower than the EU averages and other Mediterranean countries. In addition, the future diet-related GHG emissions and water footprint are not expected to exceed the average environmental impacts associated with average diets in Europe or other developed regions. However, the dietary scenarios for the current as well as future food consumption in Turkey did not reveal adherence to nutritional guidelines and low health scores when compared to dietary guidelines and the Mediterranean Diet. Eating according to the dietary guidelines is healthier but, it is also more environmentally burdensome than the current dietary patterns though balance between the two should be found. Even so, improvements in GHG emissions and WF are possible if the dietary guidelines consider the magnitude of environmental impact with food products and extend their focus to include both health and environment to ensure better outcomes. Since food is accepted as one of the environmental hotspots in the literature, numerous countries included sustainability in three pillars in the national or regional dietary guidelines (See Sweden ([199]), UK ([200], the Netherlands ([201]) and Brazil ([202]). In addition, the sustainable diet concept highlights both the nutritious property of the diets, leading to positive health outcomes, as well as the development of it into a more economical, social and environmental way [203].

To the best of the writer’s knowledge, this study is the first to measure the changes in environmental impact associated with Turkish dietary pattern from 1961 to 2013. In addition, this study is the first study to forecast the income-dependent Turkish diet for the future and associated environmental impact. Despite all the limitations, this thesis provides a useful basis for future studies in both environment and nutrition.

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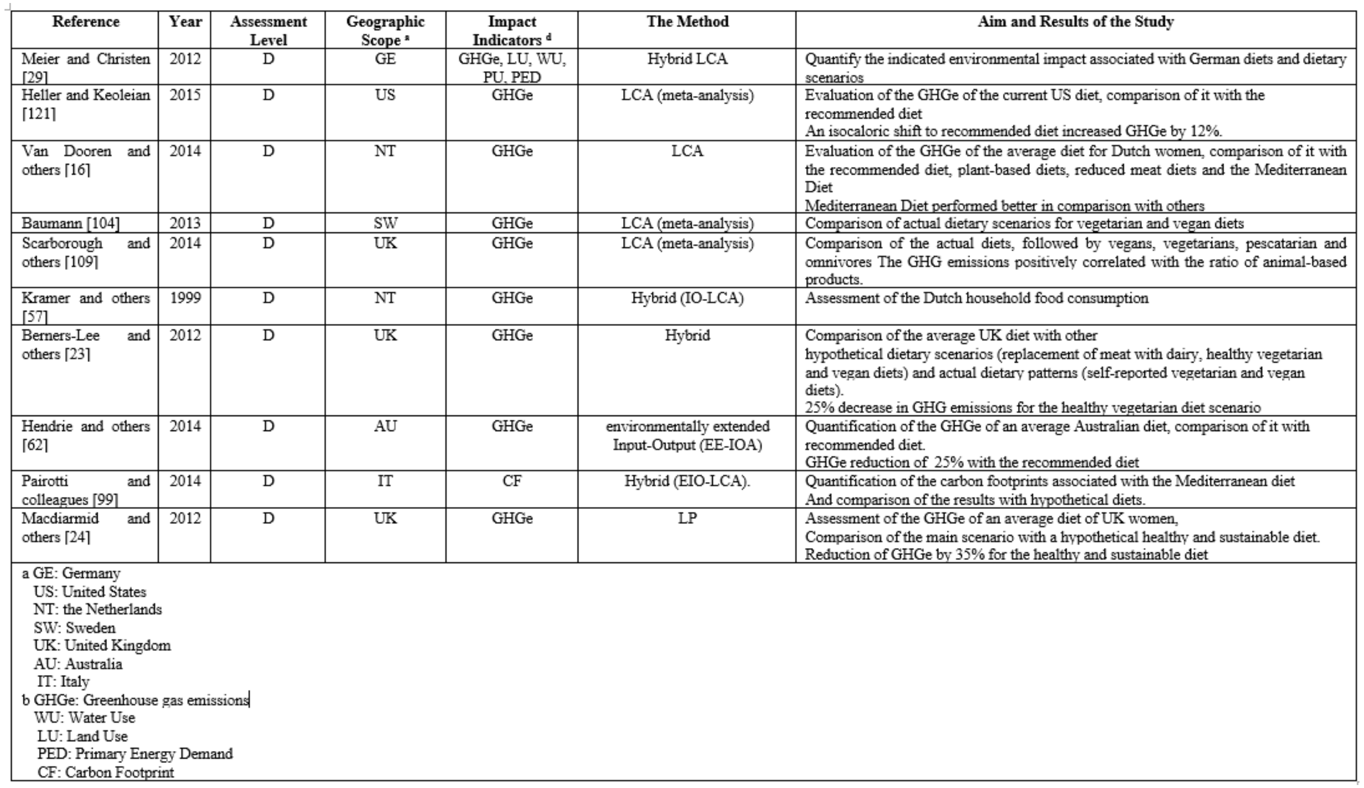
APPENDICES

APPENDIX A

Table A-1. Outstanding studies on the environmental impacts of local, regional or global food consumption with Life Cycle approaches



Reference	Year	Assessment Level	Geographic Scope [a]	Impact Indicators [d]	The Method	Aim and Results of the Study
Meier and Christen [29]	2012	D	GE	GHGe, LU, WU, PU, PED	Hybrid LCA	Quantify the indicated environmental impact associated with German diets and dietary scenarios
Heller and Keoleian [121]	2015	D	US	GHGe	LCA (meta-analysis)	Evaluation of the GHGe of the current US diet, comparison of it with the recommended diet An isocaloric shift to recommended diet increased GHGe by 12%.
Van Dooren and others [16]	2014	D	NT	GHGe	LCA	Evaluation of the GHGe of the average diet for Dutch women, comparison of it with the recommended diet, plant-based diets, reduced meat diets and the Mediterranean Diet Mediterranean Diet performed better in comparison with others
Baumann [104]	2013	D	SW	GHGe	LCA (meta-analysis)	Comparison of actual dietary scenarios for vegetarian and vegan diets
Scarborough and others [109]	2014	D	UK	GHGe	LCA (meta-analysis)	Comparison of the actual diets, followed by vegans, vegetarians, pescatarian and omnivores The GHG emissions positively correlated with the ratio of animal-based products.
Kramer and others [57]	1999	D	NT	GHGe	Hybrid (IO-LCA)	Assessment of the Dutch household food consumption
Berners-Lee and others [23]	2012	D	UK	GHGe	Hybrid	Comparison of the average UK diet with other hypothetical dietary scenarios (replacement of meat with dairy, healthy vegetarian and vegan diets) and actual dietary patterns (self-reported vegetarian and vegan diets). 25% decrease in GHG emissions for the healthy vegetarian diet scenario
Hendrie and others [62]	2014	D	AU	GHGe	environmentally extended Input-Output (EE-IOA)	Quantification of the GHGe of an average Australian diet, comparison of it with recommended diet. GHGe reduction of 25% with the recommended diet
Pairotti and colleagues [99]	2014	D	IT	CF	Hybrid (EIO-LCA).	Quantification of the carbon footprints associated with the Mediterranean diet And comparison of the results with hypothetical diets.
Macdiarmid and others [24]	2012	D	UK	GHGe	LP	Assessment of the GHGe of an average diet of UK women, Comparison of the main scenario with a hypothetical healthy and sustainable diet. Reduction of GHGe by 35% for the healthy and sustainable diet

a GE: Germany
US: United States
NT: the Netherlands
SW: Sweden
UK: United Kingdom
AU: Australia
IT: Italy
b GHGe: Greenhouse gas emissions
WU: Water Use
LU: Land Use
PED: Primary Energy Demand
CF: Carbon Footprint

Table A-1. Outstanding studies on the environmental impacts of local, regional or global food consumption with Life Cycle approaches

Reference	Year	Assessment Level	Geographic Scope ^{a}	Impact Indicators ^{d}	The Method	Aim and Results of the Study
Vanham and others [134]	2013	D	EU28	WF	WFA	Comparison of the water footprint of different diets: the average diet (1996-2005), dietary recommendations, the vegetarian diet and a reduced meat diet Reduction in the WF associated to diets by 30% in case a reduction in meat consumption by 50%
Vanham and others [137]	2013	D	EU	WF	WFA	change in WF of food consumption in case a shift from the current diets in four European zones to the alternative diets
Vanham and Bidoglio [135]	2014	D	EU river basin	WF	WFA	calculated the change in WF as a result of a shift to a healthy or vegetarian diet for 365 water basins in Europe
Vanham [136]	2013	D	AS	WF	WFA	Comparing the diets in Austria based on their WF the diet with the lowest water footprint was the vegetarian diet
Vanham and others [129]	2016	D	MED	WF	WFA	employed WF assessment to quantify and compare the water consumption of diets that are followed in selected Mediterranean cities the WF associated with food consumption per capita was approximately 20 times more than the domestic water use per capita in Mediterranean cities
Tilman and Clark [17]	2014	D	Global	LU, GHGe, HI	LCA (meta-analysis)	food production emissions will increase by 80% if current dietary trends continue shifts towards Mediterranean and other plant-based diets have the potential to reduce the total environmental impacts, while diminishing the occurrence of diet-related chronic NCDs
Springmann and colleagues [154]	2016	D	Global	GHGe, HI	LCA (meta-analysis)	Assessment of the health implications of some environmentally sustainable dietary patterns

a EU and EU28: European Union
AS: Austria
MED: Mediterranean Region
b WF: Water Footprint
LU: Land Use
GHGe: Greenhouse gas emissions
HI: Health impact

APPENDIX B

Table B-1. The literature on environmental impacts associated with food products produced in Turkey

Reference	Year	Food Products	Geographic Scope [a]	Supply Chain Stage [b]	The System Boundaries [c]	Impact Indicators [d]	Aim and Results of the Study
Özkan [204]	2004	Citrus Fruits	TR (Antalya)	P	CTG	EU	energy requirements of citrus fruit production; more than 95% of energy use in production are supplied by fossil fuels
Özkan [205]	2007	Grape	TR	P	CTG	EU	compare the energy use and cost of greenhouse and open-field grape production
Erdal [206]	2007	Sugar beet	TR (Tokat)	P	CTG	EU	input-output energy consumption analysis of sugar beet 82.43% of total energy input was from non-renewable resources
Göktolga [207]	2006	Peach	TR (Tokat)	P	CTG	EU	input-output energy requirement analysis of peach
Gökdoğan [208]	2011	Peach	TR (Isparta)	P	CTG	EU	energy requirement analysis of peach
Külekçi [209]	2013	Pistachio	TR (Gaziantep)	P	CTG	EU	input-output energy requirement analysis of pistachio
Oren [210]	2006	Wheat and cotton	TR (Southeastern Anatolia)	P	CTG	EU	input-output energy requirement analysis of wheat and cotton production
Gündoğmuş [211]	2006	Apricot	TR	P	CTG	EU	Comparison of the energy use of organically and conventionally produced apricots 38% higher energy input was used on conventional apricot farming
Gündoğmuş [212]	2010	Dried Fig	TR	P	CTG	EU	compared the energy use of organically and conventionally produced dried figs 26% higher energy input was used on conventional farming
Özilgen and Sorgüven [213]	2011	Vegetable Oils: Olive, Soybean and Sunflower Oil [206]	TR	P	CTG	EEU, GHGe	energy and exergy utilization of the production; CO_2 emissions: Sunflower Oil: 845 gCO_2eq/kg Olive Oil: 1063.2 Soybean Oil: 4160.5 gCO_2eq/kg
Karakaya and Özilgen [214]	2011	Tomato and products	TR	P, T, W	CTGr	EU	the energy utilization of tomato production processes
Yavuz [215]	2016	Potato	TR (Middle Anatolia)	P	CTG	EU	the energy consumption during drip-irrigated potato production

[a] TR: Turkey
[b] P: Production, T: Transportation, W: Waste Management
[c] CTG: Cradle-to-gate, CTGr: Cradle-to-Grave
[d] EU: Energy Use, GHGe: Greenhouse gas emissions

