Climate Change, Agriculture & Food

BARILLA CENTER FOR FOOD & NUTRITION

people, environment, science, economy

Executive Summary

SCENARIO

- According to the definition used by the United Nations Framework Convention on Climate Change (UNFCCC), climate change refers to a **change – greater than natural climate variability observed over a comparable period of time – in climate status; this variation being attributable to an alteration in the composition of the global atmosphere, directly or indirectly caused by human activity**.

- The **evidence and scenarios** presented in the IPCC report[1] raised considerable concern, above all for the potential implications for world ecosystems, populations and economic sectors that depend on the climate conditions in which they find themselves. Among the key evidence that emerged on a global level, were the following phenomena:
  A. *overall increase in temperature on a global scale*: the years between 1997 and 2008 were among the hottest ever recorded since global temperatures began to be monitored (1850). Eight of the ten hottest years ever recorded have been those since 2001. Observing more recent trends the average overall temperature increase recorded on a global level between the average of the period 1850-1899 and the 2001-2005 one was 0.76 °C;
  B. *melting and resulting decrease of land and marine surfaces covered by ice*: satellite monitoring performed since 1978 shows that the average annual extent of **Arctic marine glaciers** has decreased by 2.7% per decade with greater reduction during summer months (7.4% per decade);
  C. *rise in the sea level*: the average sea level worldwide has increased at an average rate of 1.8 mm per year between 1961 and 2003. The rate of growth was higher during the period 1993-2003: approx. 3.1 mm per year;
  D. *variation in regional precipitation levels and its intensity, as well as an increase in the frequency of "extreme" phenomena* (flooding, drought, etc.): significant increments of precipitation levels have been observed for the period 1900-2005[2] in the eastern areas of North and South America, in Northern Europe and in Northern and Central Asia. On the contrary, a diminution has been noted in countries in the sub-tropical area (between the 10th and 30th northern latitudes).

- According to the IPCC, changes in atmospheric concentration of **greenhouse gases** and aerosols (very small particles, such as nitrates, dust particles, etc.), **land cover** and **solar radiation**, are capable of altering the energy equilibrium of the climate system, thus creating serious imbalances.

- **Global emissions of greenhouse gases (GHGs) increased by 70%** between 1970 and 2004. The most significant amount of greenhouse gas was generated by activities related to: **energy supply (26%), industry (19%), deforestation and land-use (17.4%), agriculture (14%) and transport (13%)**.

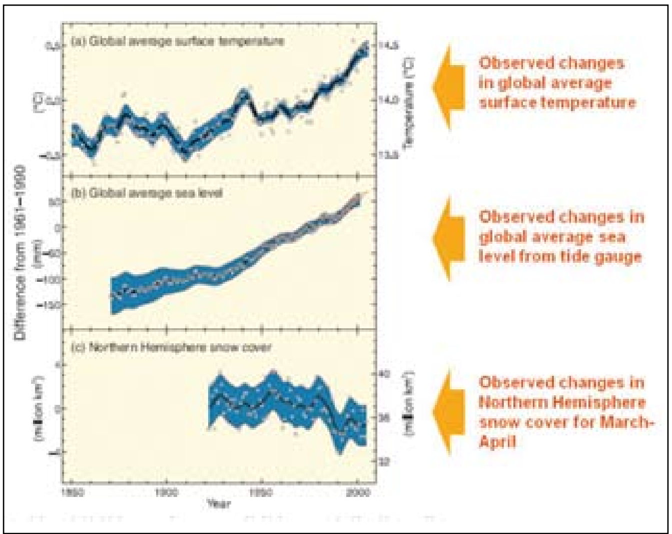
- The most recent IPCC report confirms that **future climate changes** do not only involve rising temperatures, but also cause changes in the entire climate system with serious repercussions on ecosystems and human activity (mostly in the agrifood sector). The scenarios outlined by the IPCC forecast a rise in global GHGs emissions[3] including a range of 9.7 to 36.7 million tons of $CO_{2\text{-eq}}$ between 2000 and 2030.

- **The Carbon Footprint is the overall amount of carbon dioxide (CO_2) and other greenhouse gas emissions associated with a product (consumer good, intermediate good) or service (organization of events, conferences, etc.) along its life cycle**[4]. The Carbon Footprint is measured to contain and manage current emissions with the goal of reducing them in the future in conformity with established environmental policies and to distribute and present the data to public bodies and private companies. According to the empirical evidence available, the world's greenhouse gas emissions are predominantly generated by the United States, China, EU27, Russia, India and Japan, which together account for 70% of the total emissions. Italy is in tenth place in the world for absolute emissions of greenhouse gas[5].

- The **Ecological Footprint** is a statistical measure that compares human consumption of natural resources with the ability of our planet to regenerate them. This index measures the **biologically productive area** (of sea and land) **required to produce the resources consumed by man and**

1 *"Fourth Assessment Report: Climate Change 2007", IPCC, 2007*
2 *On the basis of a long-term trend*
3 *Forecast increases over the baseline*
4 *Source: European Union, Joint Research Centre Institute for Environment and Sustainability, 2007*
5 *Source: World Research Institute – Climate Analysis Indicator Tool*

Figure 1. Recorded changes in temperature, sea level and snow cover, 1850-2005



Source: "Fourth Assessment Report: Climate Change 2007: Synthesis Report. Summary for Policymakers", IPCC, 2007

A. Increase in temperature

The warming process seems to have been particularly marked in the last 50 years. In fact, the linear warming trend recorded over this period was almost double that the one recorded over the last 100 years. In particular, observing more recent trends, the average overall temperature increase recorded on a global level between the average of the period 1850-1899 and the 2001-2005 one was 0.76 °C.

