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BARILLA CENTER FOR FOOD & NUTRITION

Photo by NATIONAL GEOGRAPHIC ITALIA

Double Pyramid: healthy food for people, sustainable food for the planet

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people, environment, science, economy

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The Barilla Center for Food & Nutrition

The Barilla Center for Food & Nutrition is a think tank with a multi-disciplinary approach whose goal is to gather the most authoritative thinking on an international level regarding issues linked to the world of food and nutrition. Its areas of study and analysis include culture, the environment, health and the economy, and - within these areas - it intends proposing solutions to take on the food challenges to be faced over the coming years.

Specifically, the Barilla Center for Food & Nutrition intends to provide a forum for the current and future needs of our society in terms of major themes tied to food and nutrition, identify key issues, bring together and examine the most advanced, cutting-edge experiences, knowledge and competencies available today on a world level. Its end-purpose is to develop and make available considerations, proposals and recommendations aimed at promoting better living and general, sustainable health and well-being for everyone.

Interpreting such complex phenomena requires a methodology which goes beyond the confines of individual disciplines and this was the approach adopted for the four thematic areas – *Food for Sustainable Growth, Food for Health, Food for All, Food for Culture* – in which, it its first year, the Barilla Center for Food & Nutrition prepared and circulated five Position Papers, providing a reasoned overview of the available scientific findings and an original analytical perspective on the phenomena covered. Through these documents, the BCFN not only expressed its own position, but also proposed a series of recommendations for individuals, the business world and the public sector.

In each area, at least one specific advisor was named, selected for his or her expertise and professional experience in the field: *Barbara Buchner* (expert in energy issues, climate change and the environment) for the *Food for Sustainable Growth* area; *Mario Monti* and *Jean-Paul Fitoussi* (economists) for the *Food For All* area; *Umberto Veronesi* (oncologist), *Gabriele Riccardi* (nutritionist) and *Camillo Ricordi* (immunologist) for the *Food for Health* area; *Joseph Sassoon* and *Claude Fischler* (sociologists) for the *Food for Culture* area.

The theme of environmental sustainability (*Food for Sustainable Growth*) and related recommendation on eco-sustainable life and eating styles was the first issue taken on by the BCFN, but, given the relevance of this issue, it is also the one which attracted particular interest from the media and opinion leaders.

The principal point to emerge from the Position Paper "Climate Change, Agriculture & Food" is that modern lifestyles tend to have a growing impact on the ecological equilibrium of our Planet. Particularly in the area of diet, models of consumption inconsistent with the goals of environmental conservation have asserted themselves. The make-up and quality of food produced and consumed have a significant impact on both greenhouse gas emissions and natural resources.

With the aim of proposing more environmentally sustainable and healthy food choices, the Barilla Center for Food & Nutrition suggests the "Double Pyramid" which flanked the "Food Pyramid" with the "Environmental Pyramid", in order to offer a new tool for solving what Michael Pollan defined the "omnivore's dilemma", i.e., the typical difficulty faced by man in deciding on a daily basis what should be included in his diet.

Executive summary

Development and modernization have made available to an increasing number of people a varied and abundant supply of foods. Without a proper cultural foundation or clear nutritional guidelines that can be applied and easily followed on a daily basis, individuals risk following unbalanced – if not actually incorrect – eating habits.

Volkmark K. Wentzel / National Geographic Image Collection

Foods with higher recommended consumption levels, are also those with lower environmental impact. Contrarily, those foods with lower recommended consumption levels are also those with higher environmental impact.

Todd Gipstein / National Geographic Image Collection

Man has long been aware that correct nutrition is essential to health. Development and modernization have made available to an increasing number of people a varied and abundant supply of foods. Without a proper cultural foundation or clear nutritional guidelines that can be applied and easily followed on a daily basis, individuals risk following unbalanced – if not actually incorrect – eating habits. Proof of this is the recent, prolific spread of pathologies caused by overeating and accompanying reduction in physical activity (including obesity, diabetes and cardiovascular disease) in all age brackets of the population, including children and young people.

In the 1970s, American physiologist Ancel Keys explained to the world the diet he dubbed "**Mediterranean**" based on balanced consumption of natural foods (olive oil, fruit, grains, legumes, etc.), thanks to which death rates from heart disease were shown to be lower than with saturated fat-rich diets typical of Northern Europe. In 1992, the US Department of Agriculture developed and released the first **Food Pyramid** which concisely and efficaciously explained how to adopt a nutritionally-balanced diet.

Today, the Barilla Center for Food & Nutrition is offering the Food Pyramid in a double version, positioning foods not only following the criteria nutritional science has long recommended on the basis of their positive impact on health, but also in terms of their impact on the environment. The result is a "**Double Pyramid**": the familiar **Food Pyramid** and an **Environmental-Food Pyramid**. The latter, placed alongside the Food Pyramid, is shown upside-down: foods with higher environmental impact are at the top and those with reduced impact are on the bottom.

From this "Double Pyramid" it can be seen that those **foods with higher recommended consumption levels, are also those with lower environmental impact**. Contrarily, those foods with lower recommended consumption levels are also those with higher environmental impact. In other words, this newly-elaborated version of the Food Pyramid illustrates, in a unified model, the connection between two different but highly-relevant goals: **health and environmental protection**.

The **Food Pyramid** presents the various food groups in a graduated order. At the base of the Pyramid are foods of vegetal origin (characteristic of the Mediterranean diet), rich in nutrients (vitamins, minerals and water) and protective compounds (fiber and bioactive compounds of vegetal origin), and with lower energy density. Gradually moving up, are those foods with higher energy density (highly present in the North American diet) which should be consumed less frequently.

The **Environmental Pyramid** was constructed on the basis of the environmental impact associated with each food estimated on the basis of the Life Cycle Assessment (LCA), an objective method for evaluating energy and environmental impact for a given process (whether an activity or product). More specifically, process assessment underscores the extent to which the main environmental impacts are seen in the generation of **greenhouse gas** (Carbon Footprint), consumption of **water resources** (Water Footprint) and Ecological Footprint "**land use**".


O. Louis Mazzatenta / National Geographic Image Collection

In order to provide a more complete and effective communications tool, **only the Ecological Footprint was used as a reference index in creating the Environmental Pyramid**. The result is an upside-down Pyramid graduated in terms of environmental impact: on the top are foods with higher impact, while on the bottom are those with minor impact.

From "Double Pyramid" can be observed that the food which is recommended more frequent consumption, are also those with minor environmental impacts. Conversely, foods for which consumption is recommended less frequent, are also those that have most impact. In other words, this developing new food pyramid shows the coincidence, in one model, two different but equally important goals: health and environmental protection.

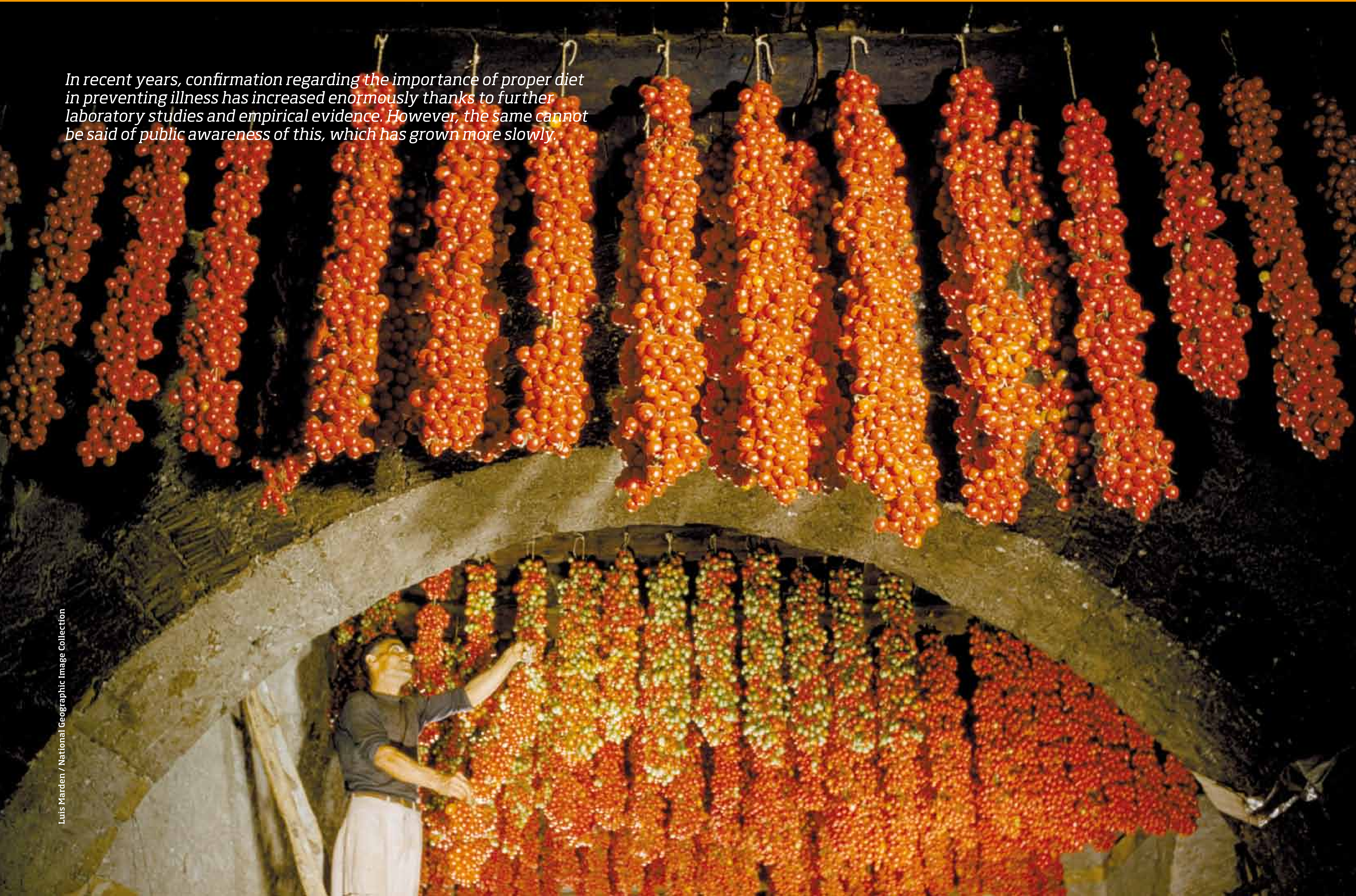
This work, far from being conclusive, aims to encourage the publication of further studies on the measurement of environmental impacts of food, which will be considered in future editions of this document. The objective is to increase the coverage of statistical data and examine the influence that may have some factors, such as, for example, geographical origin or food preservation.

1. Eating better for a better world

The mortality rate due to heart disease in the Countries of Southern Europe and Northern Africa is lower than that found in Anglo-Saxon and Northern European countries.

Sam Abell / National Geographic Image Collection

In recent years, confirmation regarding the importance of proper diet in preventing illness has increased enormously thanks to further laboratory studies and empirical evidence. However, the same cannot be said of public awareness of this, which has grown more slowly.



Luis Marden / National Geographic Image Collection

1. Eating better for a better world

Man has always been aware that correct nutrition is essential to health. Nonetheless, for millennia, the driving need to find enough food to survive has relegated this natural law to a back seat: until recently, very few had the possibility of choosing between different types of abundantly-available foods.

It has been industrial development, modernization of agriculture and the opening of markets that have made an increasing variety and quantity of food available to a growing number of people.

But the problem of hunger is certainly not solved, quite the contrary. We know that about one billion people circa throughout the world live in a state of undernutrition (or malnutrition)[1]. But on the other hand, the number of people who can choose what and how much to eat has increased significantly. However, without a proper cultural foundation or clear nutritional guidelines – illustrated and made applicable – these individuals risk following unbalanced – if not actually incorrect – eating habits.

Proof of this is the recent, prolific spread of pathologies caused by overeating and the concomitant reduction of physical activity (including obesity, diabetes and cardiovascular disease) in all age brackets of the population, including children and young people.

1.1 The Food Pyramid as an educational tool

It was American physiologist Ancel Keys who, in the 1970s, published a book entitled "*Eat Well and Stay Well*" which explained to the world why in some regions of Italy – for example in Cilento (the area in the Campania region that lies between the gulfs of Salerno and Policastro) – the population enjoyed greater longevity: their secret was the balanced consumption of natural foods (olive oil, fruit, grains, legumes, etc.). In particular, Keys discovered that thanks to this diet, which he dubbed a "Mediterranean Diet", the mortality rate due to heart disease in the Countries of Southern Europe and Northern Africa was lower than that found in Anglo-Saxon and Northern European countries where the diet is rich in saturated fats.

The mortality rate due to heart disease in the Countries of Southern Europe and Northern Africa is lower than that found in Anglo-Saxon and Northern European countries.

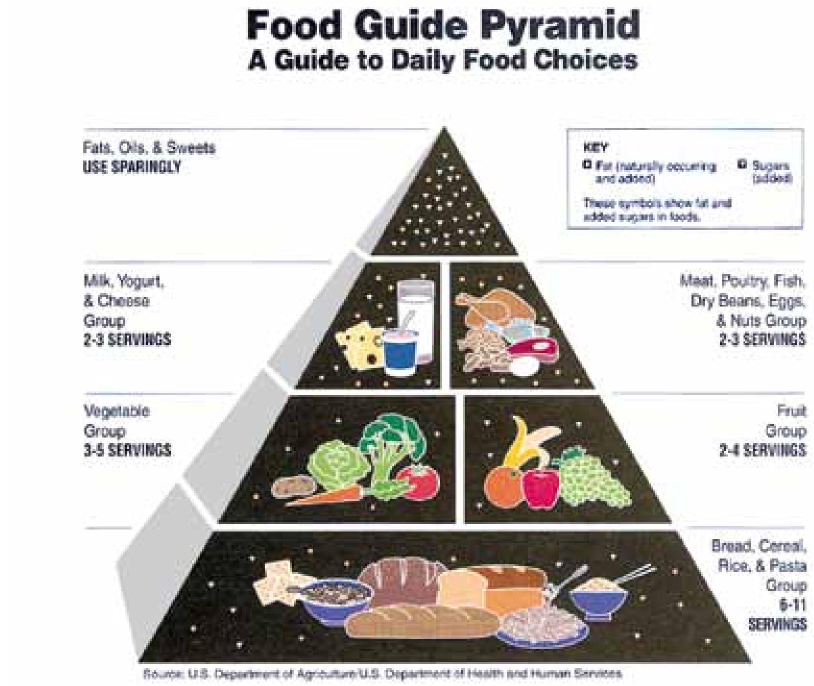
It is a shame that since then, including in Italy, the Mediterranean diet has entered into increasing competition with global dietary models (the foremost of these being "fast food", normally concentrated on North American-type foods). More generally, the growing standardization of foods oriented towards making food production, distribution and preparation more efficient and functional, has played a significant role in providing an easier access to food although, it has often also worked against correct nutritional balance[2].

In order to initiate a process of nutritional education centered on the Mediterranean diet, in 1992, the US Department of Agriculture developed and released the first Food Pyramid (Figure 1.1) which concisely and efficaciously explained how to adapt a nutritionally-balanced diet.

1 Regarding this, please see the BCFN Position Paper, *"The challenges of food security", November 2009, (http://www.barillacfn.com/uploads/file/72/1261504283_BarillaCFN_FOODforALL_ENG.pdf)*

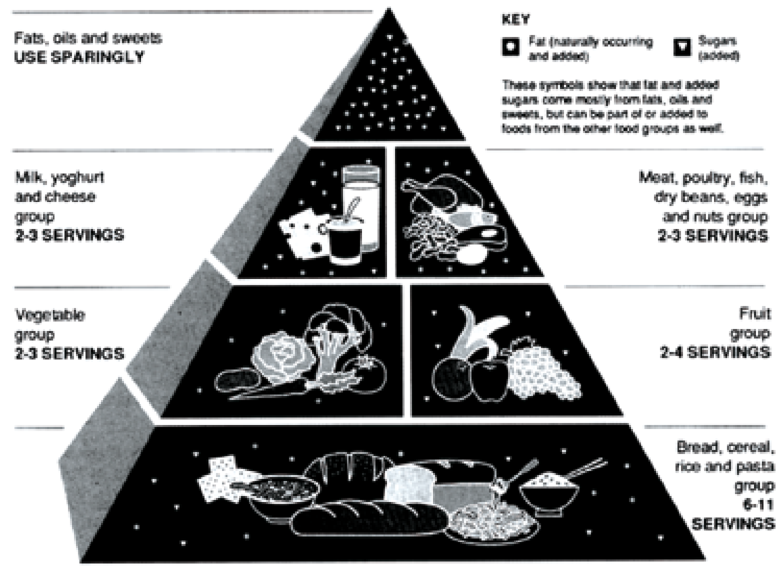
2 For a more detailed discussion, please refer to the BCFN Position Paper, *"The cultural dimension of Food", December 2009, (http://www.barillacfn.com/uploads/file/72/1261504283_BarillaCFN_FOODforCULTURE_ENG.pdf)*

Figure 1.1 - Food Pyramid proposed by the US Government – Source: http://www.health.gov/DIETARYGUIDELINES/dga 2000/document/images/pyramidbig.jpg



The success of this chart can be seen by the fact that in subsequent years numerous variations have been developed by institutions on an international (FAO, World Health Organization), national (Italian Ministry of Health) and local (e.g., the Tuscany Region) level, as well as universities, associations and private companies (see figures below).

Figure 1.2 - Food Pyramid proposed by the FAO – Source: http://www.fao.org/docrep/W0073E/p389.jpg



The Food Pyramid model proposed by FAO is identical to that proposed by the US Government, thereby emphasizing the significance of the information contained therein.

Figure 1.3. Food Pyramid proposed by the WHO – Source: http://www.euro.who.int/IMAGES/Nut/FoodPyramid2.jpg

The World Health Ogranization Food Pyramid shown above was proposed under the *Countrywide Integrated Noncommunicable Disease Intervention* - CINDI Programme, focused on the reduction of levels of major noncommunicable diseases (e.g. cardiovascular diseases, diabetes, etc.) through coordinated, comprehensive health promotion and disease prevention measures. This Programme – which was launched in 1982 as part of an international strategy to support "*Health for All by the Year 2000*" – has promoted, over the years, an integrated set of initiatives aimed to promote healthier lifestyles in communities and to prevent and control common risk factors (such as unhealthy diet, sedentary lifestyle, smoking, alcohol abuse and stress).

Figure 1.4. Food Pyramid proposed by the Italian Ministry of Health – Source: http://www.euro.piramideitaliana.it

After a careful analysis and observation of trends taking place in the Country, in 2003 (D.M., 1.09.2003) the Ministry of Health hired a group of experts to develop a reference model of diet consistent with the lifestyle and the food traditions of our Country.

Then, the Food Sciences and Nutrition Institute of the University of Rome "La Sapienza" drawn up the Italian Food Pyramid indicating which portions of each group of foods should be consumed to maintain a varied and balanced diet. It should be noted that this "daily" Pyramid is part of the weekly Italian Lifestyle Pyramid that, being based on the definition of "Quantity of Wellness" (QB), considers both food and physical activity. Thus, it also provides a "recommended daily dose of physical activity" according to the indications given in the "Pyramid of Physical Activity".

Figure 1.5. The Italian Food Pyramid – Source: Italian Ministry of Health, http://piramideitaliana.it

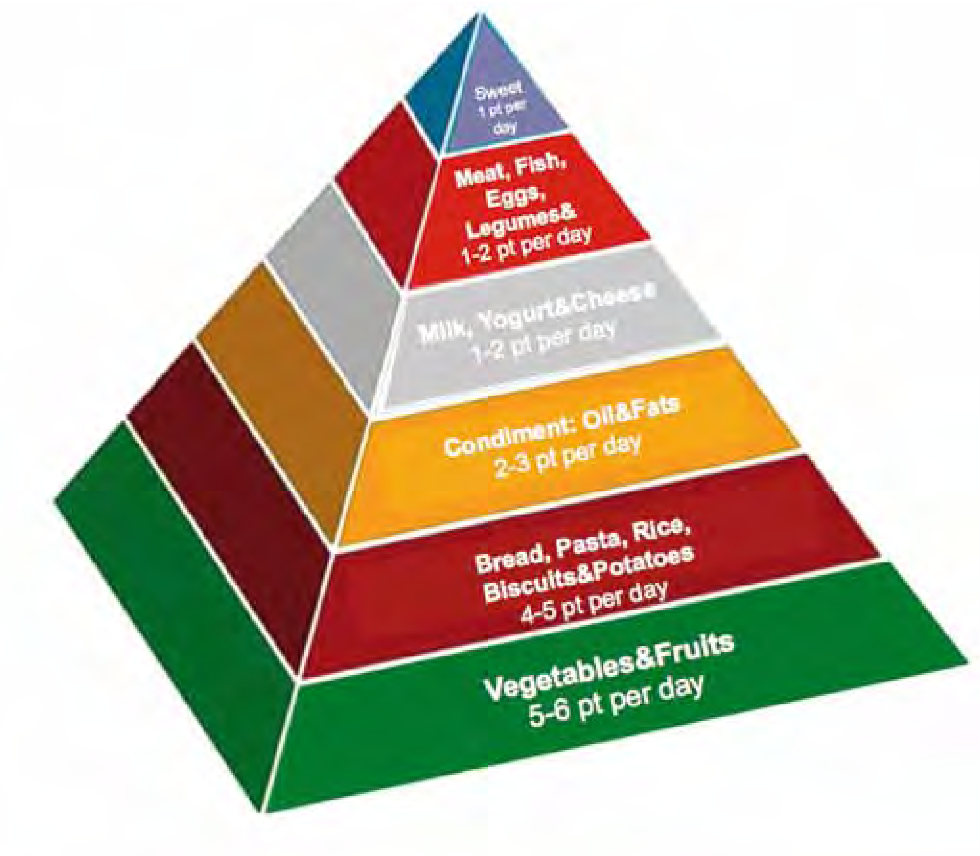
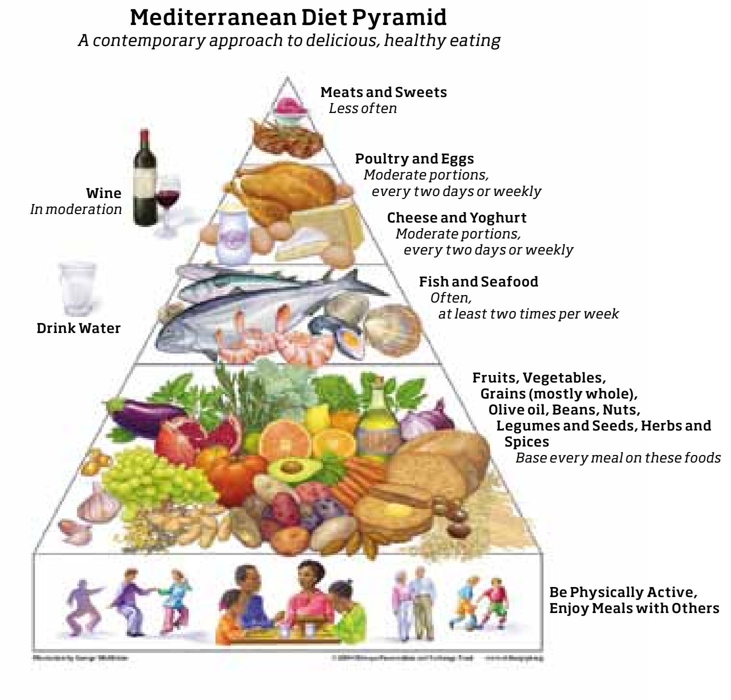


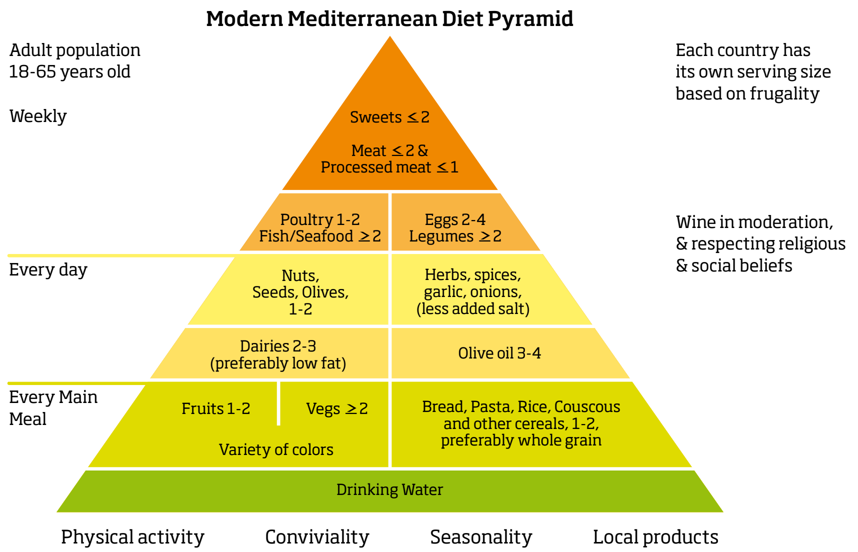
Figure 1.6. Food Pyramid proposed by Oldways - Source: http://oldwaystable.files.wordpress.com/2009/04/395oldwaysmdp_1000copyright.jpg



Oldways, an internationally-respected no-profit organization promoting healthy lifestyles through *ad hoc* projects and initiatives, in 1993 introduced (in collaboration with the Harvard School of Public Health and the European Office of the World Health Organization) the classical Mediterranean Diet along with the Mediterranean Diet Pyramid graphic, to represent it visually.

The Pyramid was created using the most current nutrition research to represent a healthy, traditional Mediterranean diet. It was based on the dietary traditions of Crete, Greece and southern Italy circa 1960 at a time when the rates of chronic disease among populations there were among the lowest in the World[3].

Figure 1.7. Food Pyramid proposed by CiiSCAM, University of Rome "La Sapienza" – Source: http://www.ciiscam.org/files/immagini/immagini/piramide3_520.jpg



In November 2009, the International University Centre for Studies on Mediterranean Food Cultures. CiiSCAM presented one of the first version of the Modern Mediterranean Diet Pyramid. This new model of the Pyramid, developed in collaboration with the National Research Institute on Food and Nutrition – INRAN and other renowned experts, highlights the importance of physical activity, conviviality, the custom of drinking water and suggests the consumption of local and seasonal foods[4].