APPENDIX C

Table C-1. Dietary scenarios constructed for environmental assessments

DIETARY SCENARIOS FOR ENVIRONMENTAL ASSESSMENT																			
		1961			2013			ID2050 (A1)			ID2050 (A2)			Simulated Mediterranean Diet			TDG-H		
TURKISH FOOD AVAILABILITY PER CAPITA		(availability/capita)			(availability/capita)			(availability/capita)			(availability/capita)			(FLW and Calorie-adj. Intake)			(FLW and Calorie-adj. Intake)		
Food Group	Food Products	IC-kcal	IC-kg/year	IC-g/day	IC-kcal	IC-kg/year	IC-g/day	IC-kcal	IC-kg/year	IC-g/day	IC-kcal	IC-kg/year	IC-g/day	IC-kcal	IC-kg/year	IC-g/day	IC-kcal	IC-kg/year	IC-g/day
Cereal	Wheat and products	893,40	118,17	323,74	693,47	91,72	251,29	656,81	86,87	238,01	753,16	99,62	272,92	536,58	70,97	194,44	620,83	82,11	224,97
	Rice (Milled Equivalent)	32,49	3,60	9,85	52,35	5,80	15,88	49,58	5,49	15,04	56,85	6,29	17,25	40,50	4,48	12,29	0,00	0,00	0,00
	Barley and products	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
	Maize and products	64,30	8,05	22,07	104,70	13,11	35,93	99,16	12,42	34,03	113,71	14,24	39,02	81,01	10,15	27,80	0,00	0,00	0,00
	Rye and products	76,48	9,24	25,31	13,49	1,63	4,47	12,78	1,54	4,23	14,65	1,77	4,85	10,44	1,26	3,45	0,00	0,00	0,00
	Oats	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
	Cereals, Other	50,08	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Starchy Roots	Potatoes and products	50,08	25,71	70,44	42,09	21,61	59,20	39,88	20,47	56,09	45,72	23,47	64,29	13,76	7,06	19,35	25,07	12,87	35,26
	Roots, Other	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Sugar & Sweeteners	Sugar (Raw Equivalent)	44,67	4,59	12,57	160,28	16,46	45,10	173,76	17,84	48,89	127,69	13,11	35,93	149,28	15,33	42,00	81,37	8,36	22,89
	Sweeteners, Other	0,00	0,00	0,00	0,54	0,09	0,24	0,59	0,09	0,26	0,43	0,07	0,19	0,50	0,08	0,22	0,00	0,00	0,00
	Honey	1,35	0,17	0,45	5,40	0,66	1,80	5,85	0,71	1,96	4,30	0,52	1,44	4,47	0,55	1,49	0,00	0,00	0,00
Pulses	Beans	19,63	2,11	5,79	13,49	1,45	3,98	12,78	1,38	3,77	14,65	1,58	4,32	42,09	4,53	12,41	16,60	1,79	4,89
	Peas	0,68	0,06	0,18	1,08	0,10	0,28	1,02	0,10	0,27	1,17	0,11	0,31	3,37	0,32	0,88	1,33	0,13	0,35
	Pulses, Other and products	40,61	4,23	11,60	52,35	5,46	14,95	49,60	5,17	14,16	56,85	5,93	16,23	163,30	17,02	46,63	64,40	6,71	18,39
Treenuts	Nuts and products	24,37	2,95	8,08	30,22	3,66	10,02	28,63	3,47	9,50	32,82	3,97	10,89	93,40	11,31	30,98	55,25	6,69	18,33
Oilcrops	Soyabeans	0,00	0,00	0,00	2,16	0,92	2,53	2,05	0,87	2,40	2,34	1,00	2,75	2,17	0,93	2,54	0,00	0,00	0,00
	Groundnuts (Shelled Eq)	4,06	0,27	0,74	9,71	0,64	1,76	9,20	0,61	1,67	10,55	0,70	1,91	9,77	0,65	1,77	0,00	0,00	0,00
	Rape and Mustardseed	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
	Coconuts - Incl Copra	0,00	0,00	0,00	1,62	0,43	1,17	1,53	0,40	1,11	1,76	0,46	1,27	1,63	0,43	1,18	0,00	0,00	0,00
	Sesame seed	4,74	0,29	0,80	4,32	0,26	0,72	4,09	0,25	0,69	4,69	0,29	0,79	4,34	0,27	0,73	0,00	0,00	0,00
	Olives (including preserved)	10,83	1,60	4,39	15,65	2,32	6,34	14,83	2,19	6,01	17,00	2,51	6,89	17,53	2,59	7,11	0,00	0,00	0,00
	Oilcrops, Other	0,00	0,00	0,00	5,40	0,39	1,08	5,11	0,37	1,02	5,86	0,43	1,17	5,43	0,40	1,09	0,00	0,00	0,00

Table C-1. Dietary scenarios constructed for environmental assessments

DIETARY SCENARIOS FOR ENVIRONMENTAL ASSESSMENT (Cont'd)																			
		1961			2013			ID2050 (A1)			ID2050 (A2)			Simulated Mediterranean Diet			TDG-H		
TURKISH FOOD AVAILABILITY PER CAPITA		(availability/capita)			(availability/capita)			(availability/capita)			(availability/capita)			(FLW and Calorie-adj. Intake)			(FLW and Calorie-adj. Intake)		
Food Group	Food Products	IC-kcal	IC-kg/year	IC-g/day	IC-kcal	IC-kg/year	IC-g/day	IC-kcal	IC-kg/year	IC-g/day	IC-kcal	IC-kg/year	IC-g/day	IC-kcal	IC-kg/year	IC-g/day	IC-kcal	IC-kg/year	IC-g/day
Vegetable Oils	Soya bean Oil	19,63	0,82	2,25	30,76	1,29	3,53	33,35	1,40	3,83	24,51	1,03	2,82	33,02	1,38	3,79	0,00	0,00	0,00
	Groundnut Oil	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
	Sunflower seed Oil	13,54	0,56	1,54	116,57	4,84	13,25	126,37	5,24	14,36	92,86	3,85	10,55	125,13	5,19	14,22	0,00	0,00	0,00
	Cottonseed Oil	29,78	1,23	3,37	36,16	1,49	4,10	39,20	1,62	4,44	28,80	1,19	3,26	38,81	1,60	4,40	0,00	0,00	0,00
	Palm kernel Oil	0,00	0,00	0,00	5,94	0,26	0,71	6,44	0,28	0,77	4,73	0,21	0,57	6,37	0,28	0,76	0,00	0,00	0,00
	Palm Oil	0,00	0,00	0,00	63,14	2,61	7,16	68,45	2,83	7,76	50,30	2,08	5,70	67,78	2,80	7,68	0,00	0,00	0,00
	Coconut Oil	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
	Sesame seed Oil	6,09	0,26	0,70	5,40	0,23	0,62	5,85	0,25	0,67	4,30	0,18	0,49	5,79	0,24	0,67	0,00	0,00	0,00
	Olive Oil	62,27	2,57	7,04	16,73	0,69	1,89	18,14	0,75	2,05	13,33	0,55	1,51	20,00	0,83	2,26	279,10	11,52	31,57
	Maize Germ Oil	5,41	0,22	0,61	16,73	0,69	1,89	18,14	0,75	2,05	13,33	0,55	1,51	17,96	0,74	2,03	0,00	0,00	0,00
	Oilcrops Oil, Other	0,00	0,00	0,00	2,70	0,12	0,34	2,93	0,13	0,37	2,15	0,10	0,27	2,90	0,13	0,37	0,00	0,00	0,00
Vegetable	Tomatoes and products	10,15	18,89	51,76	28,60	53,22	145,81	27,10	50,43	138,15	31,06	57,80	158,36	21,40	39,82	109,10	34,60	64,39	176,40
	Onions	9,48	8,85	24,23	10,79	10,08	27,60	10,23	9,55	26,15	11,72	10,94	29,98	8,08	7,54	20,65	13,06	12,19	33,39
	Vegetables, Other	45,35	78,07	213,88	38,86	66,89	183,26	36,81	63,38	173,63	42,20	72,65	199,03	29,07	50,05	137,12	47,01	80,92	221,70
Fruits	Oranges, Mandarins	3,38	4,95	13,55	8,63	12,62	34,58	8,18	11,96	32,77	9,38	13,71	37,56	10,21	14,93	40,91	18,13	26,50	72,59
	Lemons, Limes and products	0,68	1,24	3,39	1,08	1,98	5,41	1,02	1,87	5,13	1,17	2,15	5,88	1,28	2,34	6,40	2,27	4,15	11,36
	Grapefruit and products	0,00	0,00	0,00	0,54	0,59	1,61	0,51	0,56	1,53	0,59	0,64	1,75	0,64	0,70	1,91	1,13	1,23	3,38
	Citrus, Other	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
	Bananas	0,00	0,00	0,00	4,86	2,66	7,29	4,60	2,52	6,91	5,27	2,89	7,92	5,75	3,15	8,62	10,20	5,58	15,30
	Apples and products	6,77	6,13	16,79	19,97	18,08	49,55	18,92	17,13	46,94	21,69	19,64	53,81	23,62	21,39	58,61	41,91	37,96	104,00
	Pineapples and products	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
	Dates	0,00	0,00	0,00	2,16	0,35	0,95	2,05	0,33	0,90	2,34	0,38	1,03	2,55	0,41	1,12	4,53	0,73	1,99
	Grapes and products (excl wine)	108,29	58,06	159,06	26,44	14,18	38,84	25,05	13,43	36,80	28,72	15,40	42,18	31,28	16,77	45,94	55,51	29,76	81,53
	Fruits, Other	23,01	18,33	50,21	22,67	18,05	49,46	21,47	17,10	46,86	24,62	19,61	53,71	26,81	21,35	58,50	47,58	37,89	103,82
Stimulants	Coffee and products	0,00	0,00	0,00	0,54	0,25	0,68	0,54	0,25	0,68	0,54	0,25	0,68	0,00	0,00	0,00	0,00	0,00	0,00
	Cocoa Beans and products	0,68	0,18	0,48	1,08	0,28	0,77	1,08	0,28	0,77	1,08	0,28	0,77	0,00	0,00	0,00	0,00	0,00	0,00
	Tea (including mate)	0,00	0,00	0,00	1,62	1,54	4,21	1,62	1,54	4,21	1,62	1,54	4,21	0,00	0,00	0,00	0,00	0,00	0,00