3 *Oldways, "What is the Mediterranean Diet Pyramid?", http://www.oldwayspt.org/mediterranean-diet-pyramid*
4 *Ciiscam, Novembre 2009*

Although they all start from a common scientific base, each Pyramid adapts the original model to the specific characteristics of its target audience, differentiating between various age brackets (children, adults, the elderly), prevalent lifestyle (sedentary, active, etc.), specific times of life (pregnancy, nursing) or dietary practices (vegan, vegetarian, etc.). In addition, in almost all the most recent versions of the Pyramid (such as, for example, the Modern Mediterranean Diet Pyramid shown above), appended to the diagram are further recommendations for a correct lifestyle (for example, how much water should be drunk, how much time to dedicate to physical activity, etc.).

This dense and continuous communication activities is served in time to acquaint the audience our Mediterranean diet, positioning it in the common perception as style food healthier.

Its adoption is especially pronounced in the more educated segments of the population (not Europe only) which, moreover, it perceived consistency with the current socio-cultural trends, such as attention to the welfare, the fight against obesity, the promotion of typical products, the search for natural products and natural el ' attention to environmental protection.

The value of the Food Guide Pyramid is twofold: first is an excellent summary of the main knowledge gained from studies on medicine and nutrition, essential for anyone who pays attention to their health, the other is a powerful tool for consumer education, thanks also in its effective graphic form and its undoubted simplicity, plays an important promotional role for the benefit of all those foods (fruits and vegetables in particular) that it is almost always "unbranded" are not advertised by manufacturers.

1.2 Components of the Food Pyramid

As mentioned in the previous paragraph, the "Food Pyramid" – a visual tool to communicate the principles of correct diet in a concise and effective manner – was developed in order to educate the public to more balanced dietary habits (based, therefore, on the Mediterranean diet model). From the versions developed over the years, the common positions of the various food groups can easily be identified.

The concept of the Pyramid implies that, gradually moving up, the consumption frequency of the various food groups diminishes, although no specific group is excluded, thus guaranteeing a variety of foods consumption, one of the basic principles of correct nutrition.

Generally speaking, at the base of the Pyramid are foods of vegetal origin characteristic of the Mediterranean Diet, rich in nutrients (vitamins, minerals, water) and protective compounds (fiber and bioactive compounds of vegetal origin). Moving up towards the peak of the Pyramid are those foods with higher energy density (highly present in the North American diet) which should be consumed in lesser amounts.

Taking a closer look, starting from the base towards the top, are fruits and vegetables which have a lower caloric content and supply the body with water, carbohydrates, vitamins, minerals and fiber. The protein content is very low, as is the fat content. The carbohydrate content in fruit and vegetables consists primarily of simple sugars which are easily processed by the body, as well as a small amount of starch. Foods of vegetable origin are the primary source of fiber which not only keeps intestinal activity regular, but also contributes to creating a sense of satiety and therefore helps to control consumption of foods with a high-energy component.

Moving up, we find pasta, rice, potatoes, bread and legumes. Pasta is a foodstuff rich in starch with a moderate amount of protein and insignificant lipid content. Like all grains, rice has a high starch content, low protein content and even lower fat content. In addition, it also contains small amounts of B group vitamins and minerals.

The value of the Food Pyramid is two-fold: on one hand it represents an excellent synthesis of the main concepts developed by medical and nutritional science; on the other it is a powerful educational tool regarding consumption.

Potatoes have a very low fat and protein content, but are rich in starch and carbohydrates. They are one of the most important sources of potassium, phosphorus and calcium.

Bread is a basic foodstuff since it provides the body with the amount of carbohydrates required to assure the body receives the fuel necessary to produce energy.

Legumes are plant foods with higher protein and high fiber content. They provide high quality proteins, and seing rich in essential amino acids are easily digestible. Legumes are a good source of Group B vitamins, especially B1 and B12, niacin, and minerals such as iron and zinc, and can be an alternative to meat consumption.

On the next level on the Pyramid, we find **extra virgin olive oil** which is comprised of triglycerides (rich in monounsaturated fatty acids), essential fatty acids and vitamin E, and also includes substances such as polyphenols and phytosterols which have a protective effect on the human body.

Continuing up, we find a large group with many different protein sources, including **milk**, **yoghurt**, **cheese**, **white meat**, **fish**, **eggs** and **biscuits**.

Milk is almost 90% water which contains traces of high-quality proteins, predominantly easily-digestible short-chain saturated fats (many of them, however, are also rich in animal fats that promote increased levels of plasma cholesterol and, therefore, should consumed in moderation) and sugars (primarily lactose, made up of galactose and glucose). The predominant vitamins found in milk are A, B1, B2, B12 and pantothenic acid. Milk is also the main source of calcium in the human diet.

Like milk, yoghurt has high nutritional value, but can be easier to digest for lactose-intolerant individuals because of the presence of bacterial lactase.

Cheese contains protein and fats, but its carbohydrate content is virtually nil. Particularly significant is its calcium content which is present in a highly bioavailable form and makes a significant contribution to the needs of the human body. It contains small amounts of B group vitamins, while its vitamin A content is significant.

Then there are fish and eggs: fish has a high-quality protein content and variable fat content that can even reach levels of 10% of its weight. Fats in fish contain polyunsaturated fatty acids that belong to the category of essential fatty acids. The family of omega-3 fatty acids, in particular, is considered beneficial in the prevention of cardiovascular disease.

Eggs have such a high protein content that for years the protein composition of eggs was the reference standard for evaluating the quality of protein in other foods.

The biscuits are made up of several ingredients and their composition in terms of nutrients and energy value highly variable, in general, is important content into simple sugars, but is highly variable fat content, usually between about 9% to 25%.

Meat consumption, especially lean meat, is important because it provides high-quality protein required for growth in children and muscle formation. Approximately half of the proteins in meat are comprised of amino acids essential to the human body; also present are B group vitamins (especially B12), selenium, copper and zinc. Fat content can vary from almost nothing to close to 30%, depending on the type of meat, and are primarily saturated and monounsaturated, while only a small number are polyunsaturated: it is therefore to be preferred the consumption of white meat rather than red meat, as highlighted in several versions of the Food Pyramid elaborated by national and international Institutions, that rank them at the top, as well as sweets, that being high in fat and simple sugars should be eaten in moderation.

Figure 1.8. - The BCFN Food Pyramid

1.3 From the Food Pyramid to the Environmental Pyramid

In recent years, confirmation regarding the importance of proper diet in preventing illness has increased enormously thanks to further laboratory studies and empirical evidence. However, the same cannot be said of public awareness of this which has grown more slowly.

This is the reason why, 25 years later, the Barilla Center for Food & Nutrition has decided to offer once again the Food Pyramid, a familiar and well-established tool in the scientific and nutritional circles.

The second reason is less obvious and is connected to the problem of climate change and, more generally, the impact of human activity on the environment.

Not everyone knows that farming and animal husbandry activities are among the main sources of greenhouse gas emissions. For this reason, as was explicitly suggested in the document entitled *"Climate Smart Food"* – published in November 2009 by SIK (Swedish Institute for Food and Biotechnology) and commissioned by the Swedish Presidency – environmental variables must also be taken into consideration in food and dietary choices.

From this standpoint, the various food groups can be evaluated in terms of their environmental impact, i.e., in terms of greenhouse gas emissions (Carbon Footprint), water resources use (Water Footprint) and society's use of natural's assets (Ecological Footprint).

Reclassifying foods no longer in terms of their positive impact on health, but on the basis of their negative effect on the environment, produces an up-side-down Pyramid which shows the foods with greater environmental impact on the top and those with lower impact on the bottom.

When this new Environmental Pyramid is brought alongside the Food Pyramid, it creates a **Food-Environmental Pyramid** which we have called the "**Double Pyramid**".

It shows that those **foods with higher recommended consumption levels are also those with lower environmental impact**. Contrarily, those foods with lower recommended consumption levels are also those with higher environmental impact.

This illustrates, in a unified model, the connection between two different but highly-relevant goals: health and environmental protection.

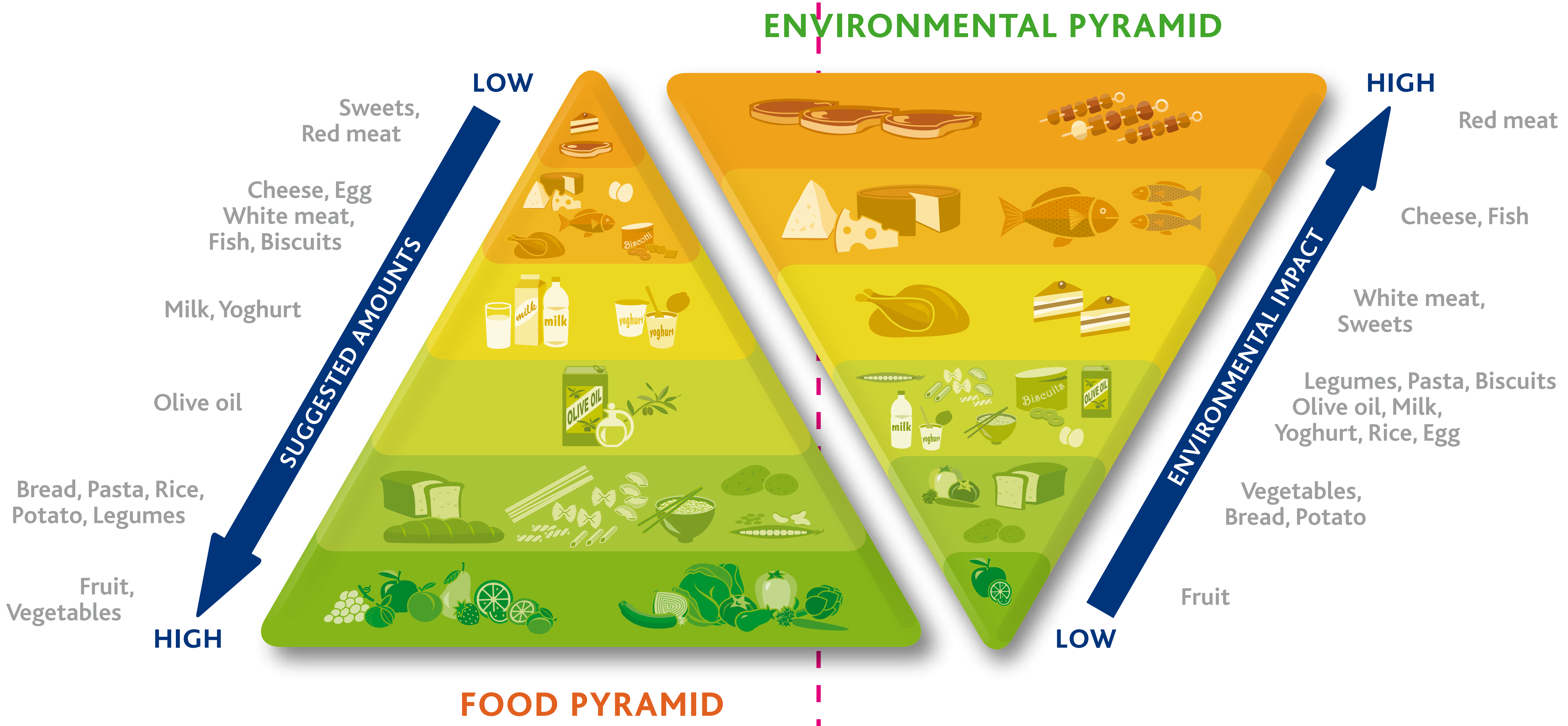
This newly-elaborated version illustrates, in a unified model, **the connection between two different but highly-relevant goals: health and environmental protection**. In other words, it shows that if the diet suggested in the traditional Food Pyramid is followed, not only do people live better (longer and healthier), but there is a decidedly lesser impact – or better, footprint – left on the environment.

All of us, through eating responsibly, can definitely reconcile our personal well-being (personal ecology) with the environment (ecological context).

In the following chapters it is described how the combination of the nutritional aspects of the various foods and their environmental impacts have created the "**Double Pyramid**".

The herewith presented Environmental Pyramid was designed without the inclusion of detailed values. However, at the base of this image there is a precise evaluation of the impact of the various foods performed utilizing the **Life Cycle Assessment** method (i.e., calculating the effects produced on the environment from the cultivation of the raw materials through the distribution chain and, when necessary, cooking of the foods analyzed).

Skip Brown / National Geographic Image Collection


ENVIRONMENTAL PYRAMID
LOW
Sweets,
Red meat
Cheese, Egg
White meat,
Fish, Biscuits
Milk, Yoghurt
Olive oil
Bread, Pasta, Rice,
Potato, Legumes
Fruit,
Vegetables
HIGH
SUGGESTED AMOUNTS
FOOD PYRAMID
HIGH
Red meat
Cheese, Fish
White meat,
Sweets
Legumes, Pasta, Biscuits
Olive oil, Milk,
Yoghurt, Rice, Egg
Vegetables,
Bread, Potato
Fruit
LOW
ENVIRONMENTAL IMPACT

2. Scientific basis of the Food Pyramid

The diet traditionally followed in the Countries of the Mediterranean Region (in particular, in Italy, Spain, Portugal, Greece and Southern France) is a dietary model characterized by its marked nutritional balance and is recognized by many nutritionists and dieticians as one of the best diets in terms of physical well-being and the prevention of chronic diseases, especially cardiovascular ones.

William Albert Allard / National Geographic Image Collection

It is desirable that the publication of this document – as it happened with recent studies published by the European Commission – will be an incentive for the publication of further studies and publications related to the environmental impacts of foods.

Tomasz Tomaszewski / National Geographic Image Collection

2. Scientific basis of the Food Pyramid

The diet traditionally followed in the Countries of the Mediterranean Region (in particular, in Italy, Spain, Portugal, Greece and Southern France) is a dietary model characterized by its marked nutritional balance and is recognized by many nutritionists and dieticians as one of the best diets in terms of physical well-being and the prevention of chronic diseases, especially cardiovascular ones.

2.1 Studies involving the Mediterranean Diet

The idea and the concept of a Mediterranean diet had already been hypothesized in 1939 by the medical nutritionist Lorenzo Piroddi, who was the first to suggest the connection between food and diabetes, overeating and obesity[1]. Subsequently, in the fifties, Ancel Keys[2] - a medical-scientist from the University of Minnesota School of Nutrition – came to Italy with the occupation troops and became aware of something that, at the time, seemed very strange. The less affluent (the so-called poor) in the small towns of Southern Italy who survived prevalently on bread, onions and tomatoes, showed a lower incidence of cardiovascular diseases, not only than the citizens of New York, but also than their own relatives who had emigrated previously to the United States.

The nutritional value of the Mediterranean diet was scientifically shown by the well-known "*Seven Countries Study*" directed by Keys (Keys *et al.*, 1955) in which the diets followed by the populations of different Countries were compared to identify the beneficial and critical aspects of each diet. This led to an understanding of the relationship between diet and risk of onset of chronic diseases (Keys *et al.*, 1967), and it was discovered that the high level of saturated fats and cholesterol in the blood represents a factor capable not only of explaining the differences in mortality rates, but also of predicting the future rates of coronary disease in the populations analyzed (Keys, 1970; Kromhout *et al.*, 1994). The study also demonstrated that the best diet was the "Mediterranean" one, the proof being that the populations of Montegiorgio (Marches) and the inhabitants of Crevalcore (a rural town in the Emilia-Romagna Region) had a very low level of cholesterol in the blood and a minimum percentage of coronary diseases, thanks to their consumption of olive oil, bread and pasta, garlic, red onions, aromatic herbs, vegetables and very little meat.

James L. Stanfield / National Geographic Image Collection

1 *"Cucina Mediterranea. Ingredienti, principi dietetici e ricette al sapore di sole", Mondadori, Milan, 1993*

2 *Ancel Benjamin Keys (1904-2004), American physician and physiologist, is famous for having been one of the main advocates of the benefits of the Mediterranean diet for combating a large number of widespread diseases in the West, particularly cardiovascular diseases*

From the first "*Seven Countries Study*" to the current days, many other studies have analyzed the characteristics and the relationships between dietary habits adopted and the onset of chronic disease[3]. Starting in the nineties, there has also developed a line of study into the relationship between diet and longevity[4]. In general, what emerges is that the adoption of a Mediterranean, or similar, diet, provides a protective factor against the most widespread chronic diseases. In other words, high consumption of vegetables, legumes, fruits and nuts, olive oil and grains (which in the past were prevalently wholemeal); moderate consumption of fish and dairy products (especially cheese and yoghurt) and wine; low consumption of red meat, white meat and saturated fatty acids (Willett & Sacks, 1995).

The interest of the scientific and medical community in the Mediterranean Diet is still extremely active, and, in fact, the current specialist literature often publishes information about the relationship between Mediterranean-style dietary habits and the impact on human health. The beneficial aspects of the Mediterranean Diet are backed by increasing evidence in terms of both prevention and clinical improvement regarding specific pathology areas. It is interesting to note that a study conducted utilizing the PubMed scientific database, over a 3-month period, indicates approximately 70 scientific publications whose primary theme is the Mediterranean Diet[5].

The Mediterranean diet has been adopted to a greater extent among the higher-educated segments of the population above all which perceives it as cohering more closely to current social/cultural trends, such as attention to well-being, fight against overweight, promotion of traditional foods, search for natural, healthy products and awareness of environmental issues.

These publications present the results of clinical or epidemiological research in which adherence to the Mediterranean Diet translates into measurable benefits in numerous areas of human health[6], which include, for example, cardiovascular disease, metabolic conditions, neurological or psychiatric pathologies (e.g., Alzheimer's), respiratory disease or allergies, female and male sexual disorders (e.g., erectile dysfunction) and certain oncological pathologies. In terms of this last point, of particular interest are the recent conclusions of a broad-ranging EPIC European study which examined 485,044 adults over the course of nine years; EPIC showed that increased adherence to the Mediterranean Diet is connected to a significant reduction (-33%) in the risk of developing gastric cancer[7].

Finally, it is interesting to note that the scientific literature demonstrates a positive impact of the Mediterranean Diet across all age brackets, starting from pre-natal to childhood, adulthood and old age.

3 *World Cancer Research Fund, 1997; Willett, 1998*

4 *Nube et al., 1993; Farchi et al., 1995; Trichopoulou et al., 1995; Huijbregts et al., 1997; Kouris-Blazos et al., 1999; Kumagai et al., 1999; Osler & Schroll, 1997; Kant et al., 2000; Lasheras et al., 2000; Osler et al., 2001; Michels & Wolk, 2002*

5 *PubMed, Search Mediterranean Diet in Title/Abstract, from January 25 to April 25, 2010*

6 *Middleton L, Yaffe K., "Targets For The Prevention Of Dementia", J. Alzheimers Dis. 2010 Apr 22; Camargo A et al. "Gene expression changes in mononuclear cells from patients with metabolic syndrome after acute intake of phenol-rich virgin olive oil", BMC Genomics. 2010 Apr 20; Camargo A et al., "A low carbohydrate Mediterranean diet improves cardiovascular risk factors and diabetes control among overweight patients with type 2 diabetes mellitus: a 1-year prospective randomized intervention study", Diabetes Obes Metab. 2010 Mar;12(3):204-9.; Vlismas K et al. Quality, but not cost, of diet is associated with 5-year incidence of CVD: the Zutphen study. Public Health Nutr. 2010 Apr 1:1-8; Castro-Rodriguez JA et al., "Olive oil during pregnancy is associated with reduced wheezing during the first year of life of the offspring", Pediatr Pulmonol. 2010 Apr;45(4):395-402; Llaneza P et al., "Soy isoflavones, Mediterranean diet, and physical exercise in postmenopausal women with insulin resistance. Menopause", 2010 Mar;17(2):372-8; Giugliano F et al. Adherence to Mediterranean Diet and Erectile Dysfunction in Men with Type 2 Diabetes. J Sex Med. 2010 Feb 25; Giugliano F et al. "Adherence to Mediterranean Diet and Erectile Dysfunction in Men with Type 2 Diabetes", J Sex Med. 2010 Feb 25*

7 *Vessby et al., "Adherence to a Mediterranean diet and risk of gastric adenocarcinoma within the European Prospective Investigation into Cancer and Nutrition (EPIC) cohort study", Am J Clin Nutr 73: 2010 Feb;91(2):381-90*

The eating habits which constitute the Mediterranean Diet would seem to cohere with the nutritional recommendations expressed by the guidelines issued by the most authoritative scientific bodies and international institutions involved with the major pathologies afflicting our era (in particular, cardiovascular disease, cancer and diabetes). In fact, one of the many tasks of medical bodies is that of preparing guidelines relating to prevention, diagnosis and treatment in their respective fields. In terms of diet, each scientific body dealing with diabetes, cardiovascular disease and cancer, whether on a national or international level, has drawn up recommendations aimed at preventing the appearance of their respective pathologies. The Barilla Center for Food & Nutrition has gathered, analyzed and summarized the guidelines published by the most authoritative Italian and international scientific bodies and institutions on this issue[8], and has found that there are many aspects on which they converge[9]. This analysis has made it possible to outline which behaviors and lifestyles should be adopted for a healthy diet to provide generalized prevention against the risk of cardiovascular disease, diabetes and cancer (Figure 2.1).

The results of the analysis underscore that, thanks to its strict similarity with the recommendations made on a scientific level, the Mediterranean model is one of the most effective in terms of promoting and preserving well-being and preventing chronic disease.

With the goal of quantifying the extent to which any given diet coincides or differs from the Mediterranean diet, a number of "Mediterranean adequacy" indices have been developed. In particular, after having created an index that quantifies adherence to the Mediterranean diet on a scale from 0 to 9 (where the maximum value means maximum adherence and vice versa), Trichopoulou (Trichopoulou *et al.*, 1995) found an inverse relationship between the score obtained by a population and the mortality rates of more elderly individuals.

Also from the studies of Panagiotakos (Panagiotakos *et al.*, 2007) it emerged that the increase in the level of adherence to the Mediterranean diet was significant for the prediction of cases of hypertension, hypercholesterolemia, diabetes and obesity in adults. An increase of approx. 20% of adherence to the Mediterranean diet[10] reduces the onset of cardiovascular disease by 4% over a ten-year period. Other studies conducted by Trichopoulou (Trichopoulou *et al.*, 2007) showed how adherence to the Mediterranean diet produces significant reductions in the overall mortality rates of the population, especially in deaths due to cardiovascular disease and tumors. The same results emerge also from the recent studies of Mitrou (Mitrou *et al.*, 2007) conducted for ten years on a sample of over 380,000 Americans. In the specific case of coronary disease, De Longeril (De Lorgeril *et al.*, 1999) demonstrated how the Mediterranean diet reduces the risk of heart attack by 72%. The results of the studies of Fung (Fung *et al.*, 2005) have confirmed, once more, the cardio protective effects of the Mediterranean diet. In a recent meta-analysis study by Sofi (Sofi *et al.*, 2008), it emerged that the Mediterranean diet provides a protective factor against all causes of mortality and, in the specific instance, towards those connected with cardiovascular disease and tumors, but also towards Parkinson's and Alzheimer's disease.

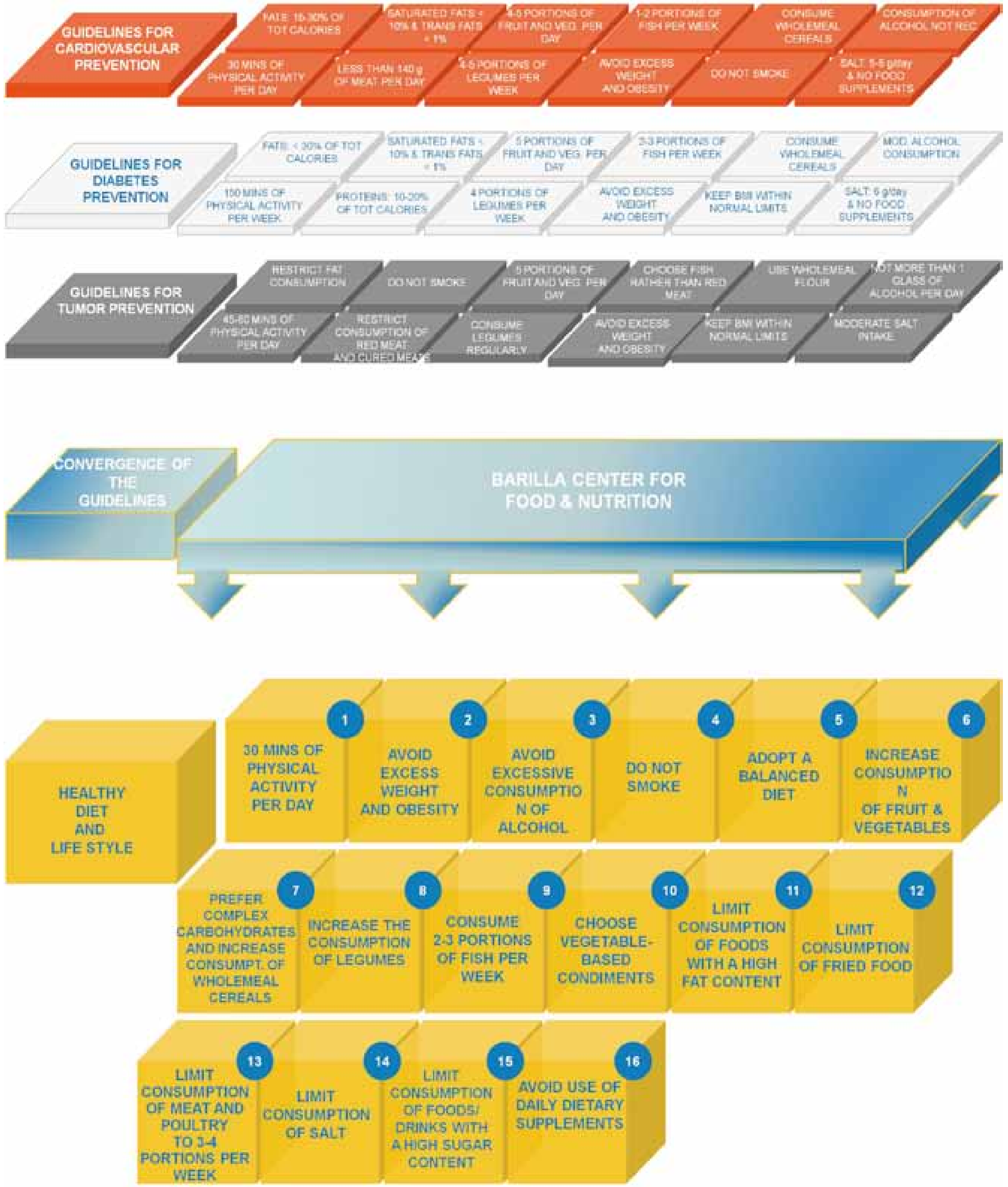
8 *Among the sources used for the analyses it can be cited: World Health Organization, International Agency for Research on Cancer, American Cancer Association, American Institute for Cancer Prevention, Federation of European Cancer Society, American Heart Association, European Society of Cardiology, Italian Society of Cardiology (SIC), National Research Institute on Food and Nutrition (INRAN), British Heart Foundation, International Diabetes Federation, American Diabetes Association, Italian Society of Diabetology*

9 *For more detailed information about this question, please refer to Chapter 3 of the "Food and Health" Position Paper published by the Barilla Center for Food & Nutrition in September 2009*

10 *The scale used in the study runs from 0 to 55, so an increase of 10 points on the Mediterranean adequacy index is equivalent to an increase of approx. 20%.*

To conclude, the majority of the most authoritative scientific studies on the relationship between diet and chronic diseases indicates, without any reasonable doubt, that the Mediterranean diet is the model to be used as the point of reference for correct dietary habits.

Figura 2.1. Convergence between guidelines for the prevention of cardiovascular disease, diabetes and cancer: summary diagram. Source: "Food and Health", Barilla Center for Food & Nutrition, September 2009



Jodi Cobb / National Geographic Image Collection

3. Indicators used to measure environmental impact

Focusing directly on the food production chain, process assessment underscores the extent to which the main environmental impacts are seen in the generation of greenhouse gas, consumption of water resources and land use.

The environmental impact associated with each food includes analyses of the entire supply chain, including cultivation and raw materials processing, manufacturing, packaging, transport, distribution, use, re-use, re-cycling and final disposal.

Medford Taylor / National Geographic Image Collection

3. Indicators used to measure environmental impact

The environmental impact associated with each food was estimated on the basis of the *Life Cycle Assessment* (LCA), an objective method for evaluating energy and environmental impact for a given process (whether an activity or a product). This evaluation includes analyses of the entire supply chain, including, cultivation and processing of raw materials, manufacturing, packaging, transport, distribution, use, re-use, re-cycling and final disposal.

The LCA method is governed by international standards ISO 14040 and 14044, which define its specific characteristics.

LCA studies are precise analysis tools which, on the one hand, offer the advantage of having as objective and complete assessment of the system as possible, and, on the other, the disadvantage that sometimes the results are difficult to communicate. In order to render the results of a study easy to understand, normally summary indicators are used that have been defined to preserve the scientific nature of the analysis as much as possible.

Generally, these indicators are selected on the basis of the type of system being analyzed and must be selected in order to represent as fully and simply as possible the interaction with the main environmental sectors.

More specifically and focusing directly on the food production chain, process assessment underscores the extent to which the main environmental impacts are seen in the generation of greenhouse gas, consumption of water resources and land use.

Starting from these assumptions, and bearing in mind that this document intends to give results at a first level of investigation, the environmental indicators that have been selected are:

- the Carbon Footprint, which represents greenhouse gas emissions responsible for climate change and is measured in terms of amount of CO_2 equivalent;
- the Water Footprint (or virtual water content), which quantifies the amount of water resources consumed and how they are consumed; it measures water use in terms of volume.
- the Ecological Footprint, which measures the biologically productive land and sea area human activity requires to produce the resources it consumes and to absorb the waste it generates; it is measured in square meters or "global hectares".

Although it was chosen to use the Ecological Footprint for the construction of the Environmental Pyramid, the document shows the environmental impacts of the various foods considered also in terms of Carbon Footprint and Water Footprint because using these three indicators in a compared manner offers a more complete view of the impacts involved, avoiding a partial one and, in some cases, one that could be misleadin.

Conceptual differences between the indicators analyzed

It was decided to use these three environmental indicators because they complement each other in the way they are designed and allow a comprehensive view of the environmental impacts involved.

The Carbon Footprint *is an indicator representing greenhouse gas emissions generated by processes which, in the specific case of the agri-food chain, are comprised primarily of CO_2 generated through the use of fossil fuels, from methane (CH_4) derived from livestock enteric fermentation, and emissions of nitrogen protoxide (N_2O) caused by the use of nitrogen-based fertilizers in farming. This indicator is also designed, to a certain extent, to represent energy consumption, especially fossil fuels.*

The Ecological Footprint *is a method for calculating society's use of natural's assets. Is a method for calculating society's use of natural's assets.*

The water component is handled by the Ecological Footprint solely as the occupied surface used for fishing, but not in terms of consumption of this resource. Thus, although the Ecological Footprint is the most complete of all the indicators, the Water Footprint *is also required to complete the set of indicators.*

Given in the box below is a brief description of these indicators (with references to where to obtain more detailed information), also providing is general information about the calculation assumptions utilized. The second part of this document presents more specific aspects of individual foods.

Currently-existing environmental indicators

The Carbon Footprint, Water Footprint and Ecological Footprint were chosen as indicators of environmental sustainability after having taken into consideration the wide range of indicators available. The decision was based on how complete an assessment is expressed by the individual indicator.

At the same time, however, the scientific world and institutions have made available myriad indicators capable of measuring sustainability in an effective and detailed manner. For example, the European Environmental Agency (EEA)[1] has identified a group of indicators which assess environmental impact in the various areas:

- Agriculture *(Area under organic farming; Gross nutrient balance);*
- Atmospheric pollution *(Emissions of acidifying substances; Emissions of ozone precursors; Emissions of primary particles and secondary particulate matter precursors; Exceedance of air quality limit values in urban areas; Exposure of ecosystems to acidification, eutrophication and ozone);*
- Biodiversity *(Designated areas; Species diversity; Threatened and protected species);*
- Climate change *(Atmospheric greenhouse gas concentrations; Global and European temperature; Greenhouse gas emission projections; Greenhouse gas emission trends; Production and consumption of ozone depleting substances);*
- Energy *(Final energy consumption by sector; Primary energy consumption by fuel; Renewable electricity consumption; Renewable primary energy consumption; Total primary energy intensity);*
- Fishing industry *(Aquaculture production; Fishing fleet capacity; Status of marine fish stocks);*
- Land *(Land take; Progress in management of contaminated site);*
- Transport *(Freight transport demand; Passenger transport demand; Use of cleaner and alternative fuels);*
- Waste *(Generation and recycling of packaging waste; Municipal waste generation);*
- Water *(Bathing water quality; Chlorophyll in transitional, coastal and marine waters; Nutrients in freshwater; Nutrients in transitional, coastal and marine waters; Oxygen consuming substances in rivers; Urban waste water treatment; Use of freshwater resources).*

Similarly, the Sustainable Development Strategy[2] defined by the European Union identifies a set of indicators that can monitor and assess the quality and efficacy of the policies implemented by individual Member States. These indicators involve ten areas (Socio-economic development; Sustainable consumption and production; Social inclusion; Demographic Changes; Public Health; Climate Change and Energy; Sustainable Transport; Natural Resources; Global Partnership; Good Governance), which are divided, in turn, into sub-categories. The large number and completeness of the group of indicators made available by the European Union makes it possible to assess whether basic and priority goals of the policies have been met and to establish if the actions developed have actually been implemented.

1 *Source: EEA Core Set of Indicators (http://themes.eea.europa.eu/IMS/CSI)*
2 *Source: Indicators for monitoring the EU Sustainable Development Strategy (http://epp.eurostat.ec.europa.eu/portal/page/portal/sdi/introduction)*

3.1 Carbon Footprint

By "Carbon Footprint" is meant the impact associated with a product (or service) in terms of emission of carbon dioxide equivalent ($CO_{2\text{-equiv}}$), calculated throughout the entire life cycle of the system under examination. It is a new term utilized to indicate the so called Global Warming Potential (GWP) and, therefore, the potential greenhouse effect of a system calculated using the LCA – Life Cycle Assessment method.

In calculating the Carbon Footprint are always taken into consideration the emissions of all greenhouse gases, which are then converted into CO_2 equivalent using the international parameters set by the Intergovernmental Panel on Climate Change (IPCC), a body operating under the aegis of the United Nations.

Correctly calculating the Carbon Footprint of a good or service must necessarily take into account all the phases of the supply chain starting with the extraction of the raw materials up through disposal of the waste generated by the system on the basis of LCA methodology. Clearly, this requires the creation of a "working model" that can fully represent the supply chain in order to take into account all aspects which actually contribute to the formation of the GWP.

Intergovernmental Panel on Climate Change (IPCC)

In 1988 the World Meteorological Organization (WMO) and the United Nations Environment Program (UNEP) created the IPCC with the purpose of providing policymakers with an objective analysis of the technical-scientific and social-economic literature available regarding climate change.

The IPCC is an intergovernmental body (and not a direct research body) open to all member Countries of the WMO and UNEP. Each Government has an IPCC Focal Point that coordinates IPCC-related activity within that Country. Currently, the IPCC Focal Point for Italy is the Euro-Mediterranean Center for Climate Change – CMCC.

The primary activity of the IPCC consists of producing regular scientific assessment reports (every 6 years) on findings related to the field of climate and climate change (Assessment Reports). The Assessment Reports, which reflect analysis and evaluation of international scientific consensus of opinion, are reviewed by experts. In recent years, the work of the IPCC has been approved by leading scientific organizations and academies throughout the world.

In particular, the most recent report of the IPCC, published in 2007, stressed even more forcefully "that the majority of the increase in average global temperature observed starting from the mid-20th century, is due to the observed increase in concentrations of anthropogenic greenhouse gas" and that future climate change does not involve solely the rise in temperature, but will also modify the entire climate system, with serious repercussions on ecosystems and human activity.

The IPCC has recently initiated preparation of a new Assessment Report (AR5) to take into consideration recent technical-scientific developments and it will outline a new set of climate, social-economic and environmental scenarios. The final document should be ready in 2014. The information produced by the IPCC is important for the negotiation process currently underway under the United Nations Framework Conference on Climate Change – UNFCCC.

On October 12, 2007, the IPCC, together with former US Vice President Al Gore, were awarded the Nobel Peace Prize. The award dedication read: "for their efforts to build up and disseminate greater knowledge about man-made climate change, and to lay the foundations for the measures that are needed to counteract such change".

Thanks above all to the ease with which it can be communicated and understood even by laymen, the concept of the Carbon Footprint has spread to the point that there are many standards recognized on an international level which define, to varying degree, the requisites to be followed for the calculations.

The most important ones, or at least those most widely used, are:

- ISO standards 14040 and 14044: in reality, they are the standards relative to life cycle assessment, but they can also be considered the methodological basis for calculating the carbon footprint;
- ISO 14064 is oriented towards defining the modality for calculating greenhouse gas emissions and verification by an independent entity;
- GHG protocol: document prepared by the Greenhouse Gas Protocol Initiative, a supra-governmental organization that prepared the calculation protocol most widely used on an international level, this protocol combines technical aspects with more economically-oriented ones of organizational management;
- PAS 2050 (Assessing the life cycle greenhouse gas emissions of goods and services): document prepared by the British Standards Institute to provide a technical document that is more detailed than the ISO standards and whose goal is to provide more specific rules to adopt in Carbon Footprint calculation. It is one of the most recent and operationally-oriented documents and, as a result, among those of greater interest to the scientific community;
- EPD™ system: prepared by the International EPD Consortium (IEC), it sets the rules for preparing, verifying and publishing the so-called product environmental declarations which, in essence, are the verified "ID" of a product's environmental characteristics. Although the system is not aimed specifically at the Carbon Footprint, in this context it is extremely relevant because greenhouse gas emissions are one of the environmental parameters which, typically, are part of an environmental declaration.

By "Carbon Footprint" is meant the impact associated with a product (or service) in terms of emission of carbon dioxide equivalent, calculated throughout the entire life cycle of the system under examination.

It must be noted that the various calculation protocols do not conflict on a technical level and, for this reason, are normally all taken into consideration contemporaneously during the Carbon Footprint assessment of a product.

3.2 Water Footprint

The Water Footprint (or virtual water content) is a specific indicator for the use of freshwater and has been designed to express both the amount of water resources actually consumed, as well as the way in which the water is utilized.

The calculation method was developed by the Water Footprint Network[3] and was designed so that the indicator calculated would take into consideration three basic components:

- the volume of rainwater evapotranspired from the ground and cultivated plants; this component is defined ***green water***;
- the volume of water coming from surface or underground water sources utilized during the course of the supply chain being analyzed, including both irrigation and process water; this component is also known as ***blue water***;
- ***grey water*** which represents the volume of polluted water deriving from the production of goods and services measured as the volume of water (theoretically) required to dilute pollutants sufficiently to guarantee the quality standard of the water itself.

Water Footprint

The Water Footprint was conceived in 2002 by Prof. Arien Y. Hoekstra of the University of Twente (The Netherlands) within the context of UNESCO-promoted activities, as an alternative to traditional indicators utilized for water resources.

This indicator measures water use in terms of volume (expressed in m^3) of evaporated and/or polluted water for the entire supply chain, from production to direct consumption, and may be calculated not only for each product or activity, but also for each well-defined group of consumers (an individual, family, inhabitants of a town or an entire nation) or producers (private companies, public entities, economic sectors). Specifically:

- *the Water Footprint of a product (tangible good or service) consists of the total volume of freshwater consumed to produce it, taking into consideration the various phases in the production chain;*
- *the Water Footprint of an individual, community or nation consists of the total volume of freshwater consumed either directly or indirectly by the individual, community or nation (water consumed to produce goods and services utilized);*
- *the Water Footprint of a company consists of the volume of freshwater consumed during the course of its activity, added to that consumed in its supply chain.*

The Water Footprint is tied to the concept of virtual water, hypothesized in 1993 by Professor John Anthony Allan of King's College London School of Oriental and African Studies, which indicates the volume of freshwater consumed to produce a product (a commodity, good or service), totaling all the phases of the production chain. The term "virtual" refers to the fact that the vast majority of water utilized to create the product is not physically contained in the product itself, but was consumed during the phases of its production.

The Water Footprint Network is a non-profit organization created in 2008 through the combined efforts of major organizations involved in the question of "water resources" (including the University of Twente, WWF, UNESCO, Water Neutral Foundation, World Business Council for Sustainable Development, and others) to coordinate the activities undertaken in this area, spread knowledge of concepts involving the Water Footprint, the various calculation methods and tools utilized, as well as promote sustainable equitable and efficient use of global freshwater resources.

The Scientific Director of the Water Footprint Network is Professor Arjen Y. Hoekstra, the creator of the concept of the Water Footprint.

3 *Source: Arjen Y. Hoekstra, et al., "Water Footprint Manual. State of the art 2009", November 2009; www.waterfootprint.org*

As can be intuited from this brief definition, the calculation method required to quantify the three components of the indicator varies on the basis of the category analyzed.

The Water Footprint is a specific indicator for the use of freshwater and has been designed to express both the amount of water resources actually consumed, as well as the way in which the water is utilized.

Specifically, *blue water* is just a simple account of water consumption. For the production chain of foods, both the water utilized during manufacturing as well as water used for irrigation during cultivation are taken into consideration.

Estimate of the *grey water* component can be made by imagining a theoretical balance of mass between the flow of polluted water and clean water. The result is an outflow which must meet acceptable standards set by local law. Practically, however, it can be hypothesized that the outflows of a production system must always be within local legislated limits of acceptability and, therefore, as a first approximation, the grey water component may be considered negligible.

The most significant component, and therefore the one most complex to evaluate, is unquestionably that of *green water* since it depends on local climatic conditions and species cultivated.

Calculating Green Water

Green Water is calculated utilizing the following equation:

$$\text{Green water}\left[\frac{l}{kg}\right]=\frac{ET0\,[mm]*Kc*10}{yield\left[\frac{t}{ha}\right]}$$

where:
- *ET0 is dependent upon local climate characteristics;*
- *Kc is dependent upon cultivated plant species;*
- *yield is dependent on the plant species under consideration and the climate characteristics of where it is cultivated.*

3.3 Ecological Footprint

The Ecological Footprint is an indicator used to estimate the impact on the environment of a given population due to its consumption; it quantifies the total area of terrestrial and aquatic ecosystems required to provide in a sustainable manner all the resources utilized and to absorb (once again in a sustainable way) all the emissions produced.

The Ecological Footprint measures the quantity of biologically productive land and water required to both provide the resources consumed and absorb the waste produced.

The calculation methodology is identified by the Global Footprint Network[4] and includes the following components in the calculation.
- ***Energy Land***, represents the land required to absorb the CO_2 emissions generated by the production of a good or service;
- ***Cropland***, represents the land required to cultivate farm products and feed for livestock;
- ***Grazing Land***, represents the land required to support the grazing of the livestock under examination;
- ***Forest Land***, represents the land utilized for the production of wood required to create raw materials;
- ***Built-up Land***, represents the land occupied by structures assigned to productive activity;
- ***Fishing Ground***, represents the land required for the natural development or farming of fish products.

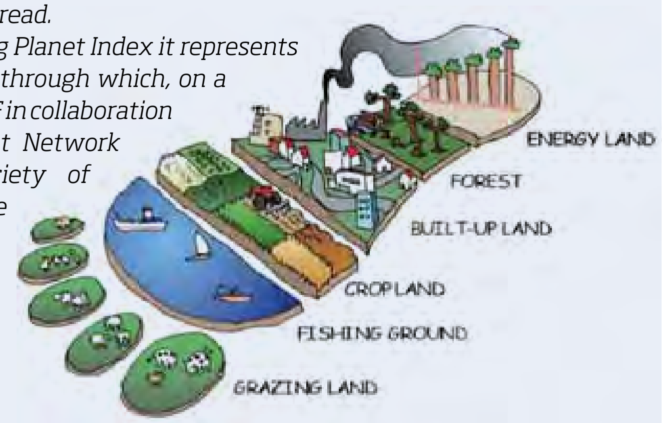
The Ecological Footprint quantifies the total area of terrestrial and aquatic ecosystems required to provide in a sustainable manner all the resources utilized and to absorb (once again in a sustainable way) all the emissions produced.

The Ecological Footprint is thus a composite indicator which, through conversion and specific equivalences, measures the various ways in which environmental resources are utilized through a single unit of measure, the global hectare (gha).

Global Footprint Network

In 2004 Mathis Wackernagel and his associates founded the Global Footprint Network, a network of research institutes, scientists and users of this indicator which aims to further improve its calculation method and bring it to higher standards, while at the same time guarantee enhanced scientific "robustness" for the indicator as well as promoting its spread.

Together with the Living Planet Index it represents one of the two indicators through which, on a two-yearly basis, the WWF in collaboration with the Global Footprint Network and the Zoological Society of London, assesses the conservation status of the planet: the results are presented in the Living Plant Report.



4 Source: Global Footprint Network, www.globalfootprint.org

The approach used in calculating the Ecological Footprint is completely analogous to a Life Cycle Assessment study. It calls for converting the environmental aspects of the productive process – specifically CO_2 emissions and land use – into surface (global hectare) "equivalents". As in the case of the Carbon Footprint, this means that the final value does not indicate the actual amount of land occupied, but rather a theoretical representation which takes into consideration the weighted differences of the various categories.

Specifically, the calculation is made in a relatively simple way by multiplying the value of the environmental aspect under examination (for example, agricultural land use) by the correct conversion factor defined by the calculation protocol. The table below provides a complete list of the conversion factors.

Table 3.3.1 - Equivalence Factors utilized to calculate the Ecological Footprint

Category	Unit of measure	Equivalence factor
Energy land	gha/t CO_2	0.277[5]
Cropland	gha/ha	2.64
Grazing Land	gha/ha	0.50
Forest	gha/ha	1.33
Built-up Land	gha/ha	2.64
Fishing Ground	gha/ha	0.40

Although the indicator takes into consideration the six land categories, in actuality, in the food chain study, Forest and Built-up Land are negligible, the former because wood is not part of food chains, and the latter because factories occupy very little space compared with the other categories, especially if "divided up" between the amount of food produced.

5 *Calculated taking into consideration: 0.208 tha/CO_2 and 1.33 gha/ha. Note that in calculating energy land, only CO_2 and not CO_2-equivalent emissions are considered*

Ecological Footprint:some points of criticism

The Ecological Footprint is an indicator with solid scientific basis. This is shown by the widespread use made of it by the scientific community, as well as the recent decision of the European Union to invest in the development and improvement of the methodology on which it is based.

Despite this, the Ecological Footprint is not exempt from criticism[6]. In particular, some observers note that the basic assumptions behind the methodology for calculating the indicator result in a measure of sustainability that is not fully correct. For example, in high- and medium-income Countries, energy consumption has a significant impact on the calculation method (it is estimated that the influence is at least 50%), resulting in a fairly substantial impact on the final result.

Along the same lines, some experts also believe that there are serious problems of comparison between indicator results and the actual physical dimension of the geographical area under examination, thus leading to problems of comparison between different Countries and cities. Often the boundaries of the cities examined do not correspond to their actual ones because the indicator does not take into consideration the mobility of inhabitants in surrounding areas.

A further potential problem area would seem to involve the technological level considered in the indicator to estimate the impact of production of goods and services. According to some experts, the myriad production and trade connections between different Countries and areas render the current method less than fully-effective since measurement is not made at the source of production, but rather utilizing the characteristics of the area of consumption. Generally stated, it is felt that sudden technological changes in production and consumption could reduce the utility and reliability of this indicator.

In conclusion, the calculation methodology utilized for the Ecological Footprint does not take into consideration such phenomena as destruction and impossibility to utilize certain land areas (so-called land degradation). According to some experts, this is an important aspect that absolutely must be considered in assessing environmental sustainability.

6 *For a more detailed discussion of this point, please refer to: Fiala N., "Measuring Sustainability: Why the Ecological Footprint is Bad Economics and Bad Environmental Science", University of California, 2008; Van den Bergh, Jeroen C.J.M., Harmen Verbruggen, "Spatial sustainability, trade and indicators: an evaluation of the 'Ecological Footprint'", 1999.*

4. Measuring the impact of foods: the three Environmental Pyramids

Jonathan Blair / National Geographic Image Collection

Foods with the lowest environmental impact are also those for which, in accordance with the international nutritional guidelines, the most frequent consumption is recommended.

The beneficial aspects of the Mediterranean Diet are backed by increasing evidence in terms of both prevention and clinical improvement.

Tino Soriano / National Geographic Image Collection

4. Measuring the impact foods: the three Environmental Pyramids

This section will present the conceptual process leading from the mass of information available to the construction of the Environmental Pyramid, the foundation of this study.

Put succinctly, the basic steps were as follows:

- analysis of the information led to the creation of a sufficiently-large data base and, for each food, its impact was calculated from the average of the data available;
- the data obtained were used to construct the specific pyramids of the individual environmental indicators used as a reference;
- from the three Environmental Pyramids constructed, one was selected (Ecological Footprint) and used to construct the Double Pyramid model.

Each of these steps is examined in more detail in the following paragraphs.

The choice to use only scientific documents and public information derived from the most authoritative and known databases, permitted to reach an adequate level of knowledge of the food chains under investigation. Nevertheless, not always the assumptions behind the construction of the given data are homogeneous or the data statistical coverage is complete, such as for meat. Sometimes, for vegetables for example, it can be improved.

It is believed that the publication of this document - as it happened with recent studies published by the European Commission - will be an incentive for the publication, in the near future, of further studies and publications related to the environmental impacts of foods, that will be used and cited in the next revision of this document.

4.1 Summary of environmental data

Details of the data analyzed are given below, subdividing the foods into categories based on similarity of production processes. Before entering into the specifics (presented in subsequent chapters), these initial tables provide the values and data ranges for each food examined.

Included in the tables is also the average value utilized to construct the different environmental impact Pyramids. This value was calculated as the arithmetic average of the data found in literature, excluding clearly anomalous data.

The **first category** is **foods from agriculture**. The special nature of vegetables should be noted and the data for them are divided between greenhouse and non-greenhouse (seasonal) production; for legumes, a cooking process based on boiling which increases impact by 420g of CO_2 equivalent and 5 global m², on the basis of the assumptions described below.

Table 4.1.1 - Foods from agriculture

Foods from agriculture		Carbon Footprint	Water Footprint	Ecological Footprint
Data per kg		[gCO_2 equivalent/kg]	[Liters of water]	[global m²/kg]
Fruit	Data range	40 - 100	500 - 700	2.3 - 3.8
	Average value	**70**	**600**	**3**
Greenhouse vegetables	Data range	3,000 - 5,000	106	9
	Average value	4,000	106	9
	Cooking (boiling)	420	Negligible	5
	Average value with cooking	**4,420**	**106**	**14**
Seasonal vegetables	Data range	100 - 500	106	2.6-5.3
	Average value	302	106	4
	Cooking (boiling)	420	Negligible	5
	Average value with cooking	**722**	**106**	**9**
Potatoes	Data range	98-220	900	1.7-2.1
	Average value	164	900	2
	Cooking	420	Negligible	5
	Average value with cooking	**584**	**900**	**7**
Legumes	Data range	890 ÷ 1,500	1,800	13 ÷ 18
	Average value	1,130	1,800	16
	Cooking	420	Negligible	5
	Average value with cooking	**1,550**	**1,800**	**21**

Within the category of **foods derived from processing of agricultural products** were included products following industrial processing of the raw materials. Once again here, some foods were considered to have been boiled.