Table C-1. Dietary scenarios constructed for environmental assessments

DIETARY SCENARIOS FOR ENVIRONMENTAL ASSESSMENT (Cont'd)																			
		1961			2013			ID2050 (A1)			ID2050 (A2)			Simulated Mediterranean Diet			TDG-H		
TURKISH FOOD AVAILABILITY PER CAPITA		(availability/capita)			(availability/capita)			(availability/capita)			(availability/capita)			(FLW and Calorie-adj. Intake)				(FLW and Calorie-adj. Intake)	
Food Group	Food Products	IC-kcal	IC-kg/year	IC-g/day	IC-kcal	IC-kg/year	IC-g/day	IC-kcal	IC-kg/year	IC-g/day	IC-kcal	IC-kg/year	IC-g/day	IC-kcal	IC-kg/year	IC-g/day	IC-kcal	IC-kg/year	IC-g/day
Spices	Pepper	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
	Pimento	2,03	0,25	0,70	1,08	0,13	0,37	1,08	0,13	0,37	1,08	0,13	0,37	0,00	0,00	0,00	0,00	0,00	0,00
	Cloves	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
	Spices, Other	14,89	1,58	4,32	8,09	0,86	2,35	8,09	0,86	2,35	8,09	0,86	2,35	0,00	0,00	0,00	0,00	0,00	0,00
Alcoholic Beverages	Wine	1,35	0,53	1,45	0,54	0,21	0,58	0,59	0,23	0,63	0,43	0,17	0,46	2,72	1,06	2,91	0,00	0,00	0,00
	Beer	2,03	1,73	4,74	7,56	6,44	17,64	8,19	6,98	19,12	6,02	5,13	14,05	38,10	32,47	88,96	0,00	0,00	0,00
	Beverages, Fermented	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
	Beverages, Alcoholic	2,71	0,33	0,91	6,48	0,79	2,17	7,02	0,86	2,36	5,16	0,63	1,73	32,66	4,00	10,96	0,00	0,00	0,00
Meat	Bovine Meat	10,15	2,95	8,09	21,59	6,28	17,21	30,37	8,84	24,22	17,14	4,99	13,67	8,85	2,58	7,06	27,58	8,03	21,99
	Mutton & Goat Meat	47,38	7,15	19,60	16,73	2,53	6,92	23,54	3,55	9,74	13,29	2,01	5,50	6,86	1,04	2,84	21,37	3,23	8,84
	Pigmeat	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
	Poultry Meat	5,41	1,61	4,42	34,00	10,13	27,77	47,84	14,26	39,07	27,00	8,05	22,05	13,94	4,16	11,39	37,75	11,25	30,83
	Meat, Other	0,68	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Offals	Offals, Edible	4,74	1,40	3,83	2,16	0,64	1,74	3,04	0,90	2,45	1,71	0,51	1,39	0,89	0,26	0,72	0,00	0,00	0,00
Animal Fats	Butter, Ghee	43,99	2,22	6,09	32,92	1,66	4,55	35,69	1,80	4,94	26,22	1,32	3,63	0,00	0,00	0,00	25,77	1,30	3,57
	Cream	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
	Fats, Animals, Raw	1,35	0,07	0,19	8,09	0,42	1,15	8,78	0,46	1,25	6,45	0,34	0,92	0,00	0,00	0,00	6,34	0,33	0,90
	Fish, Body Oil	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
	Fish, Liver Oil	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Eggs	Eggs	5,41	1,35	3,69	17,81	4,43	12,12	16,87	4,19	11,49	19,34	4,81	13,17	30,49	7,58	20,76	44,40	11,03	30,23
Milk	Milk - Excluding Butter	192,89	121,07	331,69	166,76	104,66	286,75	157,99	99,16	271,68	181,11	113,67	311,42	171,31	107,52	294,58	374,16	234,84	643,39
Fish and Seafood	Freshwater Fish	0,00	0,00	0,00	1,62	0,89	2,42	1,53	0,84	2,30	1,76	0,96	2,63	9,86	5,39	14,77	11,66	6,38	17,47
	Demersal Fish	0,00	0,00	0,00	0,54	0,56	1,54	0,51	0,53	1,46	0,59	0,61	1,67	3,29	3,42	9,36	3,89	4,04	11,08
	Pelagic Fish	2,71	1,12	3,07	3,78	1,57	4,29	3,58	1,48	4,06	4,10	1,70	4,66	23,01	9,53	26,11	27,22	11,28	30,89
	Marine Fish, Other	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
	TOTAL	2000,00	524,75	1437,66	2000,00	521,89	1429,83	2000,00	508,91	1394,27	2000,00	549,55	1505,61	2000,00	518,96	1421,82	2000,00	723,18	1981,31

Table C-2. Dietary scenarios constructed for health assessments

DIET SCENARIOS FOR HEALTH ASSESSMENT

TURKISH FOOD AVAILABILITY PER CAPITA		kcal/100 g	Food Loss and Waste Rates (%)	1961			2013			ID2050 (A1)			ID2050 (A2)			Simulated Mediterranean Diet			TDG - H		
				(loss-adjusted availablity)			(loss-adjusted availablity)			(loss-adjusted availablity)			(loss-adjusted availablity)			(Recommended Intake)			(Recommended Intake)		
Food Group	Food Products			kcal/day	kg/year	g/day	kcal/day	kg/year	g/day	kcal/day	kg/year	g/day	kcal/day	kg/year	g/day	kcal/day	kg/year	g/day	kcal/day	kg/year	g/day
Cereals	Wheat and products	275,96	0,12	1167,94	154,85	424,24	1136,97	150,38	412,00	972,21	126,34	346,13	1224,18	159,08	435,84	698,86	92,43	253,24	683,48	90,40	247,67
	Rice (Milled Equivalent)	329,66	0,12	42,47	4,72	12,92	85,83	9,50	26,03	73,39	9,54	26,13	92,41	12,01	32,90	52,75	5,84	16,00	0,00	0,00	0,00
	Barley and products	0,00	0,12	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
	Maize and products	291,40	0,12	84,06	10,48	28,73	171,65	21,50	58,91	146,78	19,07	52,26	184,82	24,02	65,80	105,51	13,22	36,21	0,00	0,00	0,00
	Rye and products	302,15	0,12	99,98	11,91	32,63	22,12	2,67	7,32	18,91	2,46	6,73	23,82	3,09	8,48	13,60	1,64	4,50	0,00	0,00	0,00
	Oats	0,00	0,12	0,00	0,00	0,00	0,00	0,02	0,05	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,01	0,03	0,00	0,00	0,00
	Cereals, Other	0,00	0,12	65,48	7,77	21,28	0,00	0,01	0,02	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,01	0,01	0,00	0,00	0,00
Starchy Roots	Potatoes and products	71,10	0,12	64,80	33,41	91,53	68,30	35,06	96,06	58,43	30,00	82,19	73,54	37,76	103,45	17,78	9,13	25,00	27,38	14,05	38,50
	Roots, Other	0,00	0,12	0,00	0,03	0,07	0,00	0,01	0,02	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Sugar & Sweeteners	Sugar (Raw Equivalent)	355,43	0,12	57,80	5,95	16,31	260,08	26,71	73,17	254,55	26,35	72,19	205,41	21,26	58,25	192,86	19,81	54,26	88,86	9,13	25,00
	Sweeteners, Other	228,13	0,12	0,00	0,00	0,00	0,88	0,14	0,38	0,86	0,09	0,24	0,69	0,07	0,20	0,65	0,10	0,28	0,00	0,00	0,00
	Honey (a)	299,18	0,00	2,00	0,28	0,77	10,00	1,22	3,34	9,79	1,01	2,78	7,90	0,82	2,24	6,49	0,79	2,17	0,00	0,00	0,00
Pulses	Beans	339,22	0,16	24,35	2,62	7,18	20,99	2,26	6,19	17,96	1,88	5,15	22,60	2,37	6,49	52,68	5,67	15,53	17,56	1,89	5,18
	Peas	384,21	0,16	0,84	0,08	0,21	1,68	0,16	0,44	1,44	0,15	0,41	1,81	0,19	0,52	4,21	0,40	1,10	1,40	0,13	0,37
	Pulses, Other and products	350,20	0,16	50,38	5,32	14,56	81,45	8,49	23,26	69,67	7,30	20,00	87,70	9,19	25,17	204,42	21,31	58,37	68,14	7,10	19,46
Treenuts	Nuts and products (a)	301,47	0,00	36,00	4,85	13,29	56,00	6,78	18,58	47,90	5,80	15,89	60,30	7,30	20,00	135,66	16,43	45,00	67,83	8,21	22,50
Oilcrops	Soyabeans	85,38	0,16	0,00	0,00	0,00	3,36	1,44	3,93	2,87	0,37	1,01	3,62	0,46	1,27	2,72	1,16	3,18	0,00	0,00	0,00
	Groundnuts (Shelled Eq)	552,10	0,16	5,04	0,31	0,85	15,11	1,00	2,74	12,93	1,65	4,53	16,27	2,08	5,70	12,23	0,81	2,22	0,00	0,00	0,00
	Rape and Mustardseed	0,00	0,16	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
	Coconuts - Incl Copra	138,61	0,16	0,00	0,00	0,00	2,52	0,66	1,82	2,15	0,28	0,75	2,71	0,35	0,95	2,04	0,54	1,47	0,00	0,00	0,00
	Sesame seed	595,92	0,16	5,88	0,39	1,08	6,72	0,41	1,13	5,75	0,73	2,01	7,23	0,92	2,53	5,44	0,33	0,91	0,00	0,00	0,00
	Olives (including preserved)	246,74	0,29	11,33	1,75	4,79	20,53	3,04	8,32	17,56	2,24	6,15	22,10	2,82	7,74	19,71	2,92	7,99	0,00	0,00	0,00
	Oilcrops, Other	500,00	0,16	0,00	0,02	0,05	8,40	0,61	1,68	7,18	0,92	2,51	9,04	1,16	3,17	6,80	0,50	1,36	0,00	0,00	0,00

Table C-2. Dietary scenarios constructed for health assessments

DIET SCENARIOS FOR HEALTH ASSESSMENT

TURKISH FOOD AVAILABILITY PER CAPITA		kcal/100 g	Food Loss and Waste Rates (%)	1961 (loss-adjusted availablity)			2013 (loss-adjusted availablity)			ID2050 (A1) (loss-adjusted availablity)			ID2050 (A2) (loss-adjusted availablity)			Simulated Mediterranean Diet (Recommended Intake)			TDG - H (Recommended Intake)		
Food Group	Food Products			kcal/day	kg/year	g/day	kcal/day	kg/year	g/day	kcal/day	kg/year	g/day	kcal/day	kg/year	g/day	kcal/day	kg/year	g/day	kcal/day	kg/year	g/day
Vegetable Oils	Soyabean Oil	870,50	0,16	24,35	1,05	2,88	47,86	2,01	5,50	46,85	1,95	5,33	37,80	1,57	4,30	41,33	1,73	4,75	0,00	0,00	0,00
	Groundnut Oil	0,00	0,16	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
	Sunflowerseed Oil	879,91	0,16	16,79	0,71	1,96	181,38	7,52	20,61	177,52	7,38	20,21	143,25	5,95	16,31	156,64	6,50	17,80	0,00	0,00	0,00
	Cottonseed Oil	882,85	0,16	36,95	1,52	4,16	56,26	2,33	6,37	55,06	2,29	6,27	44,43	1,85	5,06	48,59	2,01	5,50	0,00	0,00	0,00
	Palmkernel Oil	836,46	0,16	0,00	0,00	0,00	9,24	0,40	1,10	9,04	0,38	1,03	7,29	0,30	0,83	7,98	0,35	0,95	0,00	0,00	0,00
	Palm Oil	882,33	0,16	0,00	0,00	0,00	98,24	4,06	11,13	96,16	4,00	10,95	77,59	3,22	8,83	84,84	3,51	9,62	0,00	0,00	0,00
	Coconut Oil	0,00	0,16	0,00	0,01	0,02	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
	Sesameseed Oil	869,05	0,16	7,56	0,33	0,90	8,40	0,35	0,97	8,22	0,34	0,94	6,63	0,28	0,76	7,25	0,30	0,83	0,00	0,00	0,00
	Olive Oil	883,98	0,29	65,13	2,69	7,37	21,94	0,91	2,48	21,48	0,89	2,45	17,33	0,72	1,97	22,48	0,93	2,54	265,20	10,95	30,00
	Maize Germ Oil	883,98	0,16	6,72	0,28	0,76	26,03	1,07	2,94	25,48	1,06	2,90	20,56	0,85	2,34	22,48	0,93	2,54	0,00	0,00	0,00
	Oilcrops Oil, Other	793,48	0,16	0,00	0,01	0,02	4,20	0,19	0,53	4,11	0,17	0,47	3,32	0,14	0,38	3,63	0,17	0,46	0,00	0,00	0,00
Vegetables	Tomatoes and products	19,62	0,29	10,62	19,64	53,82	37,52	69,81	191,27	32,09	53,39	146,28	40,40	67,21	184,13	24,06	44,76	122,64	32,88	61,18	167,61
	Onions	39,10	0,29	9,91	8,69	23,80	14,16	13,22	36,21	12,11	20,15	55,20	15,24	25,36	69,48	9,08	8,47	23,22	12,41	11,58	31,73
	Vegetables, Other	21,20	0,29	47,43	77,10	211,25	50,97	87,74	240,40	43,60	72,53	198,72	54,88	91,30	250,14	32,68	56,26	154,14	44,66	76,89	210,66
Fruits	Oranges, Mandarines	24,97	0,29	3,54	4,76	13,03	11,33	16,56	45,36	9,69	7,70	21,10	12,19	9,69	26,55	11,48	16,78	45,99	17,22	25,18	68,98
	Lemons, Limes and products	19,95	0,29	0,71	1,42	3,90	1,42	2,59	7,10	1,21	0,96	2,64	1,52	1,21	3,32	1,44	2,63	7,20	2,15	3,94	10,79
	Grapefruit and products	33,49	0,29	0,00	0,04	0,10	0,71	0,77	2,11	0,61	0,48	1,32	0,76	0,61	1,66	0,72	0,78	2,14	1,08	1,17	3,21
	Citrus, Other	0,00	0,29	0,00	0,10	0,27	0,00	0,02	0,06	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,02	0,06	0,00	0,03	0,09
	Bananas	66,63	0,29	0,00	0,12	0,33	6,37	3,49	9,56	5,45	4,33	11,87	6,86	5,45	14,94	6,46	3,54	9,69	9,69	5,31	14,54
	Apples and products	40,30	0,29	7,08	6,58	18,04	26,19	23,72	64,99	22,40	17,81	48,78	28,20	22,41	61,40	26,55	24,05	65,88	39,83	36,07	98,82
	Pineapples and products	0,00	0,29	0,00	0,00	0,00	0,00	0,13	0,37	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,14	0,37	0,00	0,20	0,56
	Dates	228,13	0,29	0,00	0,03	0,08	2,83	0,45	1,24	2,42	1,92	5,27	3,05	2,42	6,64	2,87	0,46	1,26	4,31	0,69	1,89
	Grapes and products (excl wine)	68,08	0,29	113,26	62,08	170,07	34,69	18,60	50,95	29,67	23,58	64,60	37,35	29,68	81,32	35,16	18,85	51,65	52,74	28,28	77,47
	Fruits, Other	45,83	0,29	24,07	17,16	47,01	29,73	23,68	64,87	25,43	20,21	55,38	32,01	25,44	69,70	30,14	24,00	65,76	45,21	36,01	98,65