Table 4.1.2 - Foods from processing of agricultural products

Foods from processing of agricultural products		Carbon Footprint	Water Footprint	Ecological Footprint
Data per kg		[gCO_2 equivalent/kg]	[Liters of water]	[global m²/kg]
Pasta	Raw pasta	1,564	1,390	12
	Cooking (boiling)	420	Negligible	5
	Average value with cooking	**1,984**	**1,390**	**17**
Rice	Raw rice	1,800 - 3,000	3,400	7 ÷ 11
	Average value	2,750	3,400	9
	Cooking (boiling)	420	Negligible	5
	Average value with cooking	**3,170**	**3,400**	**14**
Bread	Data range	630 - 1,000	1,300	6.7
	Average value	**983**	**1,300**	**6.7**
Sugar	Data range	200 - 1,000	1,500	3 ÷ 6
	Average value	**470**	**1,500**	**4**
Oil	Data range	2,500 - 3,900	4,900	14.6
	Average value	**3,897**	**4,900**	**14.6**
Sweets	**Average value**	**3,700**	**3,140**	**30**
Biscuits	**Average value**	**2,300**	**1,800**	**16**

The category of **foods derived from animal husbandry** includes meat, milk and dairy products and eggs. For meat and eggs, the cooking processes assumed were grilling for meat (increasing impact to 1,000 g of CO_2 equivalent and 13 global m²) and boiling for eggs.

Table 4.1.3 - Foods derived from animal husbandry

Foods from animal husbandry		Carbon Footprint	Water Footprint	Ecological Footprint
Data per kg		[gCO_2 equivalent/kg]	[Liters of water]	[global m²/kg]
Beef	Data range	6,000 - 44,800	15,500	85 - 94
	Average value	30,400	15,500	92
	Cooking (grilling)	1,000	Negligible	13
	Average value with cooking	**31,400**	**15,500**	**105**
Pork	Data range	2,300 - 8,000	4,800	36
	Average value	4,359	4,800	36
	Cooking (grilling)	1,000	Negligible	13
	Average value with cooking	**5,360**	**4,800**	**49**
Poultry	Data range	1,500 - 7,300	3,900	33
	Average value	3,830	3,900	33
	Cooking (grilling)	1,000	Negligible	13
	Average value with cooking	**4,830**	**3,900**	**46**
Cheese	**Average value**	**8,784**	**5,000**	**75**
Butter	**Average value**	**8,800**	**5,000**	**75**
Milk	Data range	1,050 - 1,303	1,000	11 - 19
	Average value	**1,138**	**1,000**	**15**
Yoghurt	**Average value**	**1,138**	**1,000**	**15**
Eggs	Data range	4,038 - 5,800	3,300	9
	Average value	4,813	3,300	9
	Cooking (boiling)	420	Negligible	5
	Average value with cooking	**5,233**	**3,300**	**14**

The category of **foods from fishing** includes both fish and shellfish. Theoretically, the environmental impact range would be very wide, but it should be noted that the minimum value (40g of CO_2 equivalent per kg) and maximum value (20,000 g of CO_2 equivalent per kg) refer respectively to mussels and lobster. For this reason, the average value was based on the impact of fish most commonly used in recipes (e.g., sole and cod).

Further details about this information, as well as the cooking method (grilling in this case), are given in subsequent chapters.

Table 4.1.4 - Foods from fishing

Foods from fishing		Carbon Footprint	Water Footprint	Ecological Footprint
Data per kg		[gCO_2 equivalent/kg]	[Liters of water]	[global m²/kg]
Fish	Data range	220 - 10,500	N.A.	45 - 66
	Average value	3,273	N.A.	56
	Cooking	1,000	Negligible	13
	Average value with cooking	**4,273**	**N.A.**	**69**

The final category presented is that of **beverages**, in which mineral water and wine have been included.

Table 4.1.5 - Foods from beverages

Beverages		Carbon Footprint	Water Footprint	Ecological Footprint
Data per kg		[gCO_2 equivalent/kg]	[Liters of water]	[global m²/kg]
Mineral water	Average value	200	-	<1
Wine	Average value	2,300	1,000	20

4.2 Three possible Environmental Pyramids

Graphic representation of the numeric values for the environmental impact of individual foods results in construction of bands whose dimension are in direct relationship with the size of the range of information available. These bands are shown below for each indicator and their analysis provides the value that is then transformed into the corresponding Environmental Pyramid.

Despite the fact that data acquired for some foods vary quite significantly, "the classification" of the impact of individual foods is nonetheless sufficiently clear: red meat is the food with greatest impact, while fruit and vegetables have a decidedly limited impacts.

Table 4.2.1 - *Ecological Footprint*

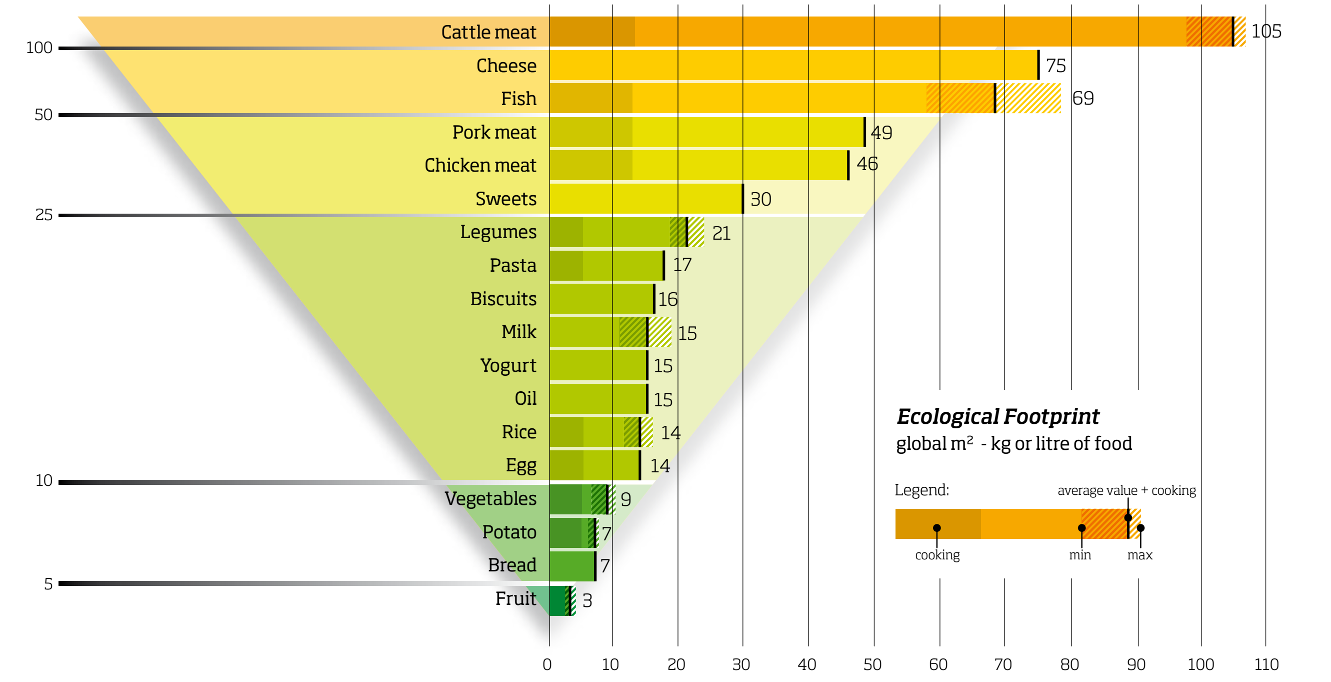


Table 4.2.2 - *Carbon Footprint*

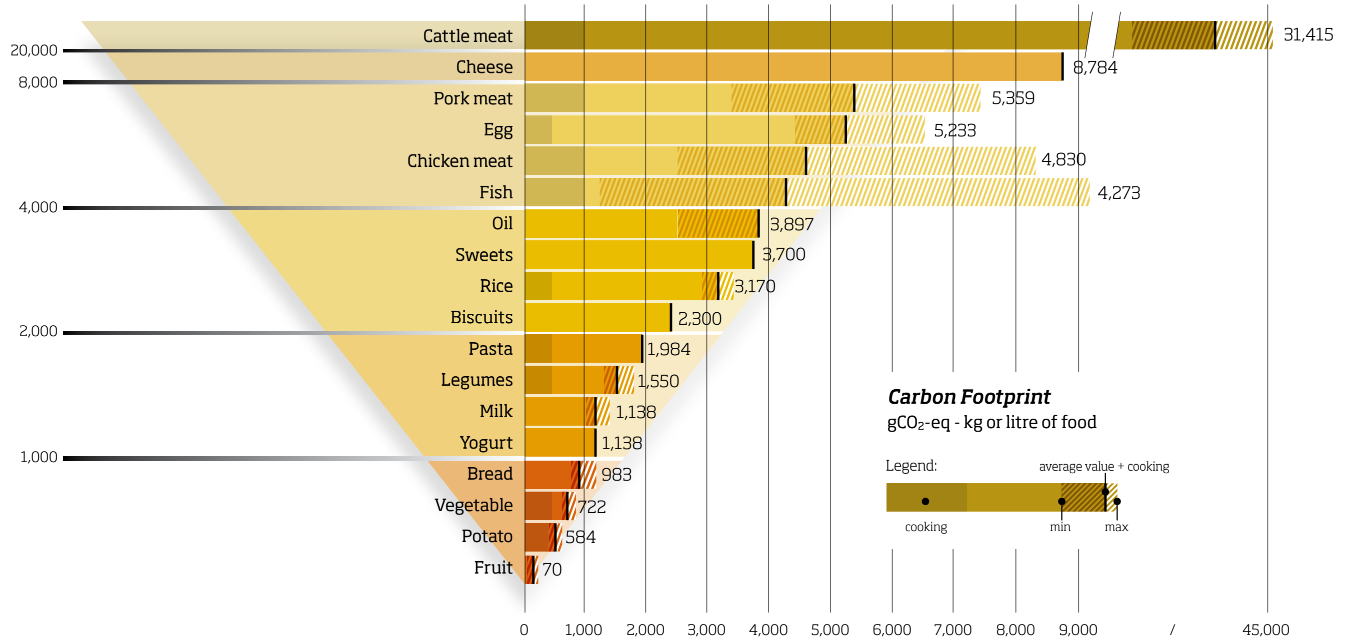
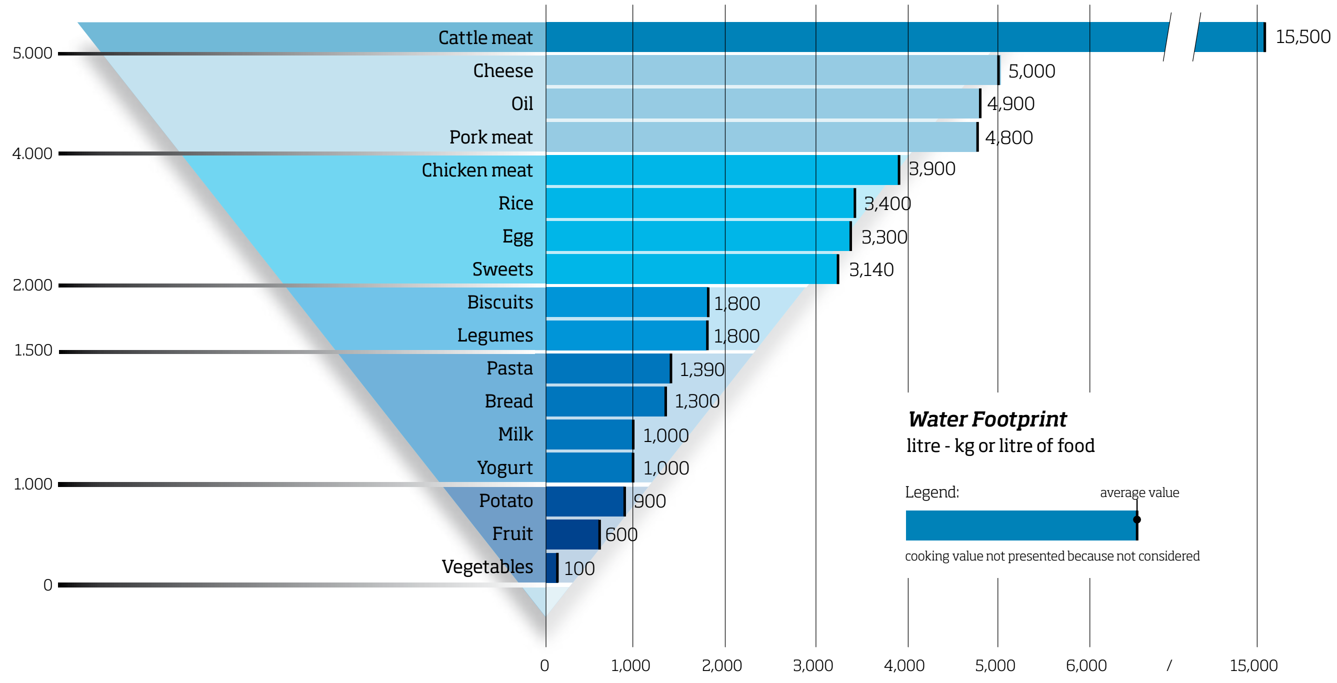


Table 4.2.3 - *Water Footprint*



4.3 The Environmental Pyramids based on the Ecological Footprint

By using the Life Cycle Assessment methodology, all environmental indicators considered for the entire analysis period were maintained on the same level. However, when making these results public, the need for conciseness and clarity dictates that a straightforward method for communicating the information obtained should be utilized.

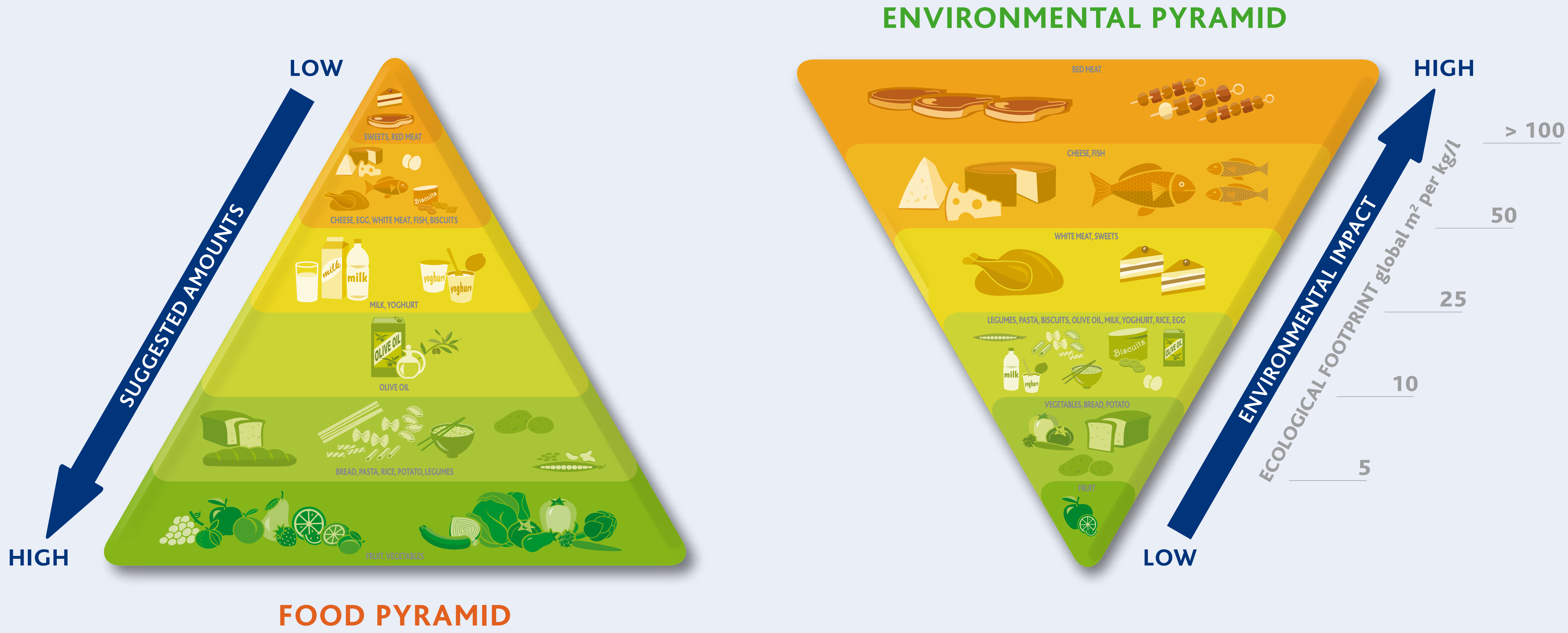
Two different approaches are possible in these phase: the first based on the construction of an aggregate indicator totaling all the various environmental information into a single value; the second based on selecting an impact indicator representative of all the results.

In constructing the Double Pyramid, we have chosen the second approach, taking as the sole reference indicator that of the Ecological Footprint.

This choice was based on the following:

- of the three indicators examined in this study, the Ecological Footprint is the most complete, because it takes into consideration both land use and CO_2 emissions;
- the Ecological Footprint is the simplest indicator to communicate because the unit of measure (global hectare) is easy to "visualize";
- the Ecological Footprint is the environmental indicator that, in a recent studied conducted for the European Commission[1], has been identified as one of the ones that should be promoted.

1 Best, Aaron, et al; 2008



LOW
SUGGESTED AMOUNTS
HIGH
SWEETS, RED MEAT
CHEESE, EGG, WHITE MEAT, FISH, BISCUITS
MILK, YOGHURT
OLIVE OIL
BREAD, PASTA, RICE, POTATO, LEGUMES
FRUIT, VEGETABLES
FOOD PYRAMID
ENVIRONMENTAL PYRAMID
RED MEAT
CHEESE, FISH
WHITE MEAT, SWEETS
LEGUMES, PASTA, BISCUITS, OLIVE OIL, MILK, YOGHURT, RICE, EGG
VEGETABLES, BREAD, POTATO
FRUIT
HIGH
ENVIRONMENTAL IMPACT
ECOLOGICAL FOOTPRINT global m² per kg/l
LOW
> 100
50
25
10
5

5. Details of environmental data gathered

Process assessment underscores the extent to which the main environmental impacts are seen in the generation of greenhouse gas, consumption of water resources and land use.

Melissa Farlow / National Geographic Image Collection

Another aspect which can certainly be considered relevant in calculating the environmental impacts in some foods is the influence of the geographical area in which they are produced.

Todd Gipstein / National Geographic Image Collection

5. Details of environmental data gathered

The information is presented grouping foods according to the following categories that reflect the detailed process description:

- Foods derived from agriculture (fruit, vegetables, grains, etc.);
- Foods derived from cultivation agricultural products (sugar, oil, pasta, etc.);
- Foods derived from animal husbandry (dairy products, meat, etc.);
- Foods from fishing;
- Beverages.

For every category examined, the values connected with each environmental indicator are given, taken from data banks and scientific studies and, when possible, these have been compared with data processed within the working group.

The results for each of the environmental indicators examined (for both scientific studies and processed data) are expressed as a range of values since a specific value would not be representative of the category as a whole. For example, fruit includes a number of varieties with different cultivation processes and, as a result, a single value for the category "fruit" cannot be given for each indicator.

For the majority of foods examined, the results given do not include the cooking phase and, therefore, it was decided to make certain assumptions about this, the details of which can be found in a section dedicated to this aspect (5.2).

5.1 Main data sources

The decision to use only "publicly available" data and information is due to the fact that in this first edition of the study it was decided to organize the presentation of results in such a way in order to allow a potential reader desirous of examining the analysis in a more in-depth and analytical manner to reconstruct the data in a relatively simple way.

In actuality, the working group which prepared this document has further information completing the data bank constructed with data taken directly from producers involved in the various supply chains and processing of this data. At this time, this information have been utilized for comparative purposes as well as guiding research and selection of the bibliographical sources utilized in constructing the Pyramid. For subsequent versions of this document, the possibility of formally involving producers, in order to expand the data base utilized as much as possible, could be taken into consideration.

Returning to the bibliographical sources, the information utilized to complete this work was taken from published literature or from those data banks normally consulted in life cycle analysis studies. The bibliography appended to this document cites all the individual sources drawn on from scientific literature, but it should be noted that, in general, the main sources of information were:

- the Ecoinvent database;
- Environmental Product Declarations (EPD)[1];
- LCA food database (www.LCAfood.dk);
- Water Footprint Network database;
- Ecological Footprint Network database.

1 Source : Environmental Product Declarations, www.environdec.com

Source type	Source list	Description
LCA data banks	Ecoinvent	Information is public and utilized by sector professionals. Its quality varies and, generally, the information is not specific to a given producer and therefore generally applicable to the product.
	LCA food	
	Water Footprint Network	
	Ecological Footprint Network	
Certified publications	EPD™	Information validated by third parties. Can be highly-specific to a single producer.
Scientific publications	Complete list is given in the bibliography	Information pertaining to a scientific study and validated by a qualified committee. Product-specific, but generally qualitatively reliable.
Generated in-house	-	Data processed specifically for this study. Because it was decided to keep this data to a minimum and use only publicly-available data, this information are less-reliable than other sources cited.

Main data sources utilized

The LCA approach, born over the 1970s and 1980s, spread significantly during the 1990s, especially following the 1997 publication of ISO standard 14040. Since then, this approach has gradually spread, starting from the manufacturing sector, to cover many production supply chains and resulting in the creation of a number of public data banks.

One of the data banks most utilized by those in this sector is that of ECOINVENT. Created by the Swiss Centre for Life Cycle Inventories, ECOINVENT is a data base available on line[2] that supplies much information and data about virtually all production supply chains. Another data base specific to the food sector is that created as part of a project financed by the Danish Ministry of Agriculture, Food and Fishing. This information is also available on line, free of charge[3].

Recent applications of the LCA methodological approach increasingly involve the desire of producers to communicate in a clear, accurate manner the environmental performance of the goods and services they place on the market. Starting in 2000, this has led to the development of the international EPD™ (environmental product declaration) system, the goal of which is to promote the spread of product environmental declarations assessed on the basis of ISO standards. These declarations (also public), are gradually creating a data bank of validated information useful in assessing environmental impact: some of these relate to food products and have been taken into consideration in this study.

In evaluating the sources utilized, it should be noted that the validated product environmental declarations refer to the creation of a good by a specific producer and, therefore, do not necessarily reflect the average environmental performance associated with the processes under examination.

2 Source: ECOINVEN database, www.ecoinvent.ch
3 Source : LCA database, http://www.LCAfood.dk/

Foods derived from agriculture

This category includes those foods produced directly from agricultural activity or, more precisely, those in which industrial processes are either inexistent or limited. For the presentation of environmental impacts, the category has been further subdivided into:

- fruit;
- legumes;
- vegetables;
- potatoes.

The system boundaries for the data provided in this section include the main process phases, which are:

- the actual agricultural production phase including, specifically, fuel consumption and fertilizer use;
- any post-harvest cleaning and treatment phases;
- transport of the products from the field to the distribution center.

Fruit

The three indicators calculated for the "fruit" category, which it is assumed is eaten raw, are summarized in Table 5.1.1, giving both the data range and the value utilized in constructing the Environmental Pyramid (average data).

Table 5.1.1 - Indicators for 1 kg of fruit

FRUIT	Carbon Footprint	Water Footprint	Ecological Footprint
	gCO_2-eq/kg	liters/kg	global m²/kg
Data range	40 - 100	500 - 700	2.3 - 6
Average value	**70**[4]	**600**	**3**

NUMBER AND TYPE OF SOURCES UTILIZED				
Source Type	LCA Data Banks	Certified publications	Scientific publications	Generated in-house
Carbon Footprint	-	1	-	-
Water Footprint	1	-	-	-
Ecological Footprint	1	1	-	-

The first information provided involves the Carbon Footprint which, as shown in Table 5.1.2, has values ranging from 40 to 100 grams of CO_2 equivalent per kg of fruit.

4 *Average of the published data range*

Table 5.1.2 - Carbon Footprint of a number of fruits from the literature

Product	Carbon Footprint	Source
	gCO_2-eq/kg	
Apples	40 ÷ 100	Milà i Canals *et al.* (2006)

For data involving water consumption, the information found in the Water Footprint Network database (creators of the method and relative calculation protocol) was utilized (Table 5.1.3).

Table 5.1.3 - Water Footprint of a number of fruits from the database - Source: data from www.waterfootprint.org

Product	Water Footprint
	liters/kg
Oranges	500
Apples	700

The Ecological Footprint values for some fruits are summarized in Table 5.1.4. In the calculation, contributions from *Cropland* (orchard land use) and *Energy Land* were taken into consideration.

Table 5.1.4 - Ecological Footprint of a number of fruits

Product	Ecological Footprint	Source
	global m²/kg	
Oranges and tangerines	2.4	Global Footprint Network in reference to the Italian situation in 2001 (GFN - Italy 2001)
Lemons and limes	2.3	
Bananas	2.9	
Apples	3.6	
Grapes	3.8	
Fruit	5 ÷ 6	Chambers *et al.* (2007)

Legumes

The three indicators calculated for the “legumes” category are summarized in Table 5.1.5.

Table 5.1.5 - Indicators for 1 kg of legumes

LEGUMES	Carbon Footprint	Water Footprint	Ecological Footprint
	gCO_2-eq/kg	liters/kg	global m²/kg
Data range	890 - 1,500	1,800	13 - 18
Average value	1,130	1,800	16
Cooking (boiling)	420	Negligible	5
Average value with cooking	**1,550**	**1,800**	**21**

NUMBER AND TYPE OF SOURCES UTILIZED				
Source Type	LCA Data Banks	Certified publications	Scientific publications	Generated in-house
Carbon Footprint	1	-	-	-
Water Footprint	1	-	-	-
Ecological Footprint	2	-	-	-

The legumes analyzed include fava beans, haricot beans, peas and soybeans. The data found in the literature do not take into account the cooking phase for legumes which has been added according to the assumptions given in the section on cooking method.

Carbon Footprint data were taken from the Ecoinvent database and are given in Table 5.1.6.

Table 5.1.6 - Carbon Footprint for 1 kg of legumes Source: www.ecoinvent.ch

Product	Carbon Footprint	Source
	gCO_2-eq/kg	
Fava beans	1,000	Ecoinvent 2004 (Fava bean IP, at farm, CH, [kg])
Peas	890	Ecoinvent 2004 (Protein pea, organic, at farm, CH, [kg])
Soybeans	1,500	Ecoinvent 2004 (soybeans, at farm, BR, [kg])

In terms of water consumption, the only available data was for soybeans from the data bank of the Water Footprint Network database.

Table 5.1.7 - Water Footprint for 1 kg of legumes. Source: www.waterfooptrint.org

Product	Water Footprint
	liters/kg
Soybeans	1,800

Finally, Table 5.1.8 provides the data for the Ecological Footprint, taken in part from the Ecoinvent database, and in part from information gleaned from the data bank of the Global Footprint Network.

Table 5.1.8 - Ecological Footprint for 1 kg of legumes

Product	Ecological Footprint	Source
	global m²/kg	
Fava beans	13.6	Ecoinvent 2004 (Fava bean IP, at farm, CH, [kg])
Peas	18.2	Elaborated from GFN - Italy 2001 data bank
	17	Ecoinvent 2004 (Protein pea, organic, at farm, CH, [kg])
Soybeans	15	Ecoinvent 2004 (soybeans, at farm, BR, [kg])

Vegetables

The three indicators calculated for the “vegetables” category are given in Table 5.1.9.

Table 5.1.9 - Indicators for 1 kg of vegetables

Foods from agriculture per kg		Carbon Footprint	Water Footprint	Ecological Footprint
		gCO_2-eq/kg	liters/kg	global m²/kg
Greenhouse vegetables	Data range	3,000 - 5,000	106	9
	Average value	4,000	106	9
	Cooking potatoes (boiling)	420	Negligible	5
	Average value with cooking	**4,420**	**106**	**14**
Seasonal vegetables	Data range	100 - 500	106	1.7 - 5.3
	Average value	250	106	3
	Cooking	420	Negligible	5
	Average value with cooking	**670**	**106**	**8**

NUMBER AND TYPE OF SOURCES UTILIZED				
Source Type	LCA Data Banks	Certified publications	Scientific publications	Generated in-house
Carbon Footprint	1	2	-	-
Water Footprint	-	-	-	1
Ecological Footprint	1	-	-	1

The vegetables analyzed include lettuce and tomatoes. In constructing the Pyramid, it was assumed that vegetables are eaten cooked. For more detailed information on this point, please refer to the section dedicated to cooking methods.

The values for the three indicators are given in the tables below.

The Carbon Footprint table (Tab. 5.1.10) distinguishes between seasonal vegetables and greenhouse vegetables (lettuce and tomatoes) because greenhouse gas emissions regarding the latter are higher due to significant energy use for heating the greenhouses.

Table 5.1.10 - Carbon Footprint for 1 kg of vegetables

Product	Carbon Footprint gCO_2-eq/kg	Source
Lettuce	400 - 500	Hospido *et al.* (2009)
	4,000 (greenhouse)	
Tomatoes	154	Andersson (2000)
	3,000 - 5,000 (greenhouse)	LCA food dk

Michael Melford / National Geographic Image Collection

Given that Water Footprint data are not available for seasonal vegetables, *ad hoc* elaboration were made, calculating *green water* and *blue water* for the cultivation of tomatoes in Italy (data used for the elaboration are synthesized in Tab. 5.1.11).

Regarding greenhouse vegetables, it is assumed that the amount of virtual water is equal to the seasonal vegetables one.

Table 5.1.11 - Water Footprint for 1 kg of tomatoes

	Parameter	Data	Source
Green water	Et0 [mm/growing period]	601	UCEA Observatory[5] Growing period: May - September
	Kc [-]	0.86	Elaborated by the working group taking into account the methodology described in Allen *et al.*, 1998
	Yield [t/ha]	60	Data about to be published
	Ete [l/kg]	86	Taking into account the methodology described in paragraph 3.2
Blue water [litri/kg]		20	Data about to be published
Water Footprint [litri/kg]		106	Taking into account the methodology described in paragraph 3.2
Value utilized for the pyramid [litri/kg]		106	

Given that out-of-season vegetables require a high level of energy for greenhouse heating and cooling, an assessment of the *Energy Land* associated solely with greenhouse conditioning was made, and this was added to the average value of the Ecological Footprint of seasonal vegetables.

The *Energy Land* assessment was made using the data reported by Hospido as the base (greenhouse gas emissions tied to conditioning: 2.3 kg CO_2 equivalent per kg of greenhouse lettuce).

Multiplying the emissions by the equivalence factor produces an *Energy Land* value of 6 global m^2/kg. This value refers to all greenhouse gas emissions and, consequently, could be an overestimate.

Adding the *Energy Land* (6 global m^2/kg) value to the Ecological Footprint average value for seasonal vegetables (3 gm^2/kg) produces an estimate of the Ecological Footprint for greenhouse vegetables (9 global m^2/kg), as shown in Table 5.1.12.

Table 5.1.12 - Ecological Footprint for 1 kg of vegetables

Product	Ecological Footprint gm^2/kg	Source
Onions	2.6	Elaborated from GFN - Italy 2001 data bank
Tomatoes	5.3	Elaborated from GFN - Italy 2001 data bank
Greenhouse vegetables	9	Elaborated by working group

5 Source: http://www.politicheagricole.it/ucea/Osservatorio/miekfyi01_index_zon.htm

Jim Richardson / National Geographic Image Collection

Potatoes

The three indicators calculated for potatoes are given in the following tables.

Table 5.1.13 - Indicators for 1 kg of potatoes

POTATOES	Carbon Footprint	Water Footprint	Ecological Footprint
	gCO_2-eq/kg	liters/kg	global m²/kg
Data range	98 ÷ 220	900	1,7 ÷ 2,1
Average value	164	900	2
Cooking (boiling)	420	Negligible	5
Average value with cooking	**584**	**900**	**7**

NUMBER AND TYPE OF SOURCES UTILIZED				
Source Type	LCA Data Banks	Certified publications	Scientific publications	Generated in-house
Carbon Footprint	2	-	-	-
Water Footprint	1	-	-	-
Ecological Footprint	2	-	-	-

Data given in literature do not include quantification of coking-related impacts of potatoes that, it is added based on the assumptions discussed in the dedicated section.

Carbon Footprint data are reported in Table 5.1.14.

Table 5.1.14 - Carbon Footprint for 1 kg of potatoes

Product	Carbon Footprint	Source
	gCO_2-eq/kg	
Potatoes	160 (at field)	LCA food dk
	220 (at retail)	
	98 - 116	Ecoinvent 2004 (Potato IP, at farm, CH, [kg])

Data for virtual water consumptions are taken from the Water Fooptrint Network database and presented in Table 5.1.15.

Table 5.1.15 - Water Footprint for 1 kg of potatoes

Product	Water Footprint	Source
	liters/kg	
Potatoes	900	www.waterfootprint.org

Finally, Tables 5.1.16 shows the Ecological Footprint data which were taken in part from the Ecoinvent database, and in part from the Global Fooptrint Network database.

Table 5.1.16 - Ecological Footprint for 1 kg of potatoes

Product	Ecological Footprint	Source
	global m²/kg	
Potatoes	2.1	Elaborated from GFN - Italy 2001 data bank
	1.7	Ecoinvent 2004 (Potato IP, at farm, CH, [kg])

Foods derived from processing of agricultural products

This category includes those foods produced following industrial processing (of varied complexity) of agricultural raw materials. For the presentation of environmental characteristics, the foods have been divided into:

- Pasta;
- Rice;
- Bread;
- Sugar;
- Condiments (oils);
- Sweets (cakes);
- Biscuits.

The system boundaries for the data presented in this section include the main process phases, which are:

- the agricultural production phase;
- the industrial processing phase;
- production of any packing materials;
- transport from the field to the distribution center.

Pasta

The indicators for hard wheat pasta are derived from the environmental declaration of the pasta certified on the basis of the EPD™ international system[6] and summarized in Table 5.1.17. In terms of cooking, although the environmental declaration includes an estimate of the impacts, it was decided to follow the same approach utilized for other foods as referenced in the information presented in the section dedicated to cooking method.

In terms of the Water Footprint, a document prepared directly by the Water Footprint Network, shows values in line with those presented in the pasta EPD declaration (Haldaya, 2009).

Because pasta is a food that is never consumed on its own, in constructing the Environmental Pyramid it was assumed that it would be cooked, but without the addition of any type of condiment. Given these assumptions, the environmental impacts taken into consideration are shown in the table below.

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6 http://www.environdec.com/pageID.asp?id=130&menu=4,14,0&epdId=195

Table 5.1.17 - Indicators for 1 kg of pasta

PASTA	Carbon Footprint	Water Footprint	Ecological Footprint	Source
	gCO_2-eq/kg	liters/kg	global m²/kg	
Raw pasta	1,564	1,390	12	Barilla pasta EPD
Cooking (boiling)	420	Negligible	5	See specific section
Cooked pasta	**1,984**	**1,390**	**17**	-

NUMBER AND TYPE OF SOURCES UTILIZED				
Source Type	LCA Data Banks	Certified publications	Scientific publications	Generated in-house
Carbon Footprint	-	-	1	-
Water Footprint	-	-	1	-
Ecological Footprint	-	-	1	-

Rice

As with pasta, it was also assumed that rice would be cooked without the addition of any type of condiment. The three indicators calculated for rice are given in the tables below.

In finding the average of the data for the Carbon Footprint, it was decided to leave out the data from the Ecoinvent database since it is referred to the production of paddy rice and not to the refined one.

Table 5.1.18 - Indicators for 1 kg of vegetable rice

RICE	Carbon Footprint	Water Footprint	Ecological Footprint
	gCO_2-eq/kg	liters/kg	global m²/kg
Raw rice	1,800 - 3,000	3,400	7 - 11
Average value	2,750	3,400	9
Cooking (boiling)	420	Negligible	5
Average value with cooking	**3,170**	**3,400**	**14**

NUMBER AND TYPE OF SOURCES UTILIZED				
Source Type	LCA Data Banks	Certified publications	Scientific publications	Generated in-house
Carbon Footprint	1	1	-	-
Water Footprint	1	-	-	-
Ecological Footprint	2	-	-	-

The values for the three indicators are summarized in Tables 5.1.19., 5.1.20 and 5.1.21. These figures do not include the cooking phase; for this aspect, please refer to the specific section dedicated to cooking method.

Table 5.1.19 - Carbon Footprint for 1 kg of rice

Product	Carbon Footprint gCO_2-eq/kg	Source
Rice	2,500 - 3,000	Blengini, Busto (2008)
	1,800[7]	Ecoinvent 2004 (Rice, at farm, 1 kg, US)

Table 5.1.20 - Water Footprint for 1 kg of rice

Product	Water Footprint liters/kg	Source
Rice	3,400	www.waterfootprint.org

Table 5.1.21 -Ecological Footprint for 1 kg of rice

Product	Ecological Footprint gm^2/kg	Source
Rice	7,8	Elaborated from GFN database - Italy 2001
	11	Ecoinvent 2004 (Rice, at farm, 1 kg, US)

Bread

The environmental indicators for bread production are summarized in Table 5.1.22.
The average value for the Carbon Footprint was calculated by finding the average of all available data, taking into consideration:

- the average data of the range as per Andersson & Ohlsson (1999);
- data for retail sale as per the Danish database.

Table 5.1.22 - Indicators for 1 kg of bread

BREAD	Carbon Footprint gCO_2-eq/kg	Water Footprint liters/kg	Ecological Footprint global m^2/kg
Data range	630 - 1,000	1,300	6.7
Average value	**983**	**1,300**	**6.7**

7 *Value not included in the calculation of average values since the data base does not take into consideration methane emission during rice cultivation*

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NUMBER AND TYPE OF SOURCES UTILIZED				
Source Type	LCA Data Banks	Certified publications	Scientific publications	Generated in-house
Carbon Footprint	1	1	-	-
Water Footprint	1	-	-	-
Ecological Footprint	-	-	-	1

The environmental values for the indicators for bread production are given in the tables below.

Table 5.1.23 - Carbon Footprint for 1 kg of bread

Product	Carbon Footprint gCO_2-eq/kg	Source
Fresh loaf	880 (at plant)	LCA food dk
	930 (at retail)	
Frozen loaf	890 (at plant)	LCA food dk
	1,260 (at retail)	
Wheat bread (fresh)	780 (at plant)	LCA food dk
	840 (at retail)	
Wheat bread (frozen)	890 (at plant)	LCA food dk
	1,260 (at retail)	
Rye bread	720 (at plant)	LCA food dk
	790 (at retail)	
Bread	630 - 1,000	Andersson & Ohlsson (1999)

Table 5.1.24 - Water Footprint for 1 kg of bread

Product	Water Footprint	Source
	liters/kg	
Bread	1,333	www.waterfootprint.org

Table 5.1.25 - Ecological Footprint for 1 kg of bread

Product	Ecological Footprint	Source
	global m²/kg	
Bread	6.7	Elaborated by the working group

Calculations for the Ecological Footprint were made on the basis of data taken from the scientific study by Andersson & Ohlsson, calculating only the contributions of *Cropland* and *Energy Land*, as shown in the table below:

Cropland			Energy land			Ecological Footprint
Land use [m²/kg]	Equivalence factor [global m²/m²]	Cropland [gm²/kg]	CO_2 emissions [gCO_2/kg]	Equivalence factor [gha/tCO_2]	Energy land [global m²/kg]	global m²/kg
2	2.64	5.3	500	0.277	1.4	**6.7**

Sugar

The indicators are summarized in Table 5.1.26.

Table 5.1.26 - Indicators for 1 kg of sugar

SUGAR	Carbon Footprint	Water Footprint	Ecological Footprint
	gCO_2-eq/kg	liters/kg	global m²/kg
Data range	200 - 1,000	1,500	3 - 6
Average value	**470**	**1,500**	**4**

NUMBER AND TYPE OF SOURCES UTILIZED				
Source Type	LCA Data Banks	Certified publications	Scientific publications	Generated in-house
Carbon Footprint	2	1	-	-
Water Footprint	1	-	-	-
Ecological Footprint	2	-	-	-

For the "sugar" category, beet sugar and cane sugar were considered and their environmental impact values are shown in the tables below.

Table 5.1.27 -Carbon Footprint for 1 kg of sugar

Product	Carbon Footprint	Source
	gCO_2-eq/kg	
Beet sugar	840 (at plant)	LCA food dk
	960 (at retail)	
	500	Ecoinvent 2004 (sugar, from sugar beet, at sugar refinery, CH, [kg])
Cane sugar	233	Ramjeawon (2004)
	190	Ecoinvent 2004 (sugar, from sugarcane, at sugar refinery, BR, [kg])

Table 5.1.28 - Water Footprint for 1 kg of cane sugar

Product	Water Footprint	Source
	liters/kg	
Cane sugar	1,500	www.waterfootprint.org

In calculating the Ecological Footprint, the contributions from *Crop Land* and *Energy Land* were taken into consideration and the information was taken from the Ecoinvent and Global Footprint Network database.

Table 5.1.29 - Ecological Footprint for 1 kg of sugar

Product	Ecological Footprint	Source
	global m²/kg	
Beet sugar	3.5	Elaborated from GFN - Italy 2001 data bank
	6	Ecoinvent 2004 (sugar, from sugar beet, at sugar refinery, CH, [kg])
Cane sugar	3.2	Elaborazione banca dati GFN - Italy 2001
	4.9	Ecoinvent 2004 (sugar, from sugar cane, at sugar refinery, BR, [kg])

Oil

The three indicators calculated for the "oil" category are given in Table 5.1.30.

Table 5.1.30 - Indicators for 1 liter of oil

OIL	Carbon Footprint	Water Footprint	Ecological Footprint
	gCO_2-eq/kg	liters/kg	global m²/kg
Data range	2,500 - 3,900	4,900	14.6
Average value	**3,897**	**4,900**	**14.6**

NUMBER AND TYPE OF SOURCES UTILIZED				
Source Type	LCA Data Banks	Certified publications	Scientific publications	Generated in-house
Carbon Footprint	1	2	-	-
Water Footprint	-	-	-	1
Ecological Footprint	-	-	-	1

For condiments, four different types of vegetable oils were considered: olive oil, palm oil, soybean oil and rapeseed oil. The values for the three indicators are shown in the tables below. To realize the three Pyramids was considered only olive oil.

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Table 5.1.31 - Carbon Footprint for 1 liter of oil

Product	Carbon Footprint	Source
	gCO_2-eq/kg	
Olive oil	3,897	Avraamides, Fatta (2008)
Palm oil	2,514[8]	Yusoff, Hansen (2007)
Soybean and rapeseed oil	3,510 (at plant)	LCA food dk[9]
	3,630 (at retail)	

Figures for the Water Footprint were developed by calculating the contribution of *green water* and *blue water*. Calculation data are summarized in Table 5.1.32.

Table 5.1.32 - Water Footprint for 1 liter of oil

	Parameter	Value	Source
Green water	Et0 [mm/month]	908	UCEA Observatory[10]
	Kc [-]	0,65	Data elaborated by the working group taking into account the methodology described in Allen *et al.*, 1998
	Yield [t/ha]	7	Hoepli Manual of Agriculture
	Ete [l/kg]	843	Data elaborated by the working group taking into account the methodology described in paragraph 3.2
Blue water [liters/kg]		4,000	Avraamides, Fatta (2008)
Water Footprint [liters/kg]		**4,843**	Data elaborated by the working group taking into account the methodology described in paragraph 3.2
Value utilized for the pyramid [liters/kg]		**4,900**	

Calculations for the Ecological Footprint were made exclusively on the basis of *Cropland* and *Energy Land* contributions, as shown in the table below:

Table 5.1.33 - Ecological Footprint assessment for 1 liter of oil

Crop land			Energy land			Ecological Footprint
Land use [m²/kg]	Equivalence factor [global m²/m²]	Crop land [global m²/kg]	CO_2 emissions [gCO_2/kg]	Equivalence factor [gha/tCO_2]	Energy land [global m²/kg]	global m²/kg
1.43[11]	2.64	3.8	3,900[12]	0.277	10.8	14.6

8 The final refining phase for palm oil was not included within the boundaries of the study
9 Soybean and rapeseed oil
10 http://www.politicheagricole.it/ucea/Osservatorio/miekfyi01_index_zon.htm
11 Hoepli, Manual of Agriculture
12 Avreemides, Fata (2008)

Table 5.1.34 -Ecological Footprint for 1 liter of oil

Product	Ecological Footprint global m²/kg	Source
Oil	14,6	Elaborated by the working group

Sweets

For this category, no publicly-available information was found, and for this reason the results of a life cycle assessment for Torta del Paradiso - a traditional Italian-style cake (Veronelli, "Il Carnacina", Garzanti) - are provided. The data was prepared by the working group in order to have a general idea of the impact associated with 1 kg of sweet.

This cake was used as a proxy of the "sweets" category. The recipe and datails about the life cycle assessment evaluation are given in Appendix A1.

The indicators for the production of 1 kg of sweets are given in Table 5.1.35.

Table 5.1.35 - Indicators for the production of 1 kg of sweets

SWEETS	Carbon Footprint	Water Footprint	Ecological Footprint
	gCO_2-eq/kg	liters/kg	global m²/kg
Data range	3,700	3,140	30
Average value	**3,700**	**3,140**	**30**

NUMBER AND TYPE OF SOURCES UTILIZED				
Source Type	LCA Data Banks	Certified publications	Scientific publications	Generated in-house
Carbon Footprint	-	-	-	1
Water Footprint	-	-	-	1
Ecological Footprint	-	-	-	1

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Biscuits

For this category, no publicly-available information was found, and for this reason the results of a life cycle assessment for biscuits are provided. The data was prepared by the working group in order to have a general idea of the impact associated with 1 kg of cookies.

As representative of this category, "healthy cookies" (Artusi, recipe no. 573) were analyzed, the detailed recipe for which is given in Appendix A1.

The indicators for the production of 1 kg of cookies are given in Table 5.1.36.

Table 5.1.36 - Indicators for the production of 1 kg of cookies

COOKIES	Carbon Footprint	Water Footprint	Ecological Footprint
	gCO_2-eq/kg	liters/kg	global m²/kg
Data range	2,300	1,800	16
Average value	**2,300**	**1,800**	**16**

NUMBER AND TYPE OF SOURCES UTILIZED				
Source Type	LCA Data Banks	Certified publications	Scientific publications	Generated in-house
Carbon Footprint	-	-	-	1
Water Footprint	-	-	-	1
Ecological Footprint	-	-	-	-

Foods derived from animal husbandry

This category includes those foods involving livestock husbandry, both for animal-based products (milk, eggs) and meat itself. The subcategories utilized are:

- beef (red meat);
- pork (white meat);
- poultry (white meat);
- cheese;
- butter;
- milk;
- yoghurt;
- eggs.

The system boundaries for these products include:

- the livestock husbandry phase including growing of feed;
- butchering phase (for meat production);
- processing of products (for milk and eggs).

As with the other foods already presented, the indicators given do not include impacts associated with cooking. For this reason, the impacts connected with this phase were calculated on the basis of the assumptions given in the section dedicated to cooking method, assuming that only cheese is consumed uncooked.

White meat and red meat

The decision was made to construct the Double Pyramid dividing meat into white and red. While continuing to maintain basic information and data in a clear, straightforward manner, the two categories have been designed in order to facilitate communication: red meat is represented by beef while white meat by pork and poultry.

Beef (red meat)

The indicators calculated for the "beef" category are given in Table 5.1.37.

Table 5.1.37 - Indicators for 1 kg of meat

BEEF	Carbon Footprint	Water Footprint	Ecological Footprint
	gCO_2-eq/kg	liters/kg	global m²/kg
Data range	6,000 - 44,800	15,500	89 - 94
Average value	30,400	15,500	92
Cooking	1,000	Negligible	13
Average value with cooking	**31,400**	**15,500**	**105**

NUMBER AND TYPE OF SOURCES UTILIZED				
Source Type	LCA Data Banks	Certified publications	Scientific publications	Generated in-house
Carbon Footprint	1	9	-	-
Water Footprint	1	-	-	-
Ecological Footprint	-	1	-	-

Data for environmental impacts associated with beef production are taken from public sources and are shown in the tables which follow.

In particular, Tables 5.1.38 and 5.1.39 provide Carbon Footprint values from, respectively, the Danish LCA food database and the "*Food Production and Emission of Greenhouse Gases*" report issued by SIK - the Swedish Institute for Food and Biotechnology and the International Journal of LCA.

The average value for the Carbon Footprint was calculated by finding the average of all available data:

- taking into consideration data for retail sale as per the Danish database;
- taking into consideration the average data, then mediated with other data;
- excluding overboard category (68,000 and values between 2,220 and 4,370).

Table 5.1.38 - Carbon Footprint for 1 kg of beef - Source: LCA food DK

Product	Carbon Footprint
	gCO_2-eq/kg
Tenderloin	67,900 (at slaughterhouse)
	68,000 (at retail)
Fillet	44,800
Top round	42,300
Steak	42,400
Fore-end	24,600
Outside	2,230
Flank steak	2,240
Round	2,210 (at slaughterhouse)
	2,220 (at retail)
Minced meat	4,320 (at slaughterhouse)
	4,370 (at retail)
Knuckle shank	4,040 (at slaughterhouse)
	4,080 (at retail)

Table 5.1.39 - Carbon Footprint for 1 kg of beef

Product	Carbon Footprint	Source
	gCO_2-eq/kg	
Beef	32,000	Ogino et al. (2007), Japan (SIK report)
	28,000 - 32,000	Casey & Holden (2006a, b), Suckler, Ireland (SIK report)
	16,000	Williams et al. (2006), "Average UK beef" (SIK report)
	25,000	Williams et al. (2006), "100% suckler", UK (SIK report)
	30,000	Verge, et al. (2008), "Average Canadian beef" (SIK report)
	40,000	Cederberg et al. (2009a), "Average Brazilian beef" (SIK report)
	28,000	Cederberg et al. (2009b), "Average Swedish beef 2005" (SIK report)
	17,000 - 19,000	Cederberg & Darelius (2000), "Swedish beef from combined systems dairy-beef" (SIK report)
	22,300	Cederberg & Stadig (2003)

In terms of water consumption, the Water Footprint data was taken from the database available on the Net (Tables 5.1.40), while for the Ecological Footprint, a study recently presented by the Piedmont Region that specifically examines beef production was utilized (Tables 5.1.41).

Table 5.1.40 - Water Footprint for 1 kg of meat

Product	Water Footprint	Source
	liters/kg	
Beef	15,500	www.waterfootprint.org

Table 5.1.41 - Ecological Footprint for 1 kg of meat

Product	Ecological Footptint	Source
	global m²/kg	
Beef	89 - 94	Regione Piemonte (Assessorato Ambiente), la contabilità ambientale applicata alla produzione zootecnica. Collana ambiente 29

Pork (white meat)

Data for environmental impacts associated with pork production are taken from public sources and are shown in Table 5.1.42.

Table 5.1.42 - Indicators for 1 kg of pork meat

PORK	Carbon Footprint	Water Footprint	Ecological Footprint
	gCO_2-eq/kg	liters/kg	global m²/kg
Data range	2,300 - 8,000	4,800	36
Average value	4,359	4,800	36
Cooking (broiling)	1	Negligible	13
Average value with cooking	**5,360**	**4,800**	**49**

NUMBER AND TYPE OF SOURCES UTILIZED				
Source Type	LCA Data Banks	Certified publications	Scientific publications	Generated in-house
Carbon Footprint	1	5	-	-
Water Footprint	1	-	-	-
Ecological Footprint	1	-	-	-

Tables 5.1.43 and 5.1.44 provide Carbon Footprint values taken from, respectively, the Danish LCA food database and the "*Food Production and Emission of Greenhouse Gases*" report issued by SIK - the Swedish Institute for Food and Biotechnology.

Table 5.1.43 - Carbon Footprint for 1 kg of pork - Source: LCA food DK

Product	Carbon Footprint
	gCO_2-eq/kg
Tenderloin	4,520 (at slaughterhouse)
	4,560 (at retail)
Ham, pork neck, streaky bacon	2,900 (at slaughterhouse)
	2,950 (at retail)
Minced meat	2,660 (at slaughterhouse)
	2,310 (at retail)

Table 5.1.44 -Carbon Footprint for 1 kg of pork

Product	Carbon Footprint	Source
	gCO_2-eq/kg	
Pork	5,600 - 6,400	Williams et al., 2006
	5,300 - 8,000	Basset Mens & van der Werf (2003)
	4,100 - 3,600	Cederberg & Flysjö (2004)
	3,200 - 3,500	Strid Eriksson *et al.* (2005)
	5,200	Cederberg m.fl. (2009)

In terms of water consumption, the Water Footprint data was taken from the database available on the Net (Tables 5.1.45), while for the Ecological Footprint, the data available on the Network database were elaborated (Tables 5.1.46).