Table C-2. Dietary scenarios constructed for health assessments

DIET SCENARIOS FOR HEALTH ASSESSMENT

TURKISH FOOD AVAILABILITY PER CAPITA			Food Loss and Waste Rates (%)	1961 (loss-adjusted availablity)			2013 (loss-adjusted availablity)			ID2050 (A1) (loss-adjusted availablity)			ID2050 (A2) (loss-adjusted availablity)			Simulated Mediterranean Diet (Recommended Intake)			TDG - H (Recommended Intake)		
Food Group	Food Products	kcal/100 g		kcal/day	kg/year	g/day	kcal/day	kg/year	g/day	kcal/day	kg/year	g/day	kcal/day	kg/year	g/day	kcal/day	kg/year	g/day	kcal/day	kg/year	g/day
Stimulants	Coffee and products (a)	79,35	0,00	0,00	0,07	0,19	1,00	0,46	1,26	0,90	0,58	1,58	0,99	0,63	1,73	0,00	0,00	0,00	0,00	0,00	0,00
	Cocoa Beans and products (a)	140,38	0,00	1,00	0,05	0,14	2,00	0,52	1,42	1,80	1,15	3,16	1,98	1,27	3,47	0,00	0,00	0,00	0,00	0,00	0,00
	Tea (including mate) (a)	38,42	0,00	0,00	0,35	0,96	3,00	2,85	7,81	2,71	1,73	4,73	2,97	1,90	5,20	0,00	0,00	0,00	0,00	0,00	0,00
Spices	Pepper (a)	0,00	0,00	0,00	0,01	0,03	0,00	0,05	0,14	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
	Pimento (a)	292,00	0,00	3,00	0,34	0,93	2,00	0,25	0,68	1,80	0,20	0,55	1,98	0,22	0,60	0,00	0,00	0,00	0,00	0,00	0,00
	Cloves (a)	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
	Spices, Other (a)	344,34	0,00	22,00	2,38	6,52	15,00	1,59	4,36	13,53	1,50	4,12	14,87	1,65	4,53	0,00	0,00	0,00	0,00	0,00	0,00
Alcoholic Beverages	Wine (a)	93,59	0,00	2,00	0,96	2,63	1,00	0,39	1,07	0,98	0,50	1,38	0,79	0,41	1,11	3,95	1,54	4,22	0,00	0,00	0,00
	Beer (a)	42,83	0,00	3,00	2,52	6,90	14,00	11,93	32,68	13,70	7,03	19,26	11,06	5,67	15,54	55,34	47,16	129,21	0,00	0,00	0,00
	Beverages, Fermented (a)	0,00	0,00	0,00	0,01	0,03	0,00	0,06	0,16	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,24	0,65	0,00	0,00	0,00
	Beverages, Alcoholic (a)	297,96	0,00	4,00	0,50	1,37	12,00	1,47	4,03	11,74	6,02	16,51	9,48	4,86	13,32	47,44	5,81	15,92	0,00	0,00	0,00
Meat	Bovine Meat	125,43	0,07	14,01	3,60	9,88	37,36	10,87	29,78	47,45	12,49	34,21	29,41	7,74	21,20	12,06	3,51	9,62	31,76	9,24	25,32
	Mutton & Goat Meat	241,77	0,07	65,37	9,80	26,84	28,95	4,37	11,97	36,78	9,68	26,51	22,79	6,00	16,43	9,35	1,41	3,87	24,60	3,71	10,18
	Pigmeat	0,00	0,07	0,00	0,01	0,03	0,00	0,01	0,03	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,01	0,00	0,00	0,00
	Poultry Meat	122,44	0,07	7,47	2,16	5,91	58,84	17,54	48,05	74,74	19,66	53,88	46,32	12,19	33,39	19,00	5,66	15,52	43,47	12,96	35,50
	Meat, Other	0,00	0,07	0,93	0,23	0,64	0,00	0,02	0,05	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,01	0,02	0,00	0,00	0,00
Offals	Offals, Edible	123,73	0,07	6,54	2,23	6,12	3,74	1,10	3,02	4,75	1,25	3,42	2,94	0,77	2,12	1,21	0,36	0,97	0,00	0,00	0,00
Animal Fats	Butter, Ghee (b)	722,89	0,10	58,69	2,97	8,14	55,08	2,78	7,62	53,91	2,74	7,50	43,50	2,21	6,05	0,00	0,00	0,00	28,84	1,46	3,99
	Cream (b)	0,00	0,10	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
	Fats, Animals, Raw (b)	701,92	0,10	1,81	0,07	0,20	13,54	0,70	1,93	13,26	0,67	1,84	10,70	0,54	1,49	0,00	0,00	0,00	7,09	0,37	1,01
	Fish, Body Oil	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
	Fish, Liver Oil	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Eggs	Eggs	146,89	0,04	7,68	1,91	5,24	31,69	7,88	21,58	27,10	6,72	18,41	34,11	8,45	23,15	42,60	10,59	29,00	52,44	13,03	35,70
Milk	Milk - Excluding Butter	58,15	0,10	257,33	161,93	443,63	279,00	175,11	479,75	237,88	149,31	409,07	299,43	187,92	514,85	226,80	142,35	390,00	418,71	262,80	720,00
Fish and Seafood	Freshwater Fish	66,77	0,02	0,00	0,19	0,51	2,94	1,61	4,40	2,51	1,27	3,49	3,16	1,60	4,39	14,03	7,67	21,01	14,03	7,67	21,01
	Demersal Fish	35,10	0,02	0,00	0,33	0,91	0,98	1,02	2,79	0,84	0,42	1,16	1,05	0,53	1,46	4,68	4,86	13,33	4,68	4,86	13,33
	Pelagic Fish	88,10	0,02	3,92	1,73	4,75	6,86	2,84	7,78	5,86	2,97	8,15	7,38	3,74	10,25	32,74	13,56	37,16	32,74	13,56	37,16
	Marine Fish, Other	0,00	0,02	0,00	0,09	0,24	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
			Loss- Adjusted TOTAL	**2551,19**	**643,48**	**1762,97**	**3211,01**	**797,13**	**2183,90**	**2901,17**	**703,61**	**1927,69**	**3181,74**	**828,94**	**2271,06**	**2579,46**	**654,94**	**1794,35**	**2140,38**	**758,06**	**2076,87**

APPENDIX D

Table D-1. The average Mediterranean life cycle GHG emissions associated with 1 kg of food product with references

		Country Averages									Mediterranean				
Food Groups	Food Products	SP	IT	FR	GR	PR	TR	CY	Other (MED)	Other (OOM)	Min	Max	Avg	SB	References
Cereal	Wheat and products	716,0	610,0	534,6	0	0	0	0	0	0	439,2	760,0	620,2	C	[216]–[219]
	Rice (Milled Equivalent)	0	2650,0	1018,0	0	0	0	0	0	0	1018,0	2750,0	1834,0	C, T	[220]–[222]
	Barley and products	0	0	360,8	0	0	0	0	0	0	310,0	411,6	360,8	CTG	[218], [223]
	Maize and products	400,0	0	320,2	0	0	0	0	0	0	200,4	440,0	360,1	CTG	[218], [223], [224]
	Rye and products	0	0	501,1	0	0	0	0	0	0	501,1	501,1	501,1	CTG	[218]
	Cereals, Other (Wheat and Products)	716,0	610,0	534,6	0	0	0	0	0	0	439,2	760,0	620,2	C	[216]–[219]
Starchy Roots	Potatoes and products	0	0	78,9	0	0	0	0	0	0	74,1	83,7	78,9	CTG	[218]
	Roots, Other (Potatoes and products)	0	0	78,9	0	0	0	0	0	0	74,1	83,7	78,9	CTG	[225]
Sugar & Sweeteners	Sugar (Raw Equivalent)	0	0	35,4	0	0	0	0	0	0	35,4	35,4	35,4	CTG	[218]
	Sweeteners, Other (Sugar Raw)	0	0	35,4	0	0	0	0	0	0	35,4	35,4	35,4	CTG	[225]
	Honey	0	0	0	0	0	0	0	0	400,0	NA	NA	NA	CTG	[94]
Pulses	Beans	219,0	0	177,1	274,5	0	0	0	0	0	177,1	302,0	223,5	CTG	[218], [226], [227]
	Peas	1090,0	0	230,6	0	0	0	0	0	0	201,2	1090,0	660,3	C	[217], [218], [223]
	Pulses, Other and products (Beans)	219,0	0	177,1	274,5	0	0	0	0	0	177,1	302,0	223,5	CTG	[218], [226], [227]

Table D-1. The average Mediterranean life cycle GHG emissions associated with 1 kg of food product with references

		Country Averages									Mediterranean				
Food Groups	Food Products	SP	IT	FR	GR	PR	TR	CY	Other (MED)	Other (OOM)	Min	Max	Avg	SB	References
Treenuts	Nuts and products	0	0	0	0	0	0	0	0	420,0	NA	NA	NA	CTG	[94]
Oilcrops	Soyabeans [a]	0	0	0	0	0	756,8	0	0	0	756,8	756,8	756,8	CTG	[213]
	Groundnuts	0	0	0	0	0	0	0	0	100,0	NA	NA	NA	CTG	[94]
	Rape and Mustardseed	0	0	1155,0	0	0	0	0	0	0	1040,0	1270,0	1155,0	CTG	[223], [228]
	Coconuts	0	0	0	0	0	0	0	0	270,0	NA	NA	NA	CTG	[223]
	Olives	235,1	625,0	0	0	0	0	0	0	0	95,4	707,0	430,1	C	[229], [230]
	Oilcrops, Other (Olives)	235,1	625,0	0	0	0	0	0	0	0	95,4	707,0	430,1	C	[229], [230]
Vegetable Oils	Soyabean Oil [a]	0	0	0	0	0	4160,5	0	0	0	4160,5	4160,5	4160,5	CTG	[213]
	Sunflowerseed Oil	0	0	544,9	0	796,0	0	0	0	0	544,9	796,0	670,4	CTG	[218], [231]
	Cottonseed Oil	0	0	0	0	0	0	0	0	2700,0	NA	NA	NA	CTG	[94]
	Palmkernel Oil	0	0	0	0	0	0	0	0	5180,0	NA	NA	NA	CTG	[223]
	Palm Oil	0	0	0	0	0	0	0	0	5180,0	NA	NA	NA	CTG	[223]
	Coconut Oil	0	0	0	0	0	0	0	0	3950,0	NA	NA	NA	CTG	[223]
	Olive Oil	1537,0	937,0	0	1087,0	0	0	3897,0	0	0	937,0	3897,0	1864,5	C, P, T	[232]–[235]
	Maize Germ Oil	0	0	1800,0	0	0	0	0	0	0	1800,0	1800,0	1800,0	CTG	[223]
	Oilcrops Oil, Other (Olive Oil)	1537,0	937,0	0	1087,0	0	0	3897,0	0	0	937,0	3897,0	1864,5	C, P, T	[232]–[235]

Table D-1. The average Mediterranean life cycle GHG emissions associated with 1 kg of food product with references