Table 5.1.45 - Water Footprint for 1 kg of pork

Product	Water Footprint	Source
	liters/kg	
Pork	4,800	www.waterfootprint.org

Table 5.1.46 - Ecological Footprint for 1 kg of pork

Product	Ecological Footptint	Source
	global m²/kg	
Pork	36	Elaborated from GFN - Italy 2001 data bank

Poultry (white meat)

The indicators calculated for the "poultry" category are given in Table 5.1.47.

Table 5.1.47 - Indicators for 1 kg of poultry meat

POULTRY	Carbon Footprint	Water Footprint	Ecological Footprint
	gCO_2-eq/kg	liters/kg	global m²/kg
Data range	1,500 - 7,300	3,900	33
Average value	3,830	3,900	33
Cooking (broiling)	1	Negligible	13
Average value with cooking	**4,830**	**3,900**	**46**

NUMBER AND TYPE OF SOURCES UTILIZED				
Source Type	LCA Data Banks	Certified publications	Scientific publications	Generated in-house
Carbon Footprint	1	5	-	-
Water Footprint	1	-	-	-
Ecological Footprint	1	-	-	-

Data for environmental impacts associated with poultry production are taken from public sources and are shown in the tables which follow.

In particular, Tables 5.1.48 and 5.1.49 provide Carbon Footprint values from, respectively, the Danish LCA food data bank and the "*Food Production and Emission of Greenhouse Gases*" report issued by SIK - the Swedish Institute for Food and Biotechnology.

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Table 5.1.48 - Carbon Footprint for 1 kg of poultry - Source www.LCAfood.dk

Product	Carbon Footprint
	gCO_2-eq/kg
Fresh chicken	3,110 (at slaughterhouse)
	3,160 (at retail)
Frozen chicken	3,280 (at slaughterhouse)
	3,650 (at retail)

Table 5.1.49 - Carbon Footprint for 1 kg of poultry

Product	Carbon Footprint	Source
	gCO_2-eq/kg	
Chicken	1,500	Thynelius (2008)
	2,600	Pelletier (2008)
	2,500	Cederberg *et al.* (2009b)
	6,100	Williams et al. (2006), conventional
	7,300	Williams et al. (2006), free-range

Data for virtual water consumption come from official data banks of the respective network.

Table 5.1.50 - Water Footprint for 1 kg of poultry

Product	Water Footprint	Source
	liters/kg	
Chicken	3,900	www.waterfootprint.org

Table 5.1.51 - Ecological Footprint for 1 kg of poultry

Product	Ecological Footptint	Source
	global m²/kg	
Chicken	33	Elaborated from GFN - Italy 2001 data bank

Cheese

The indicators utilized in creating the Environmental Pyramid are summarized in Table 5.1.52.

Table 5.1.52 - Indicators for 1 kg of cheese

CHEESE	Carbon Footprint	Water Footprint	Ecological Footprint
	gCO_2-eq/kg	liters/kg	global m²/kg
Data range	8,784	5,000	75
Average value	**8,784**	**5,000**	**75**

NUMBER AND TYPE OF SOURCES UTILIZED				
Source Type	LCA Data Banks	Certified publications	Scientific publications	Generated in-house
Carbon Footprint	-	1	-	-
Water Footprint	1	-	-	-
Ecological Footprint	-	-	-	1

The environmental indicator values for cheese are taken from published sources and are given in the tables below.

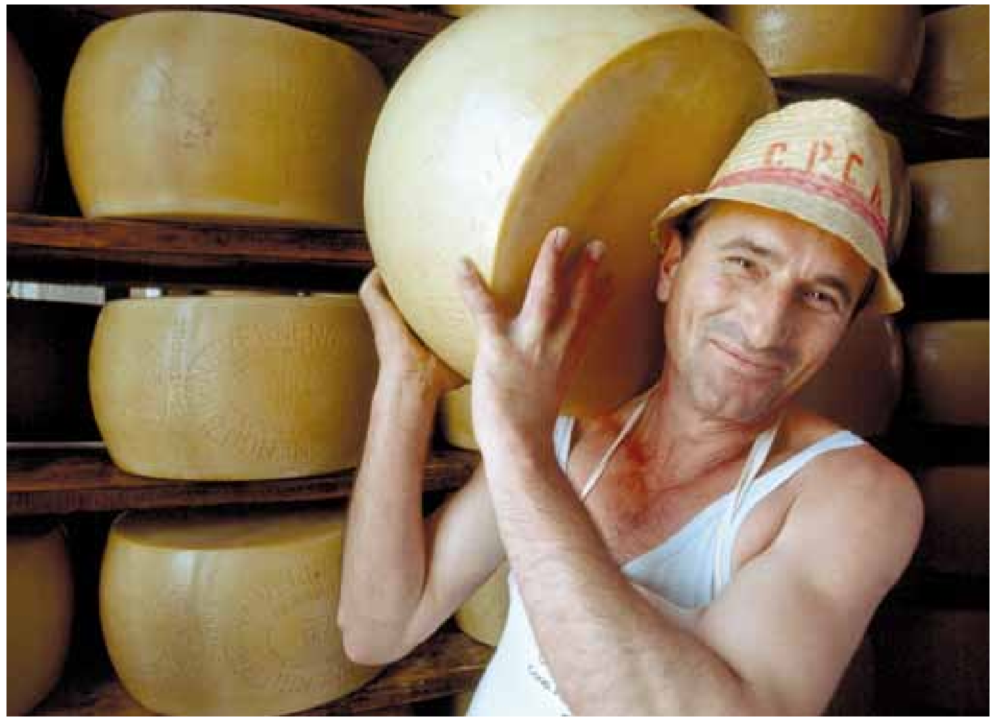

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Table 5.1.53 - Carbon Footprint for 1 kg of cheese

Product	Carbon Footprint	Source
	gCO_2-eq/kg	
Cheese	8,784	Berlin (2002)

Table 5.1.54 - Water Footprint for 1 kg of cheese

Product	Water Footprint	Source
	liters/kg	
Cheese	5,000	www.waterfootprint.org

Table 5.1.55 - Ecological Footprint for 1 kg of cheese

Product	Ecological Footprint	Source
	global m²/kg	
Cheese	75	Elaboration considering 5 liters of milk (15 global m²/liter) consumed per kg of cheese

Butter

No publicly-available information was found for this category, and for this reason it was conservatively decided to assimilate the impacts of butter with the cheese ones.

In the next edition of this document this assumption will haveto be further analyzed. The environmental impacts of butter were considered for the calculation of the sweets ones.

Table5.1.56 - Indicators for 1 kg of butter

Butter	Carbon Footprint	Water Footprint	Ecological Footprint
	gCO_2-eq/kg	liters/kg	global m²/kg
Data range	8,800	5,000	75

Milk

For milk, production of fresh pasteurized milk was examined. The environmental indicator values for milk are taken from published sources and are given in the tables below.

Table 5.1.57 - Indicators for 1 liter of milk

MILK	Carbon Footprint	Water Footprint	Ecological Footprint
	gCO_2-eq/liter	liters/liter	global m²/liter
Data range	1,050 - 1,303	1,000	11 - 19
Average value	**1,138**	**1,000**	**15**

NUMBER AND TYPE OF SOURCES UTILIZED				
Source Type	LCA Data Banks	Certified publications	Scientific publications	Generated in-house
Carbon Footprint	-	2	1	-
Water Footprint	1	-	-	-
Ecological Footprint	-	1	-	-

Table 5.1.58 –Carbon Footprint for 1 liter of milk

Product	Carbon Footprint gCO^2-eq/liter	Source
Milk	1,303	EPD for high-quality Granarolo milk[13]
	1,050	Cederberg & Stadig (2003)
	1,060	William et al. (2006)

Table 5.1.59 – Water Footprint for 1 liter of milk

Product	Water Footprint liters/liter	Source
Milk	1,000	www.waterfootprint.org

Tabella 5.1.60 – Ecological Footprint for 1 liter of milk

Product	Ecological Footptint global m²/liter	Source
Milk	11 - 19	Chambers et al (2007)

Yoghurt

No publicly-available information was found for this category, and for this reason the data was elaborated by the working group itself.

The indicators pertaining to the production of 1 liter of yoghurt are given in Table 5.1.61. They have been calculated on the basis of the ratio of milk to yoghurt which, on average, is 1:1 (Temine & Robertson, 1999; Fetiz et al., 2005). In essence, the average indicators calculated for a liter of milk were utilized for yoghurt.

13 *Environmental Product Declaration for pasteurized fresh milk packed in PET bottle, EPD, Granarolo, http://www.environdec.com/reg/epd118it.pdf*

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Table 5.1.61 – Indicators for the production of 1 liter of yoghurt

YOGHURT	Carbon Footprint gCO$_2$-eq/liter	Water Footprint liters/liter	Ecological Footprint global m²/liter
Data range	1,138	1,000	15
Average value	**1,138**	**1,000**	**15**

NUMBER AND TYPE OF SOURCES UTILIZED				
Source Type	LCA Data Banks	Certified publications	Scientific publications	Generated in-house
Carbon Footprint	-	-	-	1
Water Footprint	-	-	-	1
Ecological Footprint	-	-	-	1

Eggs

The environmental indicator values for eggs are taken from published sources and are given in the tables below.

Table 5.1.62 - Indicators for 1 kg of eggs

EGG	Carbon Footprint	Water Footprint	Ecological Footprint
	gCO_2-eq/kg	liters/kg	global m²/kg
Data range	4,038 - 5,800	3,300	9
Average value	4,813	3,300	9
Cooking (boiling)	420	Negligible	5
Average value with cooking	**5,233**	**3,300**	**14**

NUMBER AND TYPE OF SOURCES UTILIZED				
Source Type	LCA Data Banks	Certified publications	Scientific publications	Generated in-house
Carbon Footprint	-	2	-	-
Water Footprint	1	-	-	-
Ecological Footprint	-	-	-	1

Table 5.1.63 - Carbon Footprint for 1 kg of eggs

Product	Carbon Footprint	Source
	gCO_2-eq/kg	
Organic eggs	4,038	Dekker *et al.*
Organic eggs	5,800[14]	Williams *et al.*
Non-organic eggs	4,600[15]	Williams *et al.*

Table 5.1.64 - Water Footprint for 1 kg of eggs

Product	Water Footprint	Source
	liters/kg	
Eggs	3,333	www.waterfootprint.org

Calculations for the Ecological Footprint were made exclusively on the basis of *Cropland* and *Energy Land* contributions, as shown in the tables below.

14 *This value was elaborated per kg of eggs produced; the study by Williams provides an emission value of CO_2 equivalent for 20,000 eggs equal to 7,000 kg. The weight of each egg was assumed to be 60 grams (http://www.waterfootprint.org/?page=files/productgallery&product=eggs)*

15 *This value was elaborated per kg of eggs produced; the study by Williams provides an emission value of CO_2 equivalent for 20,000 eggs equal to 5,530 kg. The weight of each egg was assumed to be 60 grams (http://www.waterfootprint.org/?page=files/productgallery&product=eggs)*

Table 5.1.65 - Ecological Footprint assessment for 1 kg of eggs

Cropland			Energy land			Ecological Footprint
Land use [m²/kg]	Equivalence factor [global m²/m²]	Crop land [global m²/kg]	CO_2 emissions [gCO_2/kg]	Equivalence factor [gha/tCO_2]	Energy land [global m²/kg]	global m²/kg
2.5[16]	2.64	6.6	800[17]	0.277	2.22	8.88

Table 5.1.66 - Ecological Footprint for 1 kg of eggs

Product	Ecological Footptint	Source
	global m²/kg	
Eggs	9	Elaborated by the working group

Food from fishing

The indicators calculated for this category are given in Table 5.1.67.

The average of the values found in the literature (for the Carbon Footprint) was calculated taking into consideration the retail sales data and excluding, respectively, data for mussels and lobster because of their extreme variation.

Table 5.1.67 - Indicators for 1 kg of fish

FISH	Carbon Footprint	Water Footprint	Ecological Footprint
	gCO_2-eq/kg	liters/kg	global m²/kg
Data range	220 - 10,500	N.A.	45 - 66
Average value	3,273	N.A.	56
Cooking (broiling)	1,000	Negligible	13
Average value with cooking	**4,273**	N.A.	**69**

16 *Calculated taking into consideration that approx. 2 kg of corn per kg of eggs are required and that corn yield is 8 t/ha*

17 *Dekker et al.*

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NUMBER AND TYPE OF SOURCES UTILIZED				
Source Type	LCA Data Banks	Certified publications	Scientific publications	Generated in-house
Carbon Footprint	-	1	-	-
Water Footprint	-	-	-	-
Ecological Footprint	-	1	-	-

The data for the fish supply chain available in literature pertain to the Carbon Footprint and Ecological Footprint.

Data pertaining to the Carbon Footprint derive primarily from the Danish LCA food database.
This database differentiates the supply chains into two groups:

- wild fish;
- farmed trout.

The results for the first category are given in Table 5.1.68, while those for the second category are found in Table 5.1.69.
The data provided do not take into consideration impacts connected to the cooking phase for the fish; for this aspect, please refer to the assumptions outlined in specific section dedicated to cooking method.
Data for the Ecological Footprint are given in Table 5.1.70.

Table 5.1.68 - Carbon Footprint for 1 kg of wild fish - Source www.LCAfood.dk

Product		Carbon Footprint gCO_2-eq/kg	
Type of fish	Supply chain phase	At harbor	At retail
Cod	Fresh	1,200	1,200
	Fillet	2,700	2,800
	Frozen	2,800	3,200
Sole	Fresh	3,300	3,300
	Fillet	7,400	7,400
	Frozen	7,500	7,800
Herring	Fresh	580	630
	Fillet	1,300	1,300
	Frozen	1,400	1,800
Mackerel	Fresh	170	220
	Fillet	460	510
	Frozen	620	960
Industrial fish		220	-
Lobster		20,200	20,200
Shrimp	Fresh	2,940	3,000
	Peeled/frozen	1,010	10,500
Mussels		40	90

Table 5.1.69 - Carbon Footprint for 1 kg of farmed trout - Source www.LCAfood.dk

Product		Carbon Footprint gCO_2-eq/kg
Type of fish	Supply chain phase	
Trout	Fresh (at farm)	1,800
	Frozen fillet (at slaughterhouse)	4,090
	Frozen fillet (at retail)	4,470

Table 5.1.70 - Ecological Footprint for 1 kg of fish

Product	Ecological Footptint global m²/kg	Source
Fish	45 - 66	Chambers *et al* (2007)

No information is currently available regarding water consumption on the basis of the Water Footprint approach.

Beverages

The beverages examined were mineral water and wine.

Mineral water

The Water Footprint and Ecological Footprint values can be considered negligible. Table 5.1.71 summarizes the environmental indicators utilized for the environmental section of the Double Pyramid.

Table 5.1.71 - Indicators for 1 liter of water

MINERAL WATERS	Carbon Footprint	Water Footprint	Ecological Footprint
	gCO_2-eq/liter	liters/liter	global m²/liter
Data range	158	-	-
Average value	**200**[18]	-	-

Because mineral water processing is extremely simple (only bottling and distribution are involved), the main environmental impacts involved are those of producing the packaging and transport phase. For this reason, the only environmental indicator with significant values is the Carbon Footprint, the data for which is given in Table 5.1.72.

Table 5.1.72 - Carbon Footprint for 1 liter of water

Product	Carbon Footprint gCO_2-eq/liter	Source
Mineral water in disposable glass bottles	651	EPD Cerelia[19]
Mineral water in disposable PET bottles	157	EPD Cerelia[20]

Wine

The values for the three indicators for wine are from the literature and are given in Table 5.1.73.

Table 5.1.73 - Indicators for 1 liter of wine

Indicator	Unit of measure	Value	Source
Carbon Footprint	gCO_2-eq/liter	2,240	EPD Gasparossa[21]
Water Footprint	liters/liter	960	www.waterfooptrint.org
Ecological Footprint	global m²/liter	19	Living Planet Network for 2006 (from 2001 data)

18 *Data for water in PET was utilized because it is the most commonly available*
19 *Environmental Product Declaration, mineral water Cerelia packed in PET and glass bottles, http://www.environdec.com/reg/epd123it.pdf*
20 *Environmental Product Declaration, mineral water Cerelia packed in PET and glass bottles, http://www.environdec.com/reg/epd123it.pdf*
21 *Environmental Product Declaration, "Vino Frizzante Rosso imbottigliato Gambarossa Respighi", Rev, March 2008, http://www.environdec.com/reg/epd109it.pdf*

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5.2 Assumptions utilized for the cooking of foods

The environmental impact data presented to this point have always referred to foods on leaving industrial processes. The impacts related to the cooking required of the consumer (e.g., pasta, rice, meat) must therefore be added to the values presented.

Many of the foods analyzed may be eaten either raw or cooked. In addition, cooking can vary, depending on the recipe and personal tastes of the consumer. Given this, it was decided, on the one hand, to complete impact analysis by providing information regarding cooking, while on the other - given the virtual impossibility of providing data for every possible method - to utilize simplified assumptions for evaluation which, like the rest of the information provided in this report, have been based on easily-verifiable publicly-available data.

Clearly, this must be considered as preliminary information useful in quantifying impact orders of magnitude. Analysis of available literature led to the identification of two main sources, as given in Table 5.2.1.

Table 5.2.1 - Main sources for food cooking methods

Source	Type of information provided	Reference table	Utilization of data
Danish LCA food	Data for boiling, baking and broiling of some foods	5.2.2	Not utilized in the Pyramid
Forster *et al.*, 2006	Data for boiling, broiling, frying and microwave cooking per kg of food product	5.2.3	Utilized in the Pyramid

Table 5.2.2 - Environmental aspects associated with various types of cooking - Source: LCA food dk

Cooking method		Quantity	Energy consumed (kWh)	Comments
Boiling	Water	1 kg	0.18	Pan and electric burner
	Water	1 kg	0.12	Electric kettle
	Vegetables	1 kg	0.12 - 0.22	Pan and electric burner
	Pasta	250 g	0.24 - 0.5	Pre-cooked quantity. Cooked in pan on electric burner
	Rice	4 dl	0.24 - 0.5	Pre-cooked quantity. Cooked in pan on electric burner
	Frozen peas	500 g peas + 2 tbsp water	0.25	Cooked in microwave
	Frozen peas	500 g peas + 200 ml water	0.15	Cooked in pan on electric burner
	Fresh carrots	350 g carrots + 2 tbsp water	0.2	Cooked in microwave
Baking	Pizza	1 pc	0.1	200°C, 40 mins
	Cake	3,450 g batter	0.7 - 1.1	170°C, 60 mins
	Pre-heating oven	-	0.5	Conventional oven to 200°C
	Pre-heating oven	-	0.3	Convection oven to 200°C
	Maintain temperature at 200°C for 1 hr	-	0.5	Conventional oven
	Maintain temperature at 200°C for 1 hr	-	0.9	Convection oven
	Potatoes	4 lg potatoes	0.75	Combination of traditional/ microwave ovens
	Potatoes	4 lg potatoes	0.27	Microwave oven with broiler
Roasting	Meatballs	700 g	0.008	

From the two approaches identified, it was decided to utilize the one contained in the scientific paper of Forster et al. (Table 5.2.3) that considers the most widespread types cooking methods (boiling, frying, roasting, microwave) for kg of foods. Data contained in the Danish database are partial and referred only to some foods.

Tale 5.2.3 - Energy consumption for various cooking methods utilized in this study - Elaboration of publicly-available data: Forster et al. (2006). The values shown refer to 1 kg of food

Cooking method	Energy consumed (MJ)[22]	Carbon Footprint[23] [grams of CO_2 eq]	Ecological Footprint[24] [global m^2]
Boiling	3.5	420	5
Frying	7.5	900	12
Roasting	8.5	1,020	13
Microwave	0.34	59	1

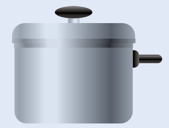
Finally, Table 5.2.4 shows for which foods it was decided to consider cooking, together with the cooking method selected. For reasons of simplification, microwave and frying were not applied to any of the foods.

Making two cups of tea using a saucepan, a kettle and a microwave oven

Analysing processes using "extended" as opposed to normal logical thinking - thus assessing the entire life cycle - sometimes produces results that are quite the opposite to what we might expect.

A typical example of this involves the preparation of food with microwave technology, which is one of the systems that consumes less energy, thus producing lower emissions of CO2.

To better illustrate this statement, let's take a simple example involving the making of two cups of tea, heating the water in a saucepan, in an electric kettle and in a microwave oven.

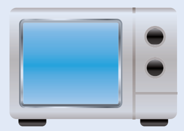


Saucepan

The boiling of half a litre of water in a saucepan using gas consumes approx. **0.49 kWh** (1.75 MJ), obtained by processing the data supplied by Forster *et al.* (2006).

Kettle

A 2400 Watt electric kettle takes around a minute and a half (i.e. 0.025 h) to bring half a litre of water to the boil (roughly two cups of tea). The relative energy consumption is obtained by multiplying the power consumed by the time for which the kettle is used: 2400 W * 0.025 h =60 Wh = **0.06 kWh** (0.216 MJ).



Microwave

The boiling of half a litre of water using a 1000 Watt microwave oven takes approx. one minute (i.e. 0.0167 h); using the same calculation method an energy consumption of approx. **0.02 kWh** (0,072 MJ) is obtained.

The resulting impact on the environment, in terms, for example, of Carbon Footprint, is roughly 116, 38 and 13 g of CO2 for the saucepan, kettle and microwave oven, respectively. In contrast with what we might normally think, the microwave oven generates a smaller impact than the other two technologies.

22 *It is assumed that 50% of the energy required is supplied by natural gas, and 50% by electrical power; the only exception is microwave cooking which is 100% electrical energy*

23 *This calculation utilized the Italian energy mix, the conversion factors for which were estimated at 174 g di CO_2 equivalent per MJ of electrical energy (620 g/kWh) and 66 g di CO_2 equivalent per MJ of natural gas*

24 *This calculation utilized data for the Italian energy mix, estimating CO_2 emissions to be 157 g per MJ of electrical energy and 54 per MJ of methane; these factors were transformed into Energy land using the conversion factors cited (2.77 global m2 per kg of CO_2)*

Table 5.2.4 - Foods analyzed in this study and the cooking method applied

Food category	Food		Food cooked by consumer		Comments/ Cooking method
			NO	YES	
Agricultural products	Fruits	All types	X		-
	Vegetables	Lettuce		X	Boiling
		Potatoes		X	Boiling
		Tomatoes		X	Boiling
	Legumes	All types		X	Boiling
Foods from processing of agricultural products	Pasta			X	Boiling
	Rice			X	Boiling
	Bread		X		-
	Sugar		X		-
	Sweets		X		-
	Condiments (oils)		X		-
	Wine		X		-
Foods derived from livestock	Poultry	All types		X	Roasting
	Beef	All types		X	Roasting
	Pork	All types		X	Roasting
	Cheese		X		-
	Milk		X		-
	Yoghurt		X		-
	Butter		X		-
	Eggs			X	Boiling
Foods from fishing	Wild fish	All types		X	Roasting
	Farmed fish	All types		X	Roasting
Beverages	Mineral water		X		-

5.3 When the impact of transport is relevant

In this study, transport was included in the data when already present in the system boundaries analyzed, without making further specific elaboration.

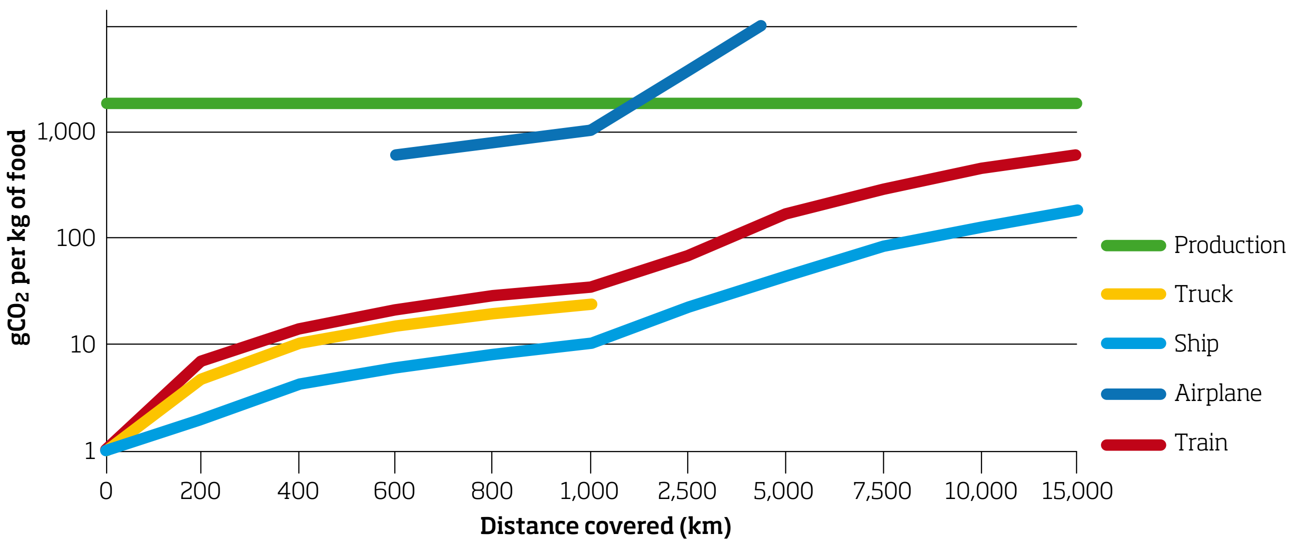
Regarding this, it was felt necessary that a more in-depth look from the standpoint of the Life Cycle Assessment be made; transport has a significant impact only when a certain distance is exceeded and only for products with a relatively low specific impact.

For example, the charts below offer the impact of road, sea and air transport for some foods.
As can be seen, the relevance of transport depends greatly on the means of transport utilized and, naturally, the specific impact of the food under consideration.
For hard wheat pasta, the overall impact on the product is only relevant if it is transported by air, while for fruit, road transport for over 500 km has a greater than 20% impact overall on greenhouse gas emissions.

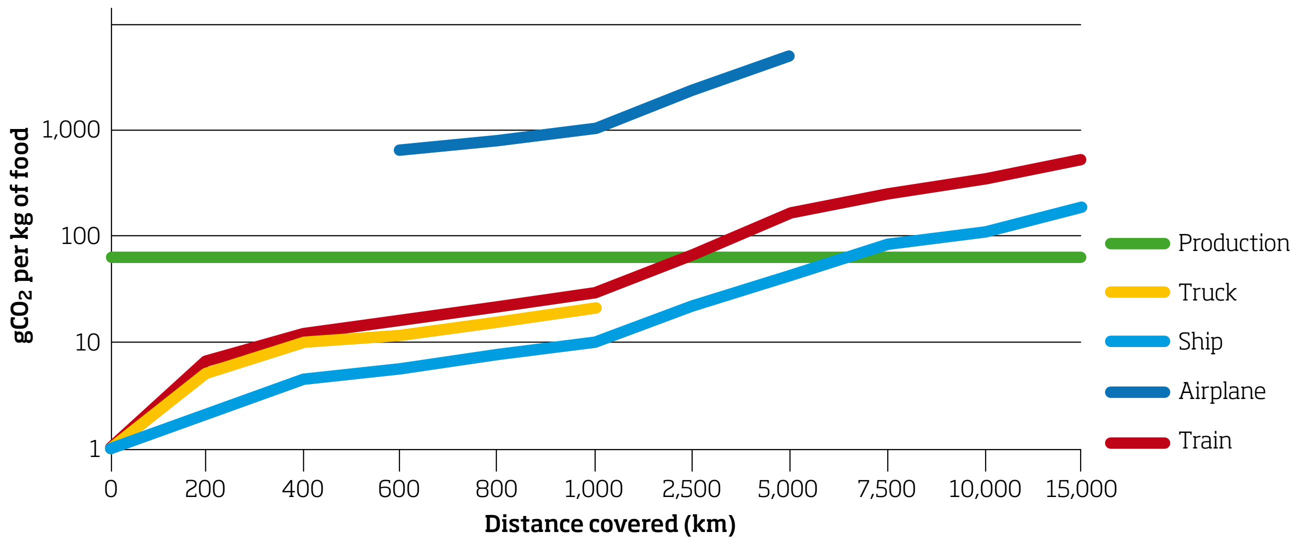
Analogously, in products with greater environmental impacts (meat, for example), transport has a much more limited effect on overall impacts.

Jason Edwards / National Geographic Image Collection

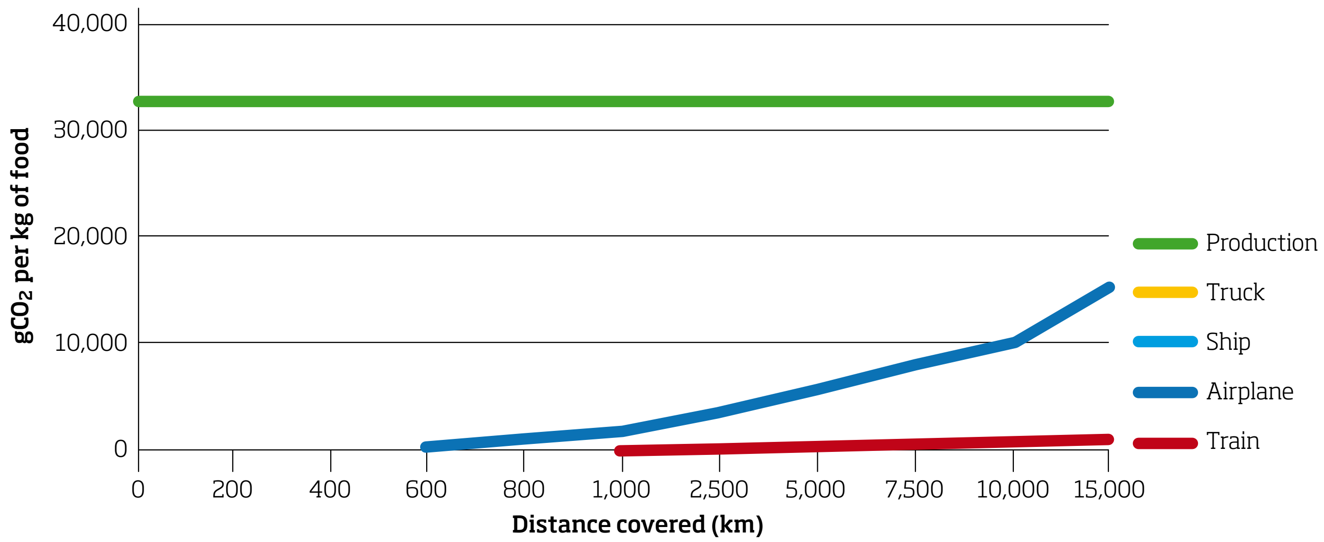
Relationship between the impacts for the production (and cooking) and transportation of pasta



Relationship between the impacts for the production and transportation of fruits



Relationship between the impacts for the production (and cooking) and transportation of beef



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6. Areas for further investigation in the subsequent edition

For every category examined, the values connected with each environmental indicator are given, taken from data banks and scientific studies.

High consumption of vegetables, legumes, fruits and nuts, olive oil and grains; moderate consumption of fish and dairy products (especially cheese and yoghurt) and wine; low consumption of meat provide a protective factor against the most widespread chronic diseases.

Gina Martin / National Geographic Image Collection

6. Areas for further investigation in the subsequent edition

The first edition of this study has been based on information currently-available to the public and elaborations made on the basis of simple and easily-verifiable assumptions.

Given the lively interest developing around these issues which we hope to encourage through this study, it is expected that new publications and the updating of data banks will create the need to update this paper in the future.

For this reason, in the sections which follow, it was decided to present guidelines for further study which we believe necessary to improve the quality of the work done to-date.

6.1 Broaden the statistical coverage of data and render LCA boundaries homogeneous

For the next revision of this study, further analyses must be done on the data in order to improve the qualitative value of the information presented, especially in terms of statistical coverage of the data – that is currently uneven for some foods – and improve the homogeneity of LCA boundaries and of the life cycle assessment assumptions.

The work to be developed will therefore be to increase the sampling of available data examining in detail those supply chains for which information is currently more limited.

For condiments, it should be noted that it involves a wide range of extremely varied products extending from vinegar (and all its varieties) to mayonnaise – products which are obviously very different from each other, both from a nutritional standpoint as well as the environmental aspects connected with them.

Another aspect which can certainly be considered relevant in calculating the environmental impacts in some foods is the influence of the geographical area in which they are produced.

At the time were not included cold cuts and condiments (except a few) because of the scarcity or absence of published studies in this regard.

Also on dairy products such as yoghurt and butter, studies are not available, so that when these foods were used in this work as an ingredient in some recipes had to make some assumptions set out clearly in the text.

6.2 Take into consideration geographical origin in evaluating impact

Another aspect which can certainly be considered relevant in calculating the environmental impacts in some foods is the influence of the geographical area in which they are produced. The geographical area affects energy-related aspects, as well as the calculation of the Water Footprint in terms of the component tied to evapotranspiration.

Influence of energy mixes

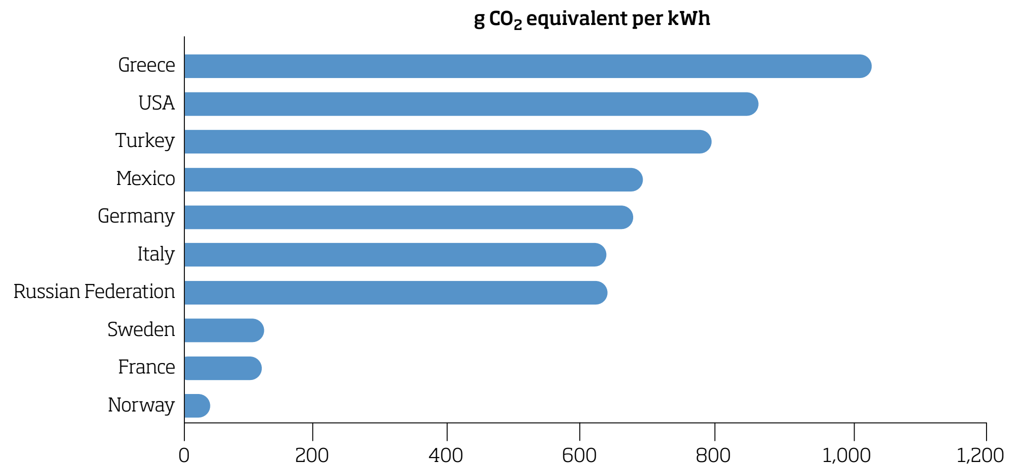
In terms of energy mixes, the most overwhelming aspect is connected to the production and use of electrical energy. The aspects to be taken into consideration are basically two:

- on the basis of the production energy mix for each Country, some industrial processes can be supplied with electrical energy from energy mixes that are very different from each other. An example of this are baked goods (bread, cookies), which in Northern Europe are normally supplied with electrical energy, while in Italy natural gas is used;
- the reference energy mix – in which renewable sources have an impact to a greater or lesser extent – has an influence on the calculation of greenhouse gas emissions and, consequently, a greater or lesser impact in terms of the Carbon Footprint and Ecological Footprint, with regard to the part connected with *Energy Land*, processes being equal.

This information should be taken into consideration in an in-depth supply chain evaluation in order not to confuse the comparison between the impacts of two manufacturers (for example, one in Sweden and one in Italy) with the comparison between two food products in general.

Figure 6.1. provides Carbon Footprint data for 1 kWh of electrical energy produced in some European and non-European Countries.

Figure 6.1 - Greenhouse gas emissions connected with the production of 1 kWh of electrical energy, including all phases from fuel extraction to energy distribution to the end-user.



Source: Data was elaborated by the working group on the basis of Ecoinvent and IEA information and refer to the 2008 energy mix.

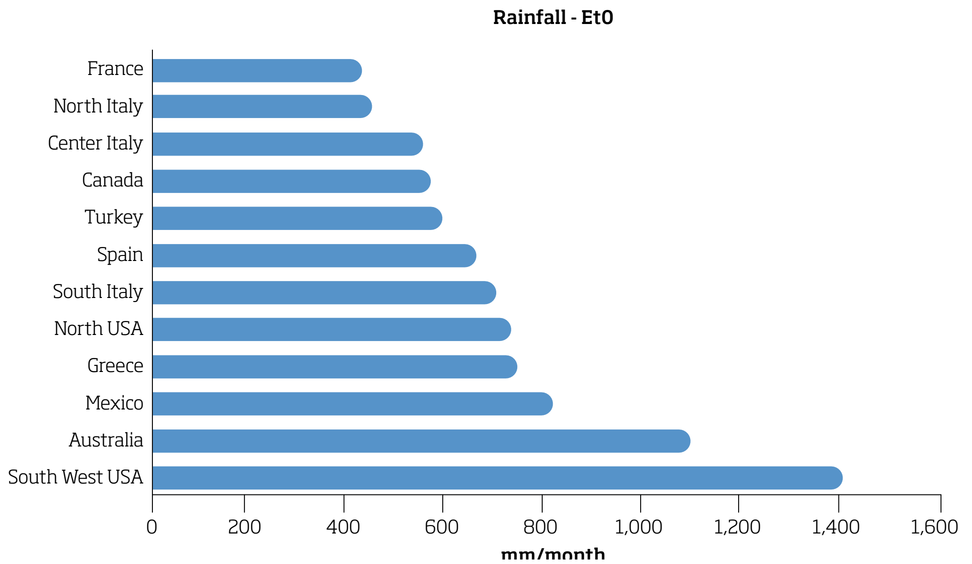
The influence of this information could be greater for those foods in which the use of electrical energy could be a significant environmental aspect within the overall supply chain, for example, pasta, baked goods or food products with a significant cold chain component.

Geographical influence on Water Footprint data

In calculating the Water Footprint, one of its components – green water – is closely dependent on geographical factors because it is calculated taking into consideration the Et0 factor that depends on the Region of the World in which the grain or plant that is the base of the food product is cultivated.

In this case, the influence of this variable is greater for crops that do not call for massive irrigation and in which, therefore, green water is the preponderant factor in calculating overall water consumption. To illustrate this, Figure 6.2 provides information regarding Et0 in different parts of the world where durum wheat is cultivated.

Figure 6.2 - Variations in EtO. Data are from Italy by: http://www.politicheagricole.it/ucea/Osservatorio/miekfyi01_index_zon.htm and other parts of the world: http://www.fao.org/nr/water/aquastat/gis/index3.stm



6.3 Evaluating the influence of food refrigeration and completing analysis of cooking methods

The food supply chain has two collateral processes involving product transport, preservation and consumption: the cold chain and cooking.

Cold chain

By cold chain is meant all those processes aimed at maintaining a product at a low temperature (4° C or even under 0° C) from the time it is produced until it is consumed. The estimate of the impacts for this phase, basically tied to energy consumption and therefore capable of influencing the Carbon Footprint and partially the Ecological Footprint, is actually very complex because it depends on many factors, the most significant of which are:

- the nature of the food product;
- the distance between where the product is made and where it is consumed.

In the first edition of this study, the cold chain was almost always ignored and, for this reason, the impact associated with some foods examined could represent an underestimate of the actual impact.

Without entering here into details of calculation for which it was felt opportune to wait for later investigation, the following points should be noted:

- cold-related processes are obviously more significant when foods requiring temperatures of under 0° C are involved, such as frozen foods, for example, which can have relatively long storage times at low temperatures;
- some foods which require the cold chain, for example milk and fresh products, have an expiration date very close to the date of production (just a few days), by which date the product must be consumed;
- fish, especially that caught in saltwater (i.e., caught on the open sea), could have a relatively long cold chain if the interval of time between the moment it is caught, its arrival in port, any processing required, transport, sale and consumption is taken into consideration.

Table 6.3.1 provides a qualitative estimate of the extent to which the cold chain could have an influence on the foods analyzed in this study.

Table 6.3.1 - Qualitative analysis of the influence of the cold chain on impacts (Carbon Footprint and Ecological Footprint) of foods analyzed

Food	Influence of the cold chain	Comments
Fruit and vegetables	Low	Could require refrigerated storage
Legumes	None	-
Pasta	None	-
Rice	None	-
Bread	None	-
Sugar	None	-
Oil	None	-
Desserts and Sweets	None	-
Cookies	None	-
Meat	Medium	Could require refrigerated storage and transport. Distances might not be short.
Eggs	Low	Could require refrigerated storage
Cheese	Low	Could require refrigerated storage
Yoghurt	Medium	Could require refrigerated storage and transport. Distances and time periods normally short.
Butter	Medium	Could require refrigerated storage and transport. Distances and time periods normally short.
Milk	Medium	Could require refrigerated storage and transport. Distances and time periods normally short.
Fish	High	Storage and transport under refrigeration or freezing temperatures could be required, including for long distances and for extended periods.

Cooking

In terms of cooking, required for consumption of some foods, this study took into consideration a number of very simplified assumptions involving only boiling or broiling. However, it should be noted that some foods could be subjected to more complex cooking methods, or at different levels, depending on individual consumer preferences. This is especially true for meat or fish.

Milk may be consumed cold or hot, and this could–to a limited extent–influence the Carbon and Ecological Footprint indicators related to CO_2 emissions.

Again here, further work for this study could include a more rigorous examination of the impacts associated with the cooking of different recipes in food production

6.4 Studying the question of the seasonal nature of agricultural products as a variable influencing impact

This study offers a preliminary look at the issue of seasonality of agricultural products, in essence fruit and vegetables.

Regarding this, an area for further impact analysis could be more rigorous study of the production chain of fruit and vegetable products, including comparing this with their actual seasonality, evaluating this and making consumers aware of how and to what extent the impacts can vary on the basis of their food choices.

Bibliography
by food product

B. Anthony Stewart / National Geographic Image Collection

Tomasz Tomaszewski / National Geographic Image Collection

Foods derived from agriculture

Apples

Indicator	Reference	Type	Unit of	System boundaries
Carbon Footprint	L. Milà i Canals, G.M. Burnip, S.J. Cowell, Evaluation of the environmental impacts of apple production using Life Cycle Assessment (LCA): Case study in New Zealand, Agriculture, Ecosystems and Environment 114 (2006) 226-238	Scientific publications	1 ton of cultivated apples, ready for storage and/or packing	Production of raw material (fertilizers and pesticides), field phase (apple cultivation)
Water Footprint	http://www.waterfootprint.org/?page=files/productgallery&product=apple	Database	1 apple (weight = 100 grams)	Information N.A.
Ecological Footprint	Global Footprint Network in reference to the Italian situation in 2001 (GFN - Italy 2001)	Certified publication	1 kg of apples	Information N.A.

Oranges and tangerines

Indicator	Reference	Type	Unit of	System boundaries
Carbon Footprint	Information N.A.			
Water Footprint	http://www.waterfootprint.org/?page=files/productgallery&product=orange	Database	1 orange (weight = 100 grams)	Information N.A.
Ecological Footprint	Global Footprint Network in reference to the Italian situation in 2001 (GFN - Italy 2001)	Database	1 kg of oranges or tangerines	Information N.A.

Lemons and limes

Indicator	Reference	Type	Unit of	System boundaries
Carbon Footprint	Information N.A.			
Water Footprint	Information N.A.			
Ecological Footprint	Global Footprint Network in reference to the Italian situation in 2001 (GFN - Italy 2001)	Database	1 kg of lemons or limes	Information N.A.

Bananas

Indicator	Reference	Type	Unit of	System boundaries
Carbon Footprint	Information N.A.			
Water Footprint	Information N.A.			
Ecological Footprint	Global Footprint Network in reference to the Italian situation in 2001 (GFN - Italy 2001)	Database	1 kg of bananas	Information N.A.

Grapes

Indicator	Reference	Type	Unit of analysis	System boundaries
Carbon Footprint	Information N.A.			
Water Footprint	Information N.A.			
Ecological Footprint	Global Footprint Network in reference to the Italian situation in 2001 (GFN - Italy 2001)	Database	1 kg of grapes	Information N.A.

Fava beans

Indicator	Reference	Type	Unit of analysis	System boundaries
Carbon Footprint	Ecoinvent 2004 (www.ecoinvent.ch)	Database	1 kg of fava beans	Production of raw material (fertilizers and pesticides), field phase (fava bean cultivation)
Water Footprint	Information N.A.			
Ecological Footprint	Ecoinvent 2004 (www.ecoinvent.ch)	Database	1 kg of fava beans	Production of raw material (fertilizers and pesticides), field phase (fava bean cultivation)

Peas

Indicator	Reference	Type	Unit of analysis	System boundaries
Carbon Footprint	Ecoinvent 2004 (www.ecoinvent.ch)	Database	1 kg of peas	Production of raw material (fertilizers and pesticides), field phase (pea cultivation) and transport to regional processing centers (distance 10 km)
Water Footprint	Information N.A.			
Ecological Footprint	Global Footprint Network in reference to the Italian situation in 2001 (GFN - Italy 2001)	Database	1 kg of peas	Information N.A.
	Ecoinvent 2004 (www.ecoinvent.ch)	Database	1 kg of peas	Production of raw material (fertilizers and pesticides), field phase (pea cultivation) and transport to regional processing centers (distance 10 km)

Soybeans

Indicator	Reference	Type	Unit of analysis	System boundaries
Carbon Footprint	Ecoinvent 2004 (www.ecoinvent.ch)	Database	1 kg of soybeans	Cultivation of soybeans in Brazil, including diesel consumption and use of equipment, fertilizers and pesticides
Water Footprint	http://www.waterfootprint.org/?page=files/productgallery&product=soybeans	Database	1 kg of soybeans	Information N.A.
Ecological Footprint	Ecoinvent 2004 (www.ecoinvent.ch)	Database	1 kg of soybeans	Cultivation of soybeans in Brazil, including diesel consumption and use of equipment, fertilizers and pesticides

Lettuce

Indicator	Reference	Type	Unit of analysis	System boundaries
Carbon Footprint	Hospido A., Milà i Canals, McLaren, Truninger, Edwards-Jones, Clift, 2009, The role of seasonality in lettuce consumption: a case study of environmental and social aspects, International Journal of LCA (14) pp. 381-391	Scientific publications	1 kg of lettuce	Production of raw material (fertilizers and pesticides), field phase (lettuce cultivation) and transport to regional distribution center
				Production of raw material (fertilizers and pesticides), field phase (lettuce cultivation from seed) and transport to regional distribution center
Water Footprint	Information N.A.			
Ecological Footprint	Information N.A.			

Tomatoes

Indicator	Reference	Type	Unit of analysis	System boundaries
Carbon Footprint	Andersson K., 2000, LCA of Food Products and Production Systems, International Journal of LCA 5 (4) pp. 239 - 248	Scientific publications	1000 kg of ketchup consumed	Field phase (tomato cultivation), transport and processing, consumption phase
	LCA Food (www.LCAfood.dk)	Database	1 kg of tomatoes	Production of raw material (fertilizers and pesticides), field phase (tomato cultivation)
Water Footprint	Information N.A.			
Ecological Footprint	Global Footprint Network in reference to the Italian situation in 2001 (GFN - Italy 2001)	Database	1 kg of tomatoes	Information N.A.

Onions

Indicator	Reference	Type	Unit of analysis	System boundaries
Carbon Footprint	Information N.A.			
Water Footprint	Information N.A.			
Ecological Footprint	Global Footprint Network in reference to the Italian situation in 2001 (GFN - Italy 2001)	Database	1 kg of onions	Information N.A.

Potatoes

Indicator	Reference	Type	Unit of analysis	System boundaries
Carbon Footprint	LCA Food (www.LCAfood.dk)	Database	1 kg of potatoes at field	Production of raw material (fertilizers and pesticides), field phase (potato cultivation)
			1 kg of potatoes at retail	Production of raw material (fertilizers and pesticides), field phase (potato cultivation) transport to retail point-of-sale
Water Footprint	http://www.waterfootprint.org/?page=files/productgallery&product=potato	Database	1 kg of potatoes	Information N.A.
Ecological Footprint	Global Footprint Network in reference to the Italian situation in 2001 (GFN - Italy 2001)	Database	1 kg of potatoes	Information N.A.
	Ecoinvent 2004 (www.ecoinvent.ch)	Database	1 kg of potatoes	Production of raw material (fertilizers and pesticides), field phase (potato cultivation) and transport to farm (distance 1 km)

Foods derived from processing of agricultural products

Pasta

Indicator	Reference	Type	Unit of analysis	System boundaries
Carbon Footprint	Barilla, Product Environmental Declaration applied to dried durum wheat pasta produced in Italy and packed in a cardboard box. Revision: 1 - Valid on year from approval, Pre-certified Product Environmental Declaration - Registered Number: S-EP-00039, Data of approval: 19/08/2009	Certified publication	1 kg dried durum wheat pasta	Wheat cultivation, flour production, pasta production, transport of raw material and products to distribution centers
Water Footprint				
Ecological Footprint				

Rice

Indicator	Reference	Type	Unit of analysis	System boundaries
Carbon Footprint	Blengini GA, Busto M., 2008, The life cycle of rice: LCA of alternative agri-food chain management systems in Vercelli (Italy), Journal of Environmental Management pp. 1512-1522, Vol. 90(3)	Scientific publications	1 kg of rice	Production of raw material (fertilizers and pesticides), field phase (rice cultivation), milling, transport to retail point-of-sale
	Ecoinvent 2004 (www.ecoinvent.ch)	Database	1 kg of rice	Production of raw material (fertilizers and pesticides), field phase (rice cultivation and harvest)
Water Footprint	http://www.waterfootprint.org/?page=files/productgallery&product=rice	Database	1 kg of rice	Information N.A.
Ecological Footprint	Global Footprint Network in reference to the Italian situation in 2001 (GFN - Italy 2001)	Database	1 kg of rice	Information N.A.
	Ecoinvent 2004 (www.ecoinvent.ch)	Database	1 kg of rice	Production of raw material (fertilizers and pesticides), field phase (rice cultivation and harvest)

Bread

Indicator	Reference	Type	Unit of analysis	System boundaries
Carbon Footprint	LCA Food (www.LCAfood.dk)	Database	1 kg fresh loaf	Wheat cultivation, flour production, bread production
				Wheat cultivation, flour production, bread production, transport to retail point-of-sale
			1 kg frozen loaf	Wheat cultivation, flour production, bread production
				Wheat cultivation, flour production, bread production, transport to retail point-of-sale
			1 kg wheat bread (fresh)	Wheat cultivation, flour production, bread production
				Wheat cultivation, flour production, bread production, transport to retail point-of-sale
			1 kg wheat bread (fresh)	Wheat cultivation, flour production, bread production
				Wheat cultivation, flour production, bread production, transport to retail point-of-sale
			1 kg wheat bread (frozen)	Wheat cultivation, flour production, bread production
				Wheat cultivation, flour production, bread production, transport to retail point-of-sale
	Andersson K., Ohlsson T., 1999, Life Cycle Assessment of Bread Produced on Different Scales, International Journal of LCA, 4 (1) 25-40	Scientific publications	1 kg of bread	Wheat cultivation, flour production, bread production (industrial, local and homemade)
Water Footprint	http://www.waterfootprint.org/?page=files/	Database	1 kg of bread	Information N.A.
Ecological Footprint	Elaborated by the working group	-	1 kg of bread	Wheat cultivation, flour production, bread production

Beet sugar

Indicator	Reference	Type	Unit of analysis	System boundaries
Carbon Footprint	LCA Food (http://www.LCAfood.dk/products/crops/sugar.htm)	Database	1 kg of beet sugar	Information N.A.
	Ecoinvent 2004 (www.ecoinvent.ch)	Database		Cultivation and transport of beets to refinery for processing into sugar (packaging not included)
Water Footprint	Information N.A.			
Ecological Footprint	Global Footprint Network in reference to the Italian situation in 2001 (GFN - Italy 2001)	Database	1 kg of beet sugar	Information N.A.
	Ecoinvent 2004 (www.ecoinvent.ch)	Database		Cultivation and transport of beets to refinery for processing into sugar (packaging not included)

Cane sugar

Indicator	Reference	Type	Unit of analysis	System boundaries
Carbon Footprint	Ramjeawon T., 2004, Life Cycle Assessment of Cane-Sugar on the Island of Mauritius, International Journal of LCA 9 (4) pp. 254 - 260	Scientific publications	1 t of cane sugar, exported	Production of raw material (fertilizers and pesticides), field phase (sugar cane cultivation and harvest), refining and production of sugar
	Ecoinvent 2004 (www.ecoinvent.ch)	Database	1 kg of cane sugar	Cultivation and transport of sugar cane to refinery for processing into sugar (packaging not included)
Water Footprint	http://www.waterfootprint.org/?page=files/productgallery&product=sugar	Database	1 kg of cane sugar	Information N.A.
Ecological Footprint	Global Footprint Network in reference to the Italian situation in 2001 (GFN - Italy 2001)	Database	1 kg of cane sugar	Information N.A.
	Ecoinvent 2004 (www.ecoinvent.ch)			Cultivation and transport of sugar cane to refinery for processing into sugar (packaging not included)

Olive oil

Indicator	Reference	Type	Unit of analysis	System boundaries
Carbon Footprint	Avraamides M., Fatta D., 2008, Resource consumption and emissions from olive oil production: a life cycle inventory case study in Cyprus, Journal of Cleaner Production 16 pp. 809-821	Scientific publications	1 l of extra virgin olive oil	Production of raw material (fertilizers and pesticides), field phase (olive cultivation and harvest), oil production and waste management
Water Footprint	Elaborated by the working group	-	1 l of olive oil	Olive cultivation and oil production
Ecological Footprint	Elaborated by the working group	-	1 l of olive oil	Olive cultivation and oil production

Palm oil

Indicator	Reference	Type	Unit of analysis	System boundaries
Carbon Footprint	Yusoff S. and Hansen SB., 2007, Feasibility Study of Performing an Life Cycle Assessment on Crude Palm Oil Production in Malaysia, International Journal of LCA 12 (1) pp 50 - 58	Scientific publications	1,000 kg of raw palm oil	Production of raw material (fertilizers and pesticides), field phase (cultivation and harvest), transport (final oil refining not included)
Water Footprint	Information N.A.			
Ecological Footprint	Information N.A.			