		Country Averages									Mediterranean				
Food Groups	Food Products	SP	IT	FR	GR	PR	TR	CY	Other (MED)	Other (OOM)	Min	Max	Avg	SB	References
Vegetable	Tomatoes and products	2024,0	2050,0	1284,0	0	0	795,0	0	0	0	342,0	2666,0	1538,3	CTG	[218], [225], [236]–[240]
	Onions	0	0	0	0	0	0	0	450,0	0	0,0	0,0	450,0	CTG	[94], [241]
	Vegetables, Other	0	0	0	0	0	0	0	0	0	0,0	0,0	700	CTG	Calculated from [218], [236], [238], [242], [243]
Fruits	Oranges, Mandarines	310,0	173,5	0	0	0	0	0	0	0	130,0	330,0	241,8	C	[244]–[246]
	Lemons, Limes and products	0	137,5	0	0	0	0	0	0	0	120,0	155,0	137,5	C	[244], [245]
	Grapefruit and products	0	35,0	0	0	0	0	0	0	0	35,0	35,0	35,0	C	[247]
	Citrus, Other (Oranges, Mandarines)	310,0	173,5	0	0	0	0	0	0	0	130,0	330,0	241,8	C	[244]–[246]
	Bananas	0	0	0	0	0	0	0	0	280,0	NA	NA	NA	CTG	[248]
	Apples and products	0	132,0	48,9	0	0	0	0	0	0	32,0	164,0	90,4	C	[218], [249]–[252]
	Dates (Grapes)	140,0	0	430,9	0	0	0	0	0	0	140,0	545,4	285,4	CTG	[218], [224]
	Grapes and products (excl wine)	140,0	0	430,9	0	0	0	0	0	0	140,0	545,4	285,4	CTG	[218], [224]
	Fruits, Other (Berries and Peach)	0	0	0	0	0	0	0	0	0	NA	NA	2626,0	C	Calculated from [237], [246], [250], [253]
Stimulants	Coffee and products	0	0	1450,2	0	0	0	0	0	0	1450,2	1450,2	1450,2	CTG	[218]
	Cocoa Beans and products	0	0	3813,5	0	0	0	0	0	0	3813,5	3813,5	3813,5	CTG	[218]
	Tea	0	0	0	0	0	0	0	0	7960,0	NA	NA	NA	CTG	[94]
Alcoholic Beverages	Wine	1000,0	1300,0	0	0	0	0	0	0	0	1000,0	1300,0	1150,0	FULL	[254], [255]
	Beer	0	0	0	0	0	0	0	0	680,0	NA	NA	NA	NA	[94]
	Beverages, Fermented (Wine)	1000,0	1300,0	0	0	0	0	0	0	0	1000,0	1300,0	1150,0	FULL	[254], [255]
	Beverages, Alcoholic (Beer)	0	0	0	0	0	0	0	0	680,0	NA	NA	NA	NA	[94]

Table D-1. The average Mediterranean life cycle GHG emissions associated with 1 kg of food product with references

		Country Averages									Mediterranean				
Food Groups	Food Products	SP	IT	FR	GR	PR	TR	CY	Other (MED)	Other (OOM)	Min	Max	Avg	SB	References
Meat	Bovine Meat	7009,0	0	12777,9	0	0	0	0	0	0	5622,3	12777,9	9893,5	CTG	[218], [256]
	Mutton & Goat Meat	24300,0	0	8627,8	0	0	0	0	0	0	4422,5	24300,0	16463,9	CTG	[218], [257], [258]
	Pigmeat	6070,0	2925,0	2620,0	0	0	0	0	0	0	2300,0	6070,0	3871,7	C, B	[232], [259]–[262]
	Poultry Meat (Poultry & Broiler)	0	0	2469,9	4775,0	2460,0	0	0	0	0	2139,7	4840,0	3235,0	CTG	[218], [262]–[264]
	Meat, Other (Poultry & Broiler)	0	0	2469,9	4775,0	2460,0	0	0	0	0	2139,7	4840,0	3235,0	CTG	[218], [262]–[264]
Offals	Offals, Edible	0	0	0	0	0	0	0	0	2360,0	NA	NA	NA	CTG	[94]
Animal Fats	Butter, Ghee	0	0	7815,0	0	0	0	0	0	0	7200,0	8430,0	7815,0	CTG, T, S	[265], [266]
	Cream	0	8310,0	0	0	0	0	0	0	0	8310,0	8310,0	8310,0	CTG, T	[232]
	Fats, Animals, Raw (Butter)	0	0	7815,0	0	0	0	0	0	0	7200,0	8430,0	7815,0	CTG, T, S	[265], [266]
Eggs	Eggs	0	0	1757,6	0	0	0	0	0	0	1715,3	1800,0	1757,6	CTG	[218], [262]
Milk	Milk - Excluding Butter	2922,5	1131,7	1061,4	0	1319,0	1600,0	0	0	0	880,0	5350,0	1606,9	CTG	[218], [232], [262], [267]–[270]
Fish and Seafood	Freshwater Fish (Farmed Trout)	0	0	2398,0	0	0	0	0	0	0	2043,0	2753,0	2398,0	CTG	[271], [272]
	Demersal Fish (Caught Fish)	0	0	2900,0	0	0	0	0	0	0	2900,0	2900,0	2900,0	C, B	[262]
	Pelagic Fish (Caught Fish)	0	0	2900,0	0	0	0	0	0	0	2900,0	2900,0	2900,0	C, B	[262]
	Marine Fish, Other (Caught Fish)	0	0	2900,0	0	0	0	0	0	0	2900,0	2900,0	2900,0	C, B	[262]

Table D-1. The average Mediterranean life cycle GHG emissions associated with 1 kg of food product with references

OTHER FOOD PRODUCTS USED IN CALCULATIONS															
Vegetable Other	Cucumber	800,0	0	0	0	0	0	0	0	0	800,0	800,0	800,0	CTG	[242]
	Pepper	0	939,0	0	0	0	0	0	0	0	939,0	939,0	939,0	CTG	[238]
	Lettuce	259,0	0	0	0	0	0	0	0	0	259,0	259,0	259,0	CTG	[243]
	Zucchini	0	1415,0	0	0	0	0	0	0	0	1415,0	1415,0	1415,0	CTG	[238]
	Carrots	0	103,0	70,6	0	0	0	0	0	0	70,6	103,0	86,8	CTG	[218], [236]
Vegetable Other (Average)													700,0	CTG	Calculated from [211], [229], [231], [235], [236]
Fruit Other	Peach	0	0	168,0	0	0	0	0	0	0	168,0	168,0	168,0	C	[250]
	Raspberries	7300,0	0	0	0	0	0	0	0	0	7300,0	7300,0	7300,0	C	[253]
	Strawberries	410,0	0	0	0	0	0	0	0	0	350,0	470,0	410,0	C	[237], [246]
Fruit Other (Average)													2626,0	C	Calculated from [237], [246], [250], [253]

Notes:
[a] Only CO^2 emissions are considered in the cited publication.
C: Cultivation Only; P: Processing; B: Breeding; T: Transport; S: Storage; CTG: Cradle-to-Farm Gate

APPENDIX E

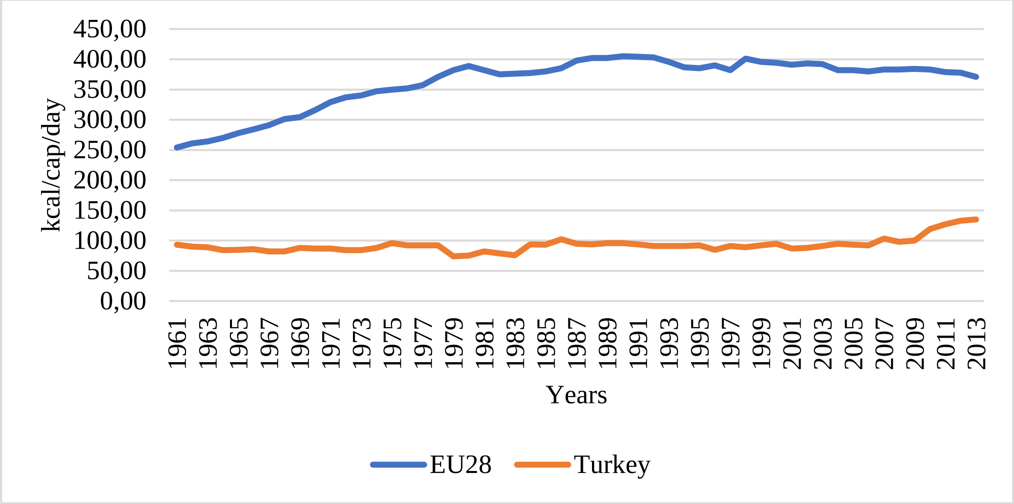


Figure E-1. The Trend in Supply of Meat calories in Turkey and EU28 (Visualized using the FBSs, [18])

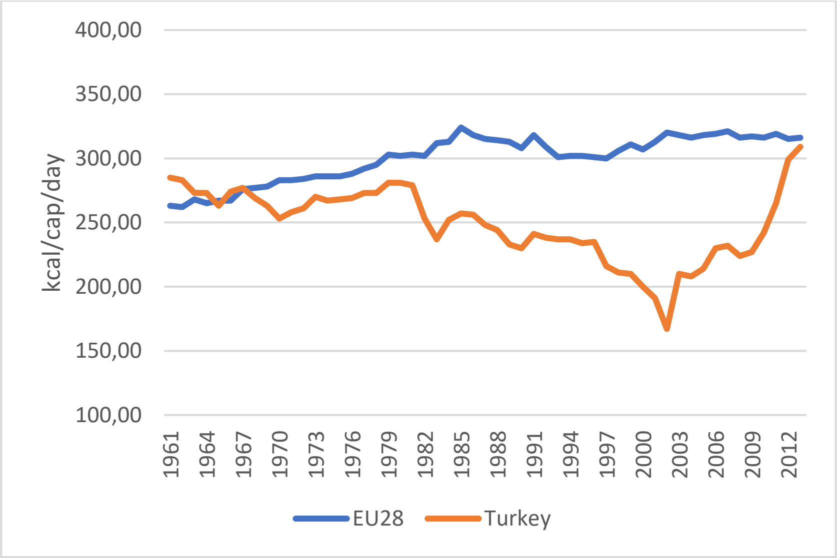


Figure E-2. The Trend in Supply of Dairy Calories in Turkey and EU28 (Visualized using the FBSs, [18])

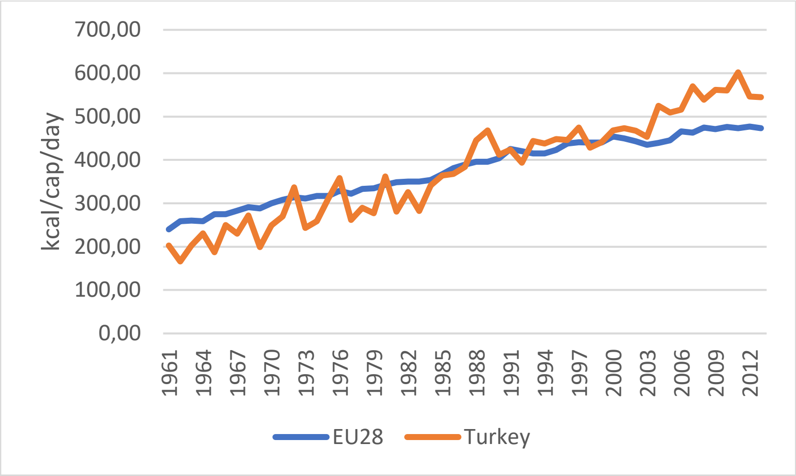


Figure E-3. The Trend in supply of vegetable oil calories in Turkey and EU28 (Visualized using the FBS data, [18])

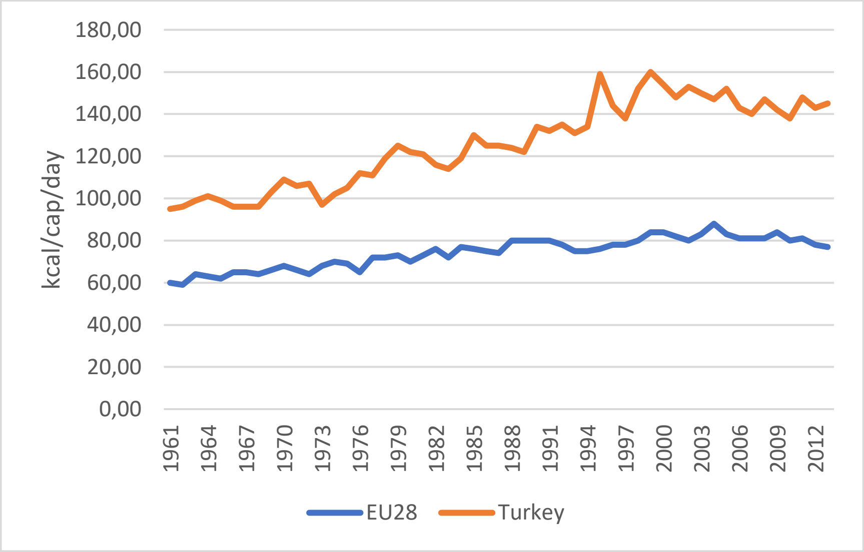


Figure E-4.The Trend in Supply of Vegetable calories in Turkey and EU28 (Visualized using the FBS data, [18])

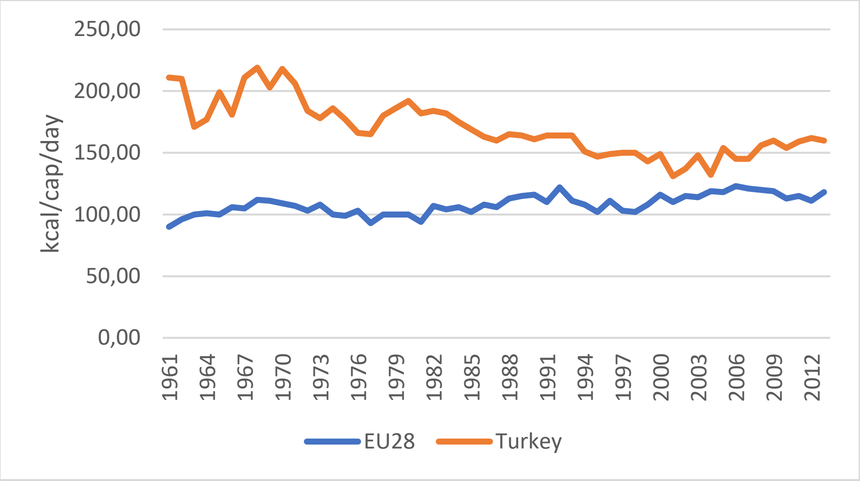


Figure E-5. The trend in supply of fruit calories in Turkey and EU28 (Visualized using the FBS data, [18])

APPENDIX F

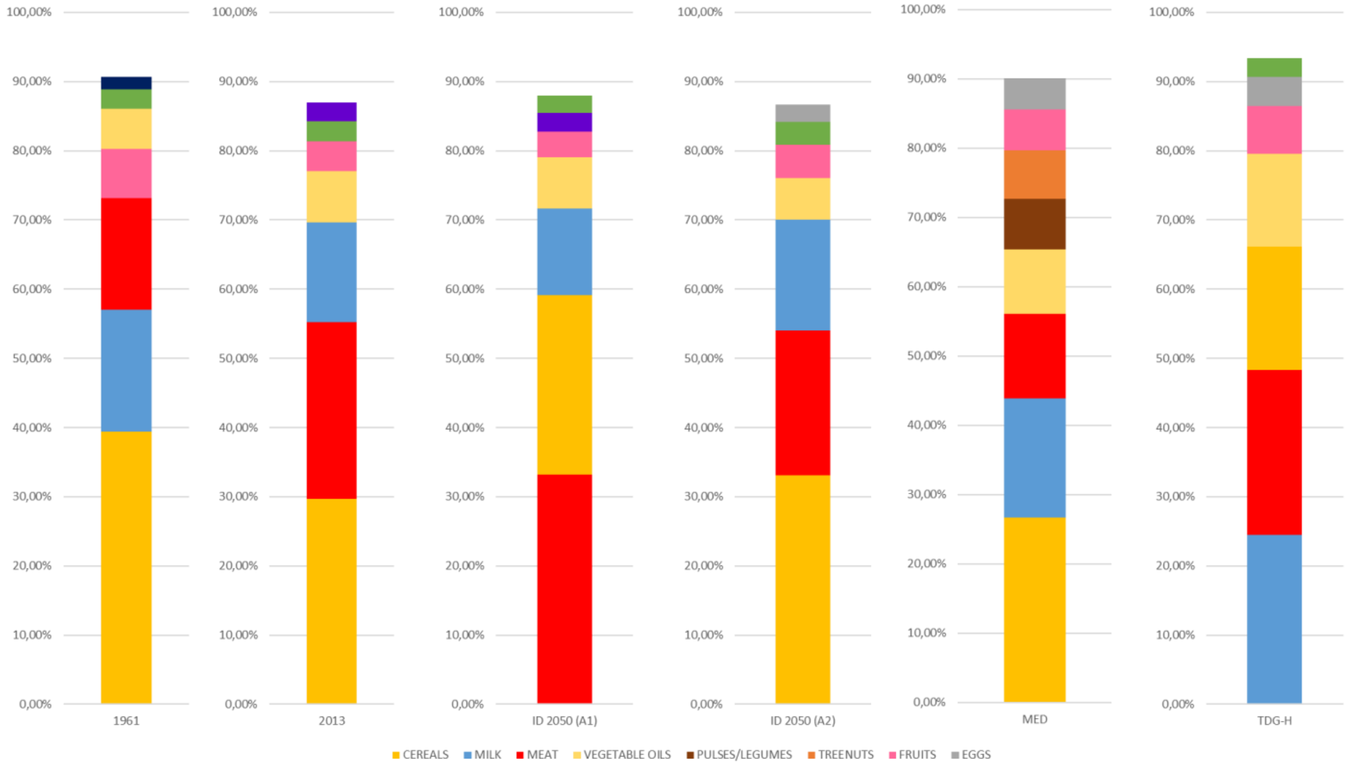


Figure F-1. Water Footprint Contributions of the Food Groups to the Dietary WF

APPENDIX G

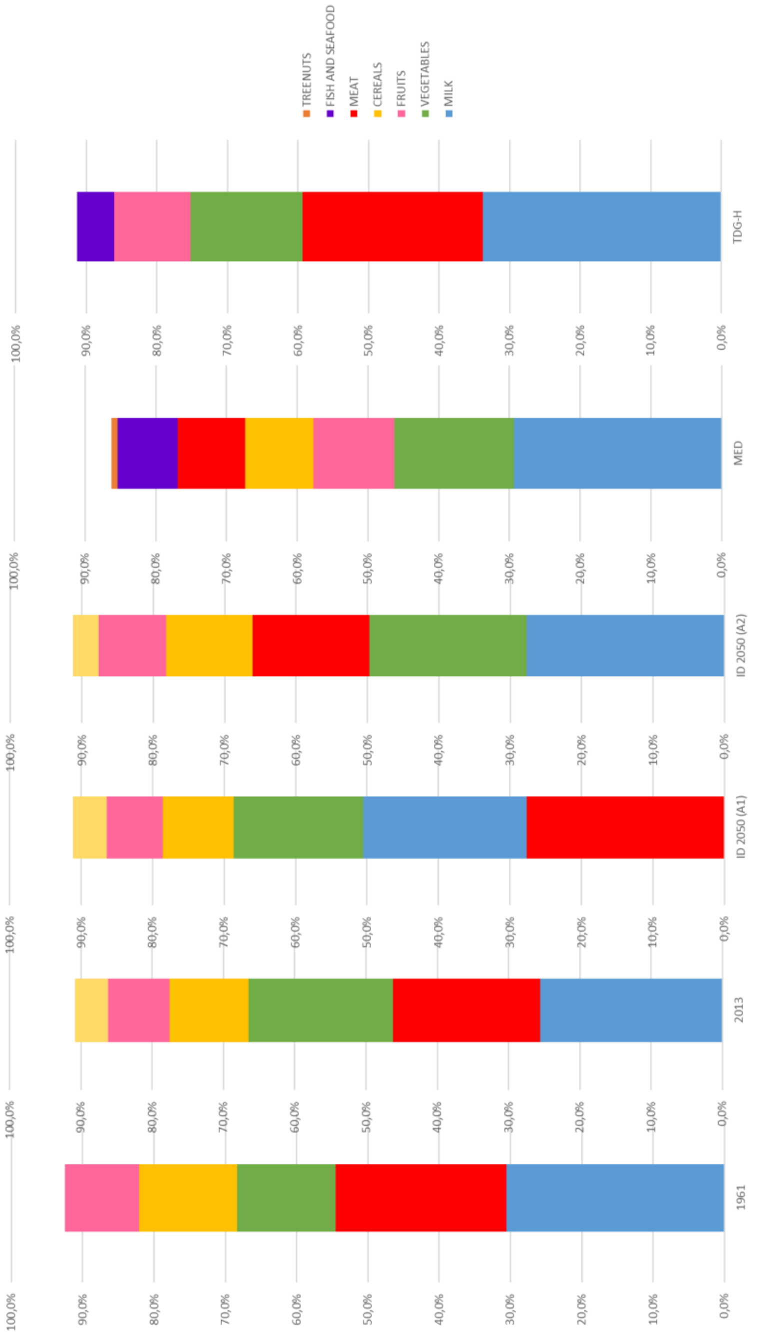


Figure G-1. Contributions of the Food Groups to Dietary GHG emissions

APPENDIX H

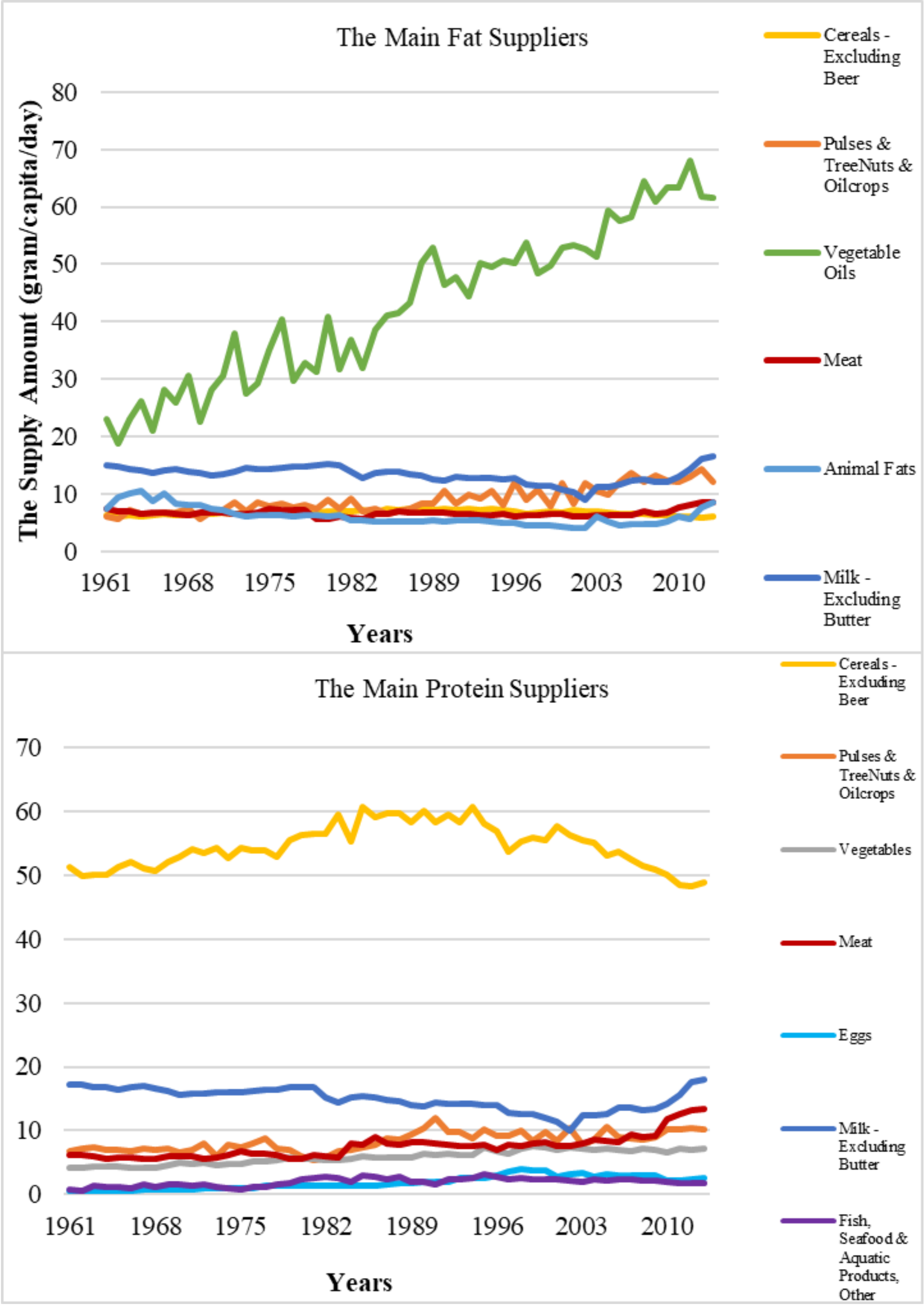


Figure H-1. The main fat and protein supplier food groups in Turkey (1961 - 2013). (Visualized using the FBS data, [18])