Vegetable oil (soybean and rapeseed oil)

Indicator	Reference	Type	Unit of analysis	System boundaries
Carbon Footprint	LCA Food (www.LCAfood.dk)	Database	1 l of vegetable oil	
Water Footprint	Information N.A.			
Ecological Footprint	Information N.A.			

Sweets

Indicator	Reference	Type	Unit of analysis	System boundaries
Carbon Footprint	Elaborated by the working group	-	1 kg of cake	Field phase (for raw materials), batter preparation and cooking (homemade)
Water Footprint				
Ecological Footprint				

Biscuits

Indicator	Reference	Type	Unit of analysis	System boundaries
Carbon Footprint	Elaborated by the working group	-	1 kg of cookies	Field phase (for raw materials), dough preparation and cooking
Water Footprint				
Ecological Footprint				

Foods derived from animal husbandry

Beef (red meat)

Indicator	Reference	Type	Unit of analysis	System boundaries
Carbon Footprint	LCA Food (www.LCAfood.dk)	Database	1 kg of tenderloin	Raising and butchering
				Raising, butchering, transport and retail sale
			1 kg of fillet	Raising, butchering, transport and retail sale
			1 kg of top round*	Raising, butchering, transport and retail sale
			1 kg of steak*	Raising, butchering, transport and retail sale
			1 kg of fore-end*	Raising, butchering, transport and retail sale
			1 kg of outside*	Raising, butchering, transport and retail sale
			1 kg of flank steak*	Raising, butchering, transport and retail sale
			1 kg of round	Raising and butchering
				Raising, butchering, transport and retail sale
			1 kg of minced meat	Raising and butchering
				Raising, butchering, transport and retail sale
		Database	1 kg of knuckle shank	Raising and butchering
				Raising, butchering, transport and retail sale
	Ogino, A et al., 2007, Evaluating Environmental Impacts of the Japanese beef cow-calf system by the life cycle assessment method, Animal Science Journal 78, pp. 424-432	Scientific publications	1 beef calf *(ready for butchering)*	Birth of calf, fattening, raising (cradle to gate)

Indicator	Reference	Type	Unit of analysis	System boundaries
	Casey, J.W. & Holden, N.M., 2006a, Quantification of GHG emissions from suckler-beef production in Ireland, Agricultural Systems 90, 79-98 Casey, J.W. & Holden, N.M., 2006b, GHG emissions from conventional, agri-environmental and organic Irish suckler beef units, Journal of Environmental Quality 35, 231-239	Scientific publications	1 kg of meat	Birth of calf, fattening, raising (cradle to gate)
	Williams, A.G., Audsley, E & Sanders, D.L., 2006, Determining the environmental burdens and resource use in the production of agricultural and horticultural commodities, Main Report, Defra Research project IS0205, Bedford: Cranfield University and Defra, available at www.silsoe.cranfield.ac.uk University and Defra, available at www.silsoe.cranfield.ac.uk	Scientific publications	1 t of meat *(dead weight)*	Birth of calf, fattening, raising (cradle to gate)
				Birth of calf (100% suckled by cow), fattening, raising (cradle to gate)
	Verge, XCP et al., 2008, Greenhouse gas emissions from the Canadian beef industry, Agricultural Systems 98, 126-134	Scientific publications	1 kg of meat	Birth of calf, fattening, raising
	Cederberg C., Meyer, D. & Flysjö, A., 2009a, Life Cycle Inventory of greenhouse gas emissions and use of land and energy of Brazilian beef exported to Europe, SIK-Rapport 792, SIK - Institutet för Livsmedel och Bioteknik, Göteborg, ISBN 978-91-7290-283-1			Fattening, raising (butchering not included)
	Cederberg C., Sonesson, U., Davis, J. & Sund, V., 2009b, Greenhouse gas emissions from production of meat, milk and eggs in Sweden 1990 and 2005, SIK-Rapport 793, SIK - Institutet för Livsmedel och Bioteknik, Göteborg, ISBN 978-91-7290-284-8			Birth of calf, fattening, raising, butchering, transport and retail sale
	Cederberg C. & Darelius, K., 2000, Livscykelanalys (LCA) av nötkött - en studie av olika produktionsformer (Life Cycle Assessment (LCA) of beef - a study of different production forms, in Swedish), Naturresursforum, Landstinget Halland, Halmstad			Fattening, raising (to gate)
	Cederberg C. and Stadig M., 2003, System Expansion and Allocation in Life Cycle Assessment of Milk and Beef Production, International Journal of LCA 8 (6) pp. 350 -356			Birth of calf, fattening, raising (cradle to gate)
Water Footprint	http://www.waterfootprint.org/?page=files/productgallery&product=beef	Database	1 kg of meat	Information N.A.
Ecological Footprint	Bagliani M., Carechino M., Martini F., 2009, La contabilità ambientale applicata alla produzione zootecnica, l'impronta ecologica dell'allevamento di bovini di razza piemontese, IRES (Istituto Ricerche Economico Sociali del Piemonte), Regione Piemonte, Collana ambiente 29	Scientific publications	1 kg of meat	Birth of calf, fattening, raising

** The CF value for 1 kg of this type of meat is the same ex-slaughterhouse and ex-retail*

Pork (red meat)

Indicator	Reference	Type	Unit of analysis	System boundaries
Carbon Footprint	LCA Food (www.LCAfood.dk)	Database	1 kg of tenderloin	Raising and butchering
				Raising, butchering, transport and retail sale
			1 kg of ham and bacon	Raising and butchering
				Raising, butchering, transport and retail sale
			1 kg of minced meat	Raising and butchering
				Raising, butchering, transport and retail sale
	Williams, A.G., Audsley, E & Sanders, D.L., 2006, Determining the environmental burdens and resource use in the production of agricultural and horticultural commodities, Main Report, Defra Research project IS0205, Bedford: Cranfield University and Defra, available at www.silsoe.cranfield.ac.uk	Scientific publications	1 t of meat *(dead weight)*	Birth of pig, fattening, raising (cradle to gate)
	Basset-Mens, C. & van der Werf, H., 2003 , Scenario-based environmental assessment of farming systems - the case of pig production in France, Agriculture, Ecosystems and Environment (105), pp. 127-144		1 kg of meat	Birth of calf, fattening, raising
	Cederberg C. & Flysjö A., 2004, Environmental assessment of future pig farming systems - quantification of three scenarios from the FOOD 21 synthesis work, SIK Report 723, SIK - The Swedish Institute for Food and Biotechnology, Göteborg, ISBN91-7290-236-1			Birth of pig, fattening, raising and butchering
	Eriksson S., Elmquist H., Stern S. & Nybrant T., 2005, Environmental systems analysis of pig production - The impact of feed choice, International Journal of LCA 10 (2) pp. 143-154	Scientific publications	1 kg of meat	Birth of pig, fattening, raising
	Cederberg C., Sonesson, U., Davis, J. & Sund, V., 2009b, Greenhouse gas emissions from production of meat, milk and eggs in Sweden 1990 and 2005, SIK-Rapport 793, SIK - Institutet för Livsmedel och Bioteknik, Göteborg, ISBN 978-91-7290-284-8			Birth of pig, fattening, raising, butchering, transport and retail sale
Water Footprint	http://www.waterfootprint.org/?page=files/productgallery&product=pork	Database	1 kg of meat	Information N.A.
Ecological Footprint	Global Footprint Network in reference to the Italian situation in 2001 (GFN - Italy 2001)	Database	1 kg of meat	Information N.A.

Poultry (white meat)

Indicator	Reference	Type	Unit of analysis	System boundaries
Carbon Footprint	LCA Food (www.LCAfood.dk)	Database	1 kg of fresh chicken	Raising and butchering
				Raising, butchering, transport and retail sale
			1 kg of frozen chicken	Raising and butchering
				Raising, butchering, transport and retail sale
	Tynelius, G., 2008, Klimatpåverkan och förbättringsåtgärder för Lantmännens livsmedel- fallstudie Kronfågels slaktkyckling (Climate Impact and Improvement potentials for Lantmännen's chicken, in Swedish), Masters Thesis 2008, Dept. of Technology and Society, Environmental and Energy Systems Studies, Lund University, Lund, Sweden	Scientific publications	1 kg of meat	Raising, fattening and butchering
	Pelletier N., 2008, Environmental performance in the US poultry sector: Life cycle energy use and greenhouse gas, ozone depleting, acidifying and eutrophying emissions, Agricultural Systems 98, pp. 67-73	Scientific publications	1 t of chicken (live weight)	Chicken hatching, fattening, raising (cradle to gate)
	Cederberg C., Sonesson, U., Davis, J. & Sund, V., 2009b, Greenhouse gas emissions from production of meat, milk and eggs in Sweden 1990 and 2005, SIK-Rapport 793, SIK - Institutet för Livsmedel och Bioteknik, Göteborg, ISBN 978-91-7290-284-8	Scientific publications	1 kg of meat	Chicken hatching, fattening, raising, butchering, transport and retail sale
	Williams, A.G., Audsley, E & Sanders, D.L., 2006, Determining the environmental burdens and resource use in the production of agricultural and horticultural commodities,	Scientific publications	1 kg of meat	Chicken hatching, fattening, raising (traditional raising)
				Chicken hatching, fattening, raising (free-range)
Water Footprint	http://www.waterfootprint.org/?page=files/productgallery&product=chicken	Database	1 kg of meat	Information N.A.
Ecological Footprint	Global Footprint Network in reference to the Italian situation in 2001 (GFN - Italy 2001)	Database	1 kg of meat	Information N.A.

Cheese

Indicator	Reference	Type	Unit of analysis	System boundaries
Carbon Footprint	Berlin J., Environmental life cycle assessment (LCA) of Swedish semi-hard cheese , International Dairy Journal 12 (2002) pp. 939-953	-	1 kg of semi-hard cheese (plastic-wrapped)	Extraction of raw materials and ingredients required to product cheese, up through waste management
Water Footprint	http://www.waterfootprint.org/?page=files/productgallery&product=cheese	-	1 kg of cheese	Information N.A.
Ecological Footprint	Elaborated by the working group	-	1 kg of cheese	Boundaries same as those for milk

Milk

Indicator	Reference	Type	Unit of analysis	System boundaries
Carbon Footprint	Granarolo, Dichiarazione ambientale di prodotto per il latte fresco pastorizzato di alta qualità confezionato in bottiglia di PET, revisione 0 del 9/3/2007, Certificazione N. S-EP 00118	Certified publication	1 l of milk	Milk production on the farm, packaging production, pasteurization/packaging and transport to end-sites
	Cederberg C. and Stadig M., 2003, System Expansion and Allocation in Life Cycle Assessment of Milk and Beef Production, International Journal of LCA 8 (6) pp. 350 -356	Scientific publications		Raising of milk cows, milking
	Williams, A.G., Audsley, E & Sanders, D.L., 2006, Determining the environmental burdens and resource use in the production of agricultural and horticultural commodities, Main Report, Defra Research project IS0205, Bedford: Cranfield University and Defra, available at www.silsoe.cranfield.ac.uk	Scientific publications	10,000 l of milk	Raising of milk cows, milking
Water Footprint	http://www.waterfootprint.org/?page=files/productgallery&product=milk	Database	1 l of milk	Information N.A.
Ecological Footprint	Chambers N., Simmons C., Wackernagel M., Sharing Nature's Interest, Ecological Footprints as an indicator of sustainability, Earthscan, 2007, chapter 5, pp.79 - 105	Scientific publications	1 l of milk	Milk production on the farm, product processing and transport

Eggs

Indicator	Reference	Type	Unit of analysis	System boundaries
Carbon Footprint	Dekker S.E.M., de Boer I.J.M., Aarnink A.J.A. and P.W.G. Groot Koerkamp, Environmental hotspot identification of organic egg production, Farm Technology Engineering Group, Animal Production Systems Group, Animal Sciences Group, Wageningen University and Research Centre. Sanne.Dekker@wur.nl (from: "Proceedings of the 6th Int. Conf. on LCA in the Agri-Food Sector, Zurich, November 12-14, 2008", pp 371-380)	Scientific publications	1 kg of organic eggs	Field phase (raw materials required for rations), raising of hens (including brooding of eggs for reproduction)
	Williams, A.G., Audsley, E & Sanders, D.L., 2006, Determining the environmental burdens and resource use in the production of agricultural and horticultural commodities, Main Report, Defra Research project IS0205, Bedford: Cranfield University and Defra, available at www.silsoe.cranfield.ac.uk	Scientific publications	20,000 eggs	Field phase (raw materials required for rations), non-organic raising of hens
				Field phase (raw materials required for rations), organic raising of hens
Water Footprint	http://www.waterfootprint.org/?page=files/productgallery&product=eggs	Database	1 kg of eggs	Information N.A.
Ecological Footprint	Elaborated by the working group	-	1 kg of eggs	Field phase (raw materials required for rations), non-organic raising of hens

Foods from fishing

Indicator	Reference	Type	Unit of analysis	System boundaries
Carbon Footprint	LCA Food (www.LCAfood.dk)	Database	1 kg of fresh cod	Fishing only (at harbor)
				Fishing and retail sale
			1 kg of cod fillet	Fishing only (at harbor)
				Fishing and retail sale
			1 kg of frozen cod	Fishing only (at harbor)
				Fishing and retail sale
			1 kg of fresh sole	Fishing only (at harbor)
				Fishing and retail sale
			1 kg of sole fillet	Fishing only (at harbor)
				Fishing and retail sale
			1 kg of frozen sole	Fishing only (at harbor)
				Fishing and retail sale

Fish

Indicator	Reference	Type	Unit of analysis	System boundaries
Carbon Footprint	LCA Food (www.LCAfood.dk)	Database	1 kg of fresh herring	Fishing only (at harbor)
				Fishing and retail sale
			1 kg of herring fillet	Fishing only (at harbor)
				Fishing and retail sale
			1 kg of frozen herring	Fishing only (at harbor)
				Fishing and retail sale
			1 kg of fresh mackerel	Fishing only (at harbor)
				Fishing and retail sale
			1 kg of mackerel fillet	Fishing only (at harbor)
				Fishing and retail sale
			1 kg of frozen mackerel	Fishing only (at harbor)
				Fishing and retail sale
			1 kg of industrial fish	Fishing only (at harbor)
			1 kg of lobster	Fishing only (at harbor)
				Fishing and retail sale
			1 kg of fresh shrimp	Fishing only (at harbor)
				Fishing and retail sale
			1 kg of peeled/ frozen shrimp	Fishing only (at harbor)
				Fishing and retail sale
			1 kg of mussels	Fishing only (at harbor)
				Fishing and retail sale
			1 kg of fresh trout (farmed)	Fishing only (at farm)
			1 kg of trout fillet (farmed)	Fishing, slaughter (at slaughterhouse)
			1 kg of frozen trout (farmed)	Fishing, slaughter and retail sale
Water Footprint	Information N.A.			
Ecological Footprint	Chambers N., Simmons C., Wackernagel M., Sharing Nature's Interest, Ecological Footprints as an indicator of sustainability, Earthscan, 2007, chapter 5, pp.79 - 105	Scientific publications	1 kg of fish	Information N.A.

Beverages

Water

Indicator	Reference	Type	Unit of analysis	System boundaries
Carbon Footprint	Cerelia, EPD Cerelia natural mineral water, bottled in: PET da 1,5l and glass - 1l, Rev.0 - Data: 30/07/2008, Registration N°: S-P-00123	Certified publication	1000 l of water	Production phase (water extraction, bottle preparation, packaging and warehousing) and utilization phase (distribution and consumption)
Water Footprint	Information N.A.			
Ecological Footprint	Information N.A.			

Wine

Indicator	Reference	Type	Unit of analysis	System boundaries
Carbon Footprint	Consorzio Interprovinciale vini (C.I.V), EPD, Sparkling red wine biological Lambrusco Grasparossa "Fratello Sole", Rev. Marzo 2008, N° Registration: S-P-00119	Certified publication	1 l of sparkling red wine	Production phase (vineyard activities, pressing, 1st/2nd vinification, bottling) and utilization phase (distribution and product use)
Water Footprint	http://www.waterfootprint.org/?page=files/productgallery&product=wine	Database	1 l of wine	Information N.A.
Ecological Footprint	WWF, Global Footprint Network, Zoological Society of London, "Living Planet Report 2008", WWF (2008)	Database	1 l of wine	Information N.A.

Appendix

James A. Sugar / National Geographic Image Collection

Marc Moritsch / National Geographic Image Collection

A.1 Calculation of the environmental impacts associated with the production of baked goods

This appendix provides the detailed assumptions pertaining to the analysis of the life cycle of two types of baked goods:

- Paradise Cake;
- Healthy cookies.

Paradise Cake

The recipe for this cake was taken from the cookbook entitled "Il Carnacina", published by Garzanti (edition 1961), edited by Luigi Veronelli: Paradise Cake no. 2176.

2176. PARADISE CAKE

Serves for 6 persons

250 gr. softened butter, kneaded by hand inside a cloth
240 gr. powdered sugar and 15 gr. vanilla-flavored sugar, mixed
110 gr. potato starch
The grated peel of ½ lemon
5 yolks and 3 whole eggs
125 gr. sifted flour
10 gr. baking powder
Extra butter, flour and vanilla-flavored sugar

Place the softened butter in a heated and thoroughly dried bowl, beat with a whisk until creamy and add the sugar mixed with vanilla-flavored sugar. As soon as it is creamy, add 10 gr. starch and the lemon peel and whisk to obtain a smooth, uniform batter. Beat in the yolks, then, still beating, add the whole eggs and continue beating energetically for about ten minutes. Sift the flour with the 100 gr. of starch remaining, add the baking powder, blend and sift again. Still beating, add the flour to the batter, sprinkling it slowly in so that it does not form any lumps. Butter a low, wide cake pan and dust with flour. Pour in the batter and bake in a moderate oven. Remove the cake from the oven when done and cool in the pan. Before serving the cake, sprinkle with the vanilla-flavored sugar.

Unit of analysis

The unit of reference is 1 kg of finished cake (after baking).

System boundaries and main assumptions

The system boundaries include the following phases:

- production of raw materials;
- preparation and baking of the cake in an oven (typical household oven).

The phase of creating the batter has not been included because it was presumed to be done by hand without involving the consumption of raw materials and energy. Moreover, it is assumed that the batter undergoes a 15% moisture loss following oven baking.

Analysis of ingredients

The ingredients that, in the recipe shown in table A.1, amount to less than 1% have not been included.

These tables also provide the source of the data for each ingredient used for the calculation of the Carbon Footprint.

Used, respectively, for the Water Footprint and Ecological Footprint, was the information found on the website www.waterfootprint.org and information derived from elaboration of the Global Footprint Network (Italy 2001) database.

Table A.1 - Ingredients associated with the produciton of 1 kg of Paradise Cake

Ingredient	Unit of	Value	Percentage of recipe (%)	Data source	Assumptions
Butter	kg	0,28	24%	Busser & Jungbluth (2009)	Considered to have an impact analogous to that of cheese
Sugar	kg	0,269	23%	Ecoinvent 2004	-
Vanilla-flavored sugar	kg	0,017	1%	Ecoinvent 2004	Considered equivalent to beet sugar
potato starch	kg	0,123	10%	Paragraph 5.1	Considered equivalent to potatoes
Eggs	kg	0,336	29%	Dekker et al.	Weight of 1 egg = 60 grams
Flour	kg	0,14	12%	confidential primary data	Working group elaborations
Baking powder	kg	0,011	1%	-	Negligible

Data for oven baking were taken from the Danish data bank (LCA food DK) and are given in Table A.2.

Table A.2 - Energy consumption associated with 1 kg of cake batter (cook for 1 hour at 170° C)

Energy source	Unit of	Q.ty for batter	Source	Assumptions
Electrical power	kWh	0,261	Elaborations in table 5.2.2 of this document	-

Results

The results for 1 kg of cake are given in Table A.3.

Table A.3 - Indicators for the production of 1 kg of cake

"Sweet: Paradise Cake ("Il Carnacina" Cookbook recipe no. 2176)"	Carbon Footprint	Water Footprint	Ecological Footprint
	gCO_2-eq/kg	Liters/kg	global m²/Kg
Data range	3.700	3.100	30

Healthy biscuits

The recipe for this cake was taken from the "Pellegrino Artusi" recipe book: healthy buiscuits no. 573 downloadable from the www.pellegrinoartusi.it web site

Unit of analysis

The reference quantity is 1 kg of buiscuits (after baking).

System boundaries and main assumptions

The system boundaries include the following phases:

- Production of raw materials;
- Preparation and baking of the cookies in an oven (typical household oven).

The phase of creating the dough has not been included because it was assumed that it was done by hand without involving consumption of raw materials and energy. Ingredients weighing less than 3% of the recipe have not been included.

573. HEALTHY BISCUITS
Be happy, because, with these cookies you will never die or you will live to be as old as Methuselah.
In fact I eat them often and if someone, seeing me more sprightly than my heavy burden of years would allow, indiscreetly asks me my age, I reply that I am as old as Methuselah, son of Enoch.

Flour, 350 grams
Unrefined cane sugar, 100 grams
Butter, 50 grams
Cream of tartar, 10 grams
Bicarbonate of soda, 5 grams
2 eggs
A pinch of vanilla-flavoured sugar
Milk, as required.

Mix the sugar and the flour together, make a mound and then make a hole in the centre of the mound in which to place the rest of the ingredients. Moisten with a little milk and mix until you have obtained a soft dough. Work into a flattish cylindrical shape half a metre long. To bake it in the oven or in a "country oven", grease a baking tin with butter, and cut the dough into two pieces, placing them well apart as they swell considerably. The next day, cut them into the shape of biscuits – this amount of dough makes about thirty – and toast them.

It is assumed that the dough undergoes a 15% moisture loss following oven baking.
Cookie browning was not included in analysis boundaries.

Ingredient analysis

The ingredients and assumptions for each are given in Table A.4.
The tables also provide the source of the data for each ingredient for the calculation of the Carbon Footprint.
Used, respectively, for the Water Footprint and Ecological Footprint, was the information found on the website www.waterfootprint.org and information derived from elaboration of the Global Footprint Network (Italy 2001) database.

Table A.4 - Ingredients for 1 kg of baked biscuits

Ingredient	Unit of Measure	Value	Percentage of recipe (%)	Data source	Assumptions
Wheat flour	kg	0,56	48	Confidential primary data	Elaborated by the working group
Brown sugar	kg	0,169	14	Ecoinvent 2004	Considered comparable to beet sugar
Butter	kg	0,08	7	Busser & Jungbluth (2009)	It was assumed an impact equal to the cheese one
Eggs	kg	0,192	16	Dekker et al.	Weight of egg = 60 grams
Milk	kg	0,16	14	EPD Granarolo Milk	It was assumed to use 100 grams of milk
Cream of tartar	kg	0,016	1	-	Not included
Bicarbonate of soda	kg	0,008	1	-	Not included

Data for oven baking were taken from the Danish data bank (LCA food DK) and are given in Table A.5.

Table A.5 - Energy consumption for oven use

Type of cooking	Energy source	Unit of Measure	Dough data	Source
Heating convection oven to 200° C	Electrical energy	kWh	0,3	Table 5.2.2 in present document
Maintain temperature at 200° C for 1 hr	Electrical energy	kWh	0,9	Table 5.2.2 in present document

It was assumed that the cookies were baked in the oven in four batches for 15 minutes each, using two trays for each batch.
The weight of the dough baked in an hour is 3660 grams, on the basis of the following assumptions:

- Tray size: 40 cm X 35 cm
- Size of baked biscuit: 5 cm X 5 cm
- Number of cookies per tray: 39
- Weight of baked cookie: 10 grams
- Weight of unbaked biscuit: 11.76 grams.

The energy consumption values shown in the table are those required to bake 1 kg of biscuits.

Table A.6 - Energy consumption to bake 1 kg of biscuits

Procedure	Energy source	Unit of Measure	Value for dough/ finished biscuit
Heating convection oven to 200°C	Electrical energy	kWh	0,3
Maintain temperature at 200°C for 1 hr (for 1 kg of cookies)	Electrical energy	kWh	0,289
Total consumption (for 1 kg of cookies)	Electrical energy	kWh	0,589

Results

The results for 1 kg of bookies are given in Table A.7.

Table A.7 - Indicators for the production of 1 kg of biscuits

Healthy Buiscuits (P. Artusi recipe books n. 573)	Carbon Footprint	Water Footprint	Ecological Footprint
	gCO_2-eq/kg	liters/kg	gm^2/kg
Data range	2.300	1.800	16

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