APPENDIX I

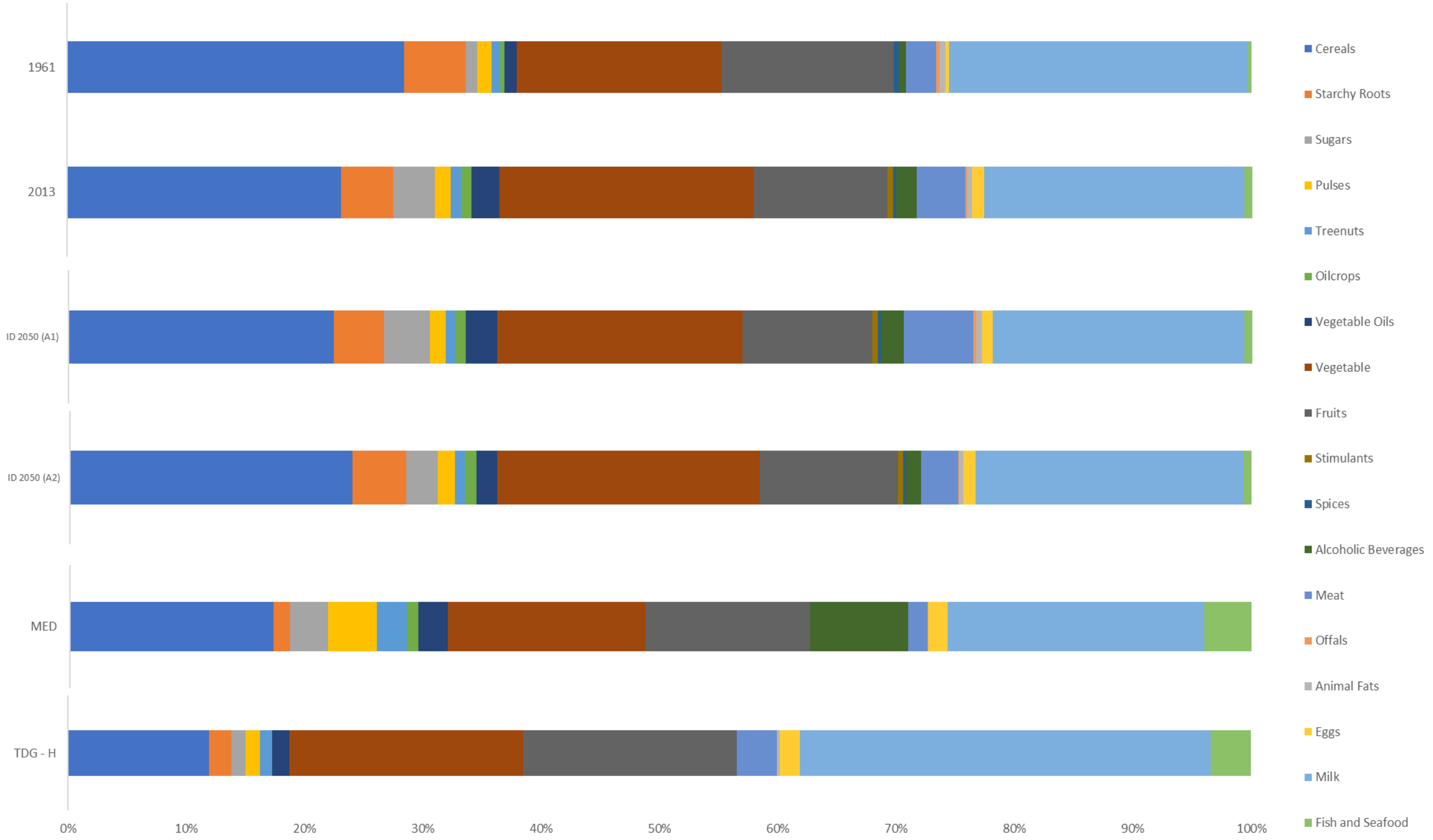


Figure I-1. The Composition of the Dietary Scenarios, representing the consumption in 1961 and 2013, income-dependent dietary scenarios for 2050, the Mediterranean and the healthy diet (by weight)

APPENDIX J

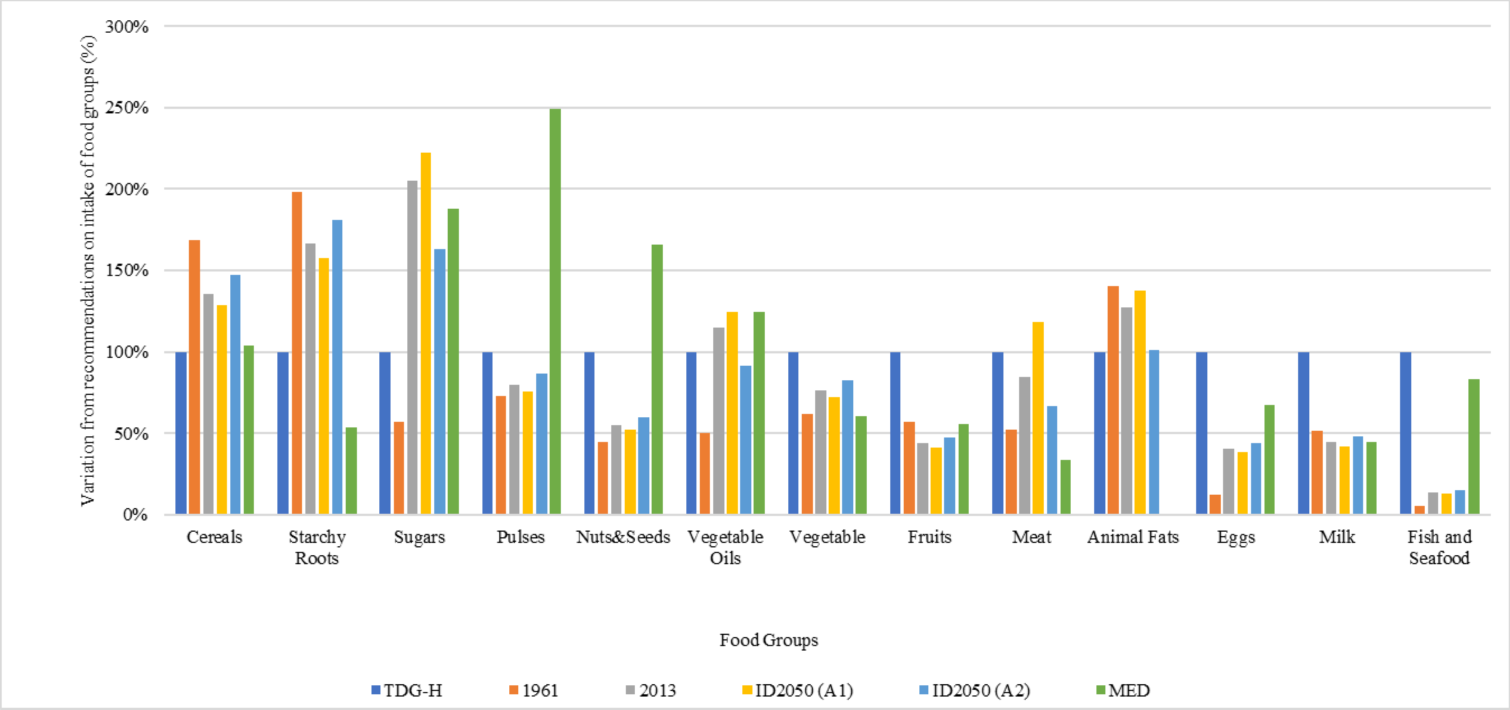


Figure J-1. Variation from the Recommended Intake given in TDG for a 2000 kcal diet. For all the food groups, the recommended intake, as calculated in TDG-H, was displayed with 100%. For the other dietary scenarios, the relative intake levels for the food groups were calculated based on the recommended intake.

APPENDIX K

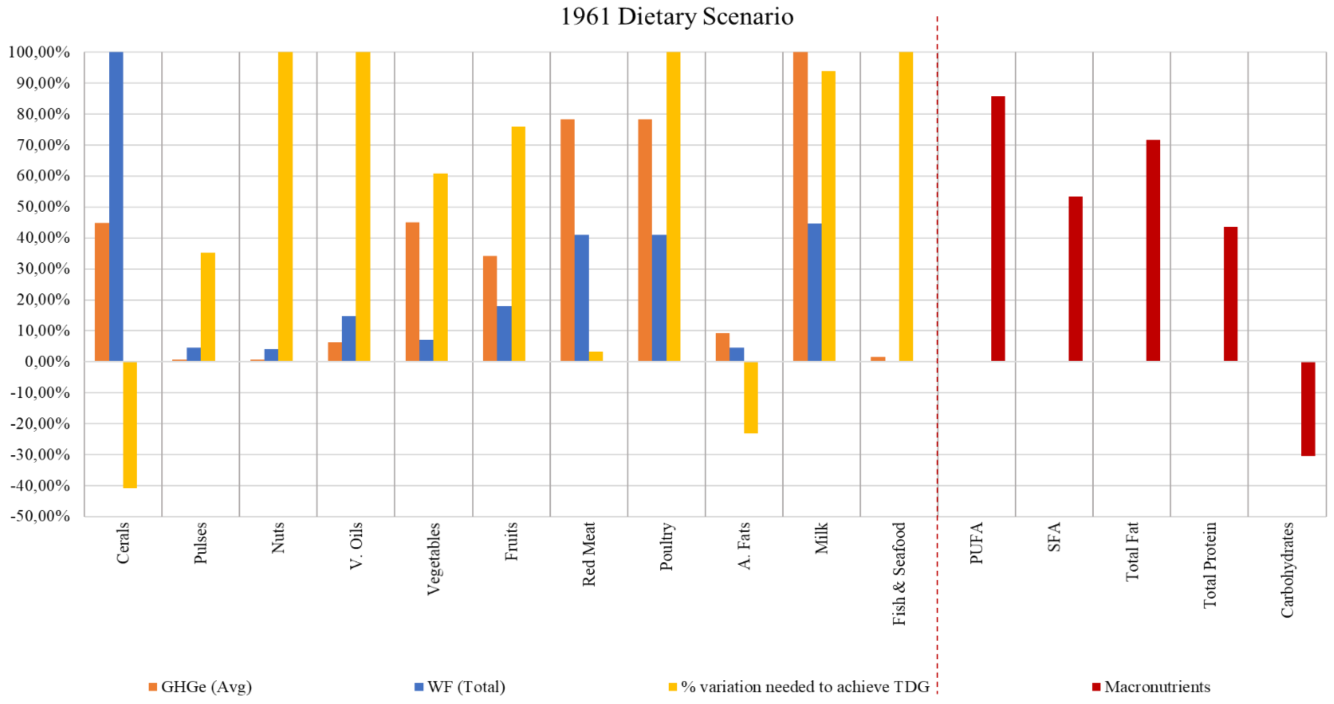


Figure K-1. The GHG emission and Water Footprint Impacts of the 1961 Dietary Scenario with the recommended change in intake levels of the food groups to achieve the Dietary Guidelines. The highest contributors were demonstrated with the highest index score, 100%, per the 2000 kcal diet. The index scores of other food groups were calculated based on the highest contributor in the specific environmental impact category. The food groups which had 100% for the variation to reach the TDG requires at least a doubling of dietary intake levels. The negative values, on the other hand, stand for a decrease from the dietary intake levels.

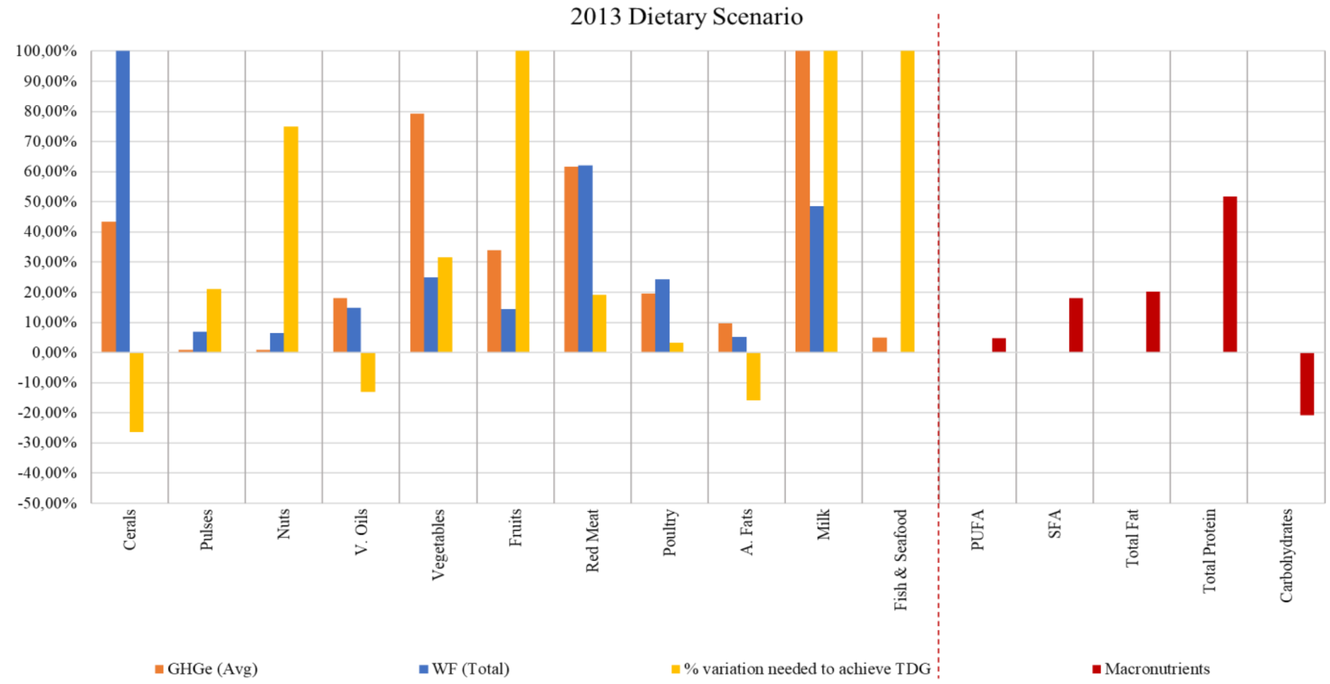


Figure K-2. The GHG emission and Water Footprint Impacts of the 2013 Dietary Scenario with the recommended change in intake levels of the food groups to achieve the Dietary Guidelines

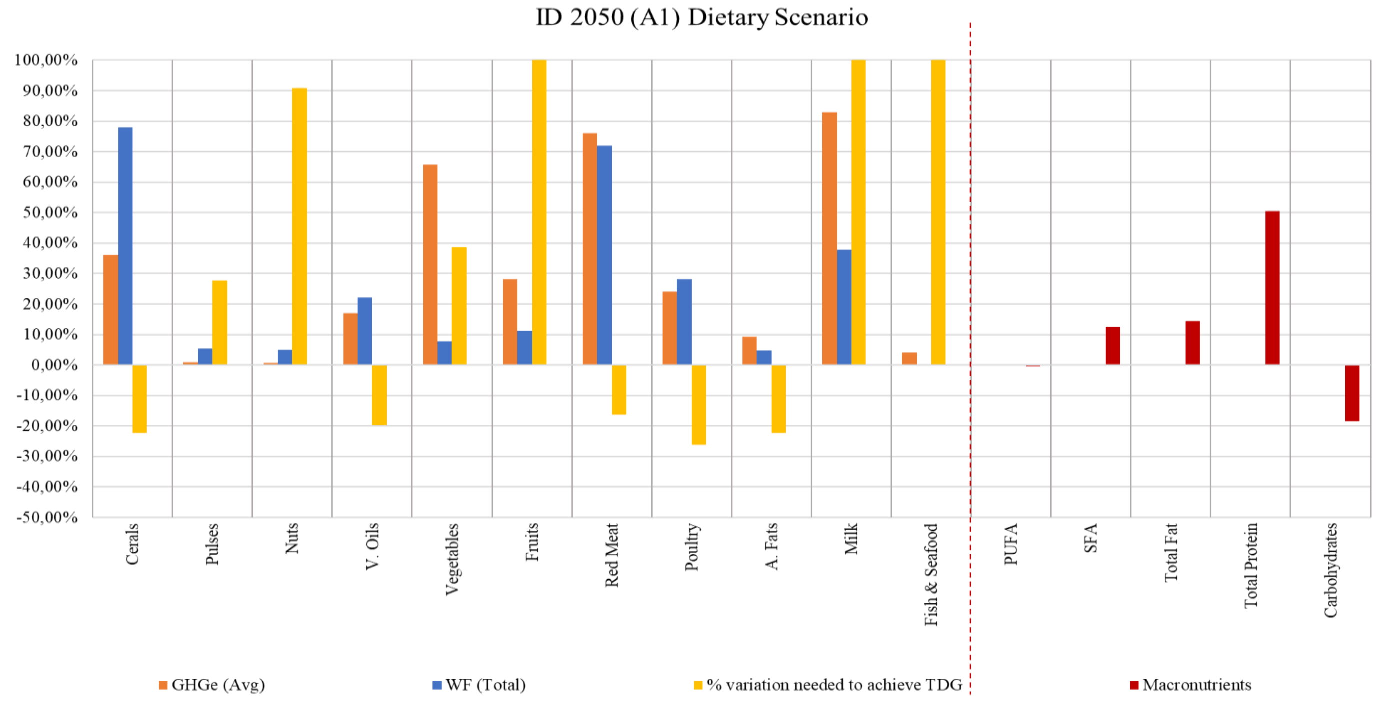


Figure K-3.The GHG emission and Water Footprint Impacts of the income dependent 2050 Dietary Scenario (A1) with the recommended change in intake levels of the food groups to achieve the Dietary Guidelines

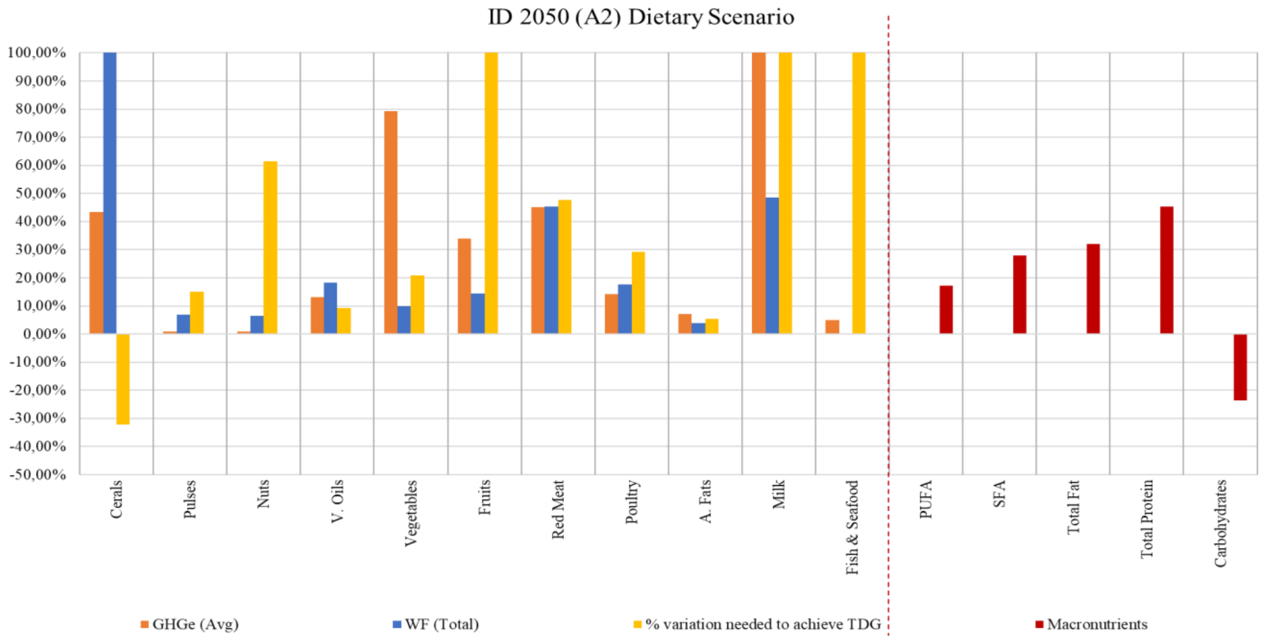


Figure K-4. The GHG emission and Water Footprint Impacts of the income dependent 2050 Dietary Scenario (A2) with the recommended change in intake levels of the food groups to achieve the Dietary Guidelines

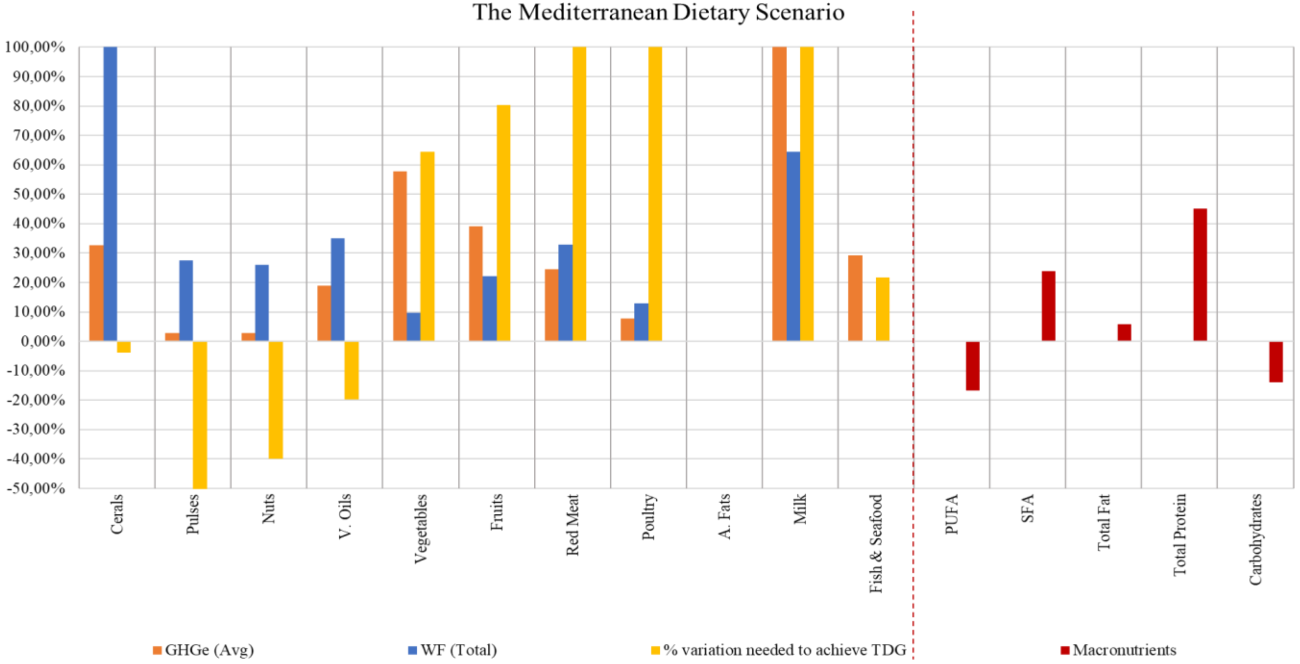


Figure K-5. The GHG emission and Water Footprint Impacts of the income dependent 2050 Dietary Scenario (A2) with the recommended change in intake levels of the food groups to achieve the Dietary Guidelines