This warming trend has generally affected the entire planet equally. Nonetheless, the intensity of these changes did not manifest themselves in a geographically uniform way, but affected primarily above-sea level land and the Northern Hemisphere.[6] For example, average polar temperatures have increased at a rate almost double the average global one over the last 100 years.

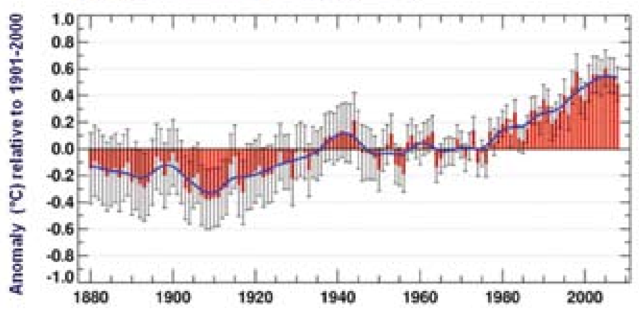
In the Euro-Mediterranean region (including the Alps region), considered a "hot spot" by experts, temperatures have increased more than the global average (+0.95 °C since 1900[7]), and forecasts for the future expect a further increment.

In addition, observational evidence shows that in the last 50 years, there have been[8] significant changes in the occurrence of extreme temperatures. Cold days, cold nights and frosts have become less frequent, while hot days and nights and heat waves have become particularly frequent. Apropos this point were the exceptionally high temperatures (more than 3 °C above the average for the period 1961-1990) that occurred during the extended heat wave which hit Europe in the summer of 2003. These particular environmental conditions caused over 35,000 deaths, numerous fires and damages to agriculture and the economic system.[9]

In particular, the years between 1997 and 2008 were among the hottest ever recorded since global temperatures began to be monitored (1850). Eight of the ten hottest years ever recorded have been those since 2001 (Figure 2).

Figure 2. The ten hottest years: recorded anomalies in average temperature[10] from the period 1901-2000

Global Top 10 Warm Years (Jan-Dec)	Anomaly °C
2005	0.61
1998	0.58
2002	0.56
2003	0.56
2006	0.55
2007	0.55
2004	0.53
2001	0.49
2008	0.49
1997	0.46



Source: "Climate of 2008 Annual Report" NOAA[11] Satellite and Information Services, January 2009

Monitoring since 1961 shows that the oceans have absorbed more than 80% of the heat added to the climate system and that their average global temperature has increased down to a depth of at least 3000 m. This warming has resulted in the expansion of sea water and a rise in sea level.

The last IPCC report also notes that the generalized warming seen in the last 50 years cannot be explained solely by the effect of natural forces and that the influence of outside forces (anthropogenic interference) must also be taken into consideration. As shown in Figure 3 below, the simulation models of the growth trend in temperatures based solely on the action of

6 Since 1900, the average temperature in the Northern Hemisphere has increased by 0.87 °C.
7 0.7 °C in the summer and 1.1 °C in the winter. Source: European Environment Agency - EEA
8 Evidence seen on a global level
9 "Dossier: ENEA per lo studio dei cambiamenti climatici e dei loro effetti", ENEA, 2007
10 Combined average of air temperature at surface level over land and air temperature at surface level over the sea
11 National Environmental Satellite, Data, and Information Service NOAA, http://www.ncdc.noaa.gov

to absorb the waste generated[6]. The sum of these various components of the index provides the "equivalent area" required to produce the amount of biomass utilized by a given population, measured in "global hectares" (gha).

- Currently mankind would need 1.3 planet Earths to sustain its consumption and absorb its waste (this means that the Earth needs approximately one year and four months to regenerate the resources consumed by man in a year and absorb the waste produced). The countries with the highest per capita Ecological Footprint are the United Arab Emirates and the United States. Among the top 15 countries are also some northern European countries (such as Denmark, Norway, Estonia and Ireland) and southern Europe (Greece and Spain). Italy, on the other hand, is in 24th place, with an Ecological Footprint of 4.76 global hectares per person. On average, the Ecological Footprint of each Italian represents an area which, if imagined as a flat surface, would be equivalent to a square of over 218 metres per side, equal to 6 soccer fields. Taking into consideration the various components of the Ecological Footprint, this surface should be seen as covered 1.4% by the sea, 9.1% by forests, 24.9% by cropland, 4.5% by grazing land, 2% by built-up areas (cities, roads, infrastructure) and a full 58.1% of the area covered by the forests required to absorb carbon dioxide.

- Looking to future scenarios for growth of the Ecological Footprint, humanity will face in 2050 such a large ecological deficit that two planet Earths will be needed to sustain consumption levels and absorb the waste generated.

- In the light of the impacts of climate change and the future prospects described, the UNFCC has developed, in particular, two specific strategies:
  - Mitigation strategy: this strategy aims to act on the causes of climate change, particularly on reducing and stabilizing emissions and the concentration of greenhouse gases in the atmosphere that come from man's activities. The success of this strategy requires global and therefore international action.
  - Adaptation strategy: this strategy aims to act on the effects of climate change by drafting plans, programmes, actions and measures that minimize the negative consequences resulting from climate change. The intrinsic nature of this strategy means that its implementation calls for coordinating measures to be carried out on a local level.

Climate Change and the Agrifood sector

- The agrifood supply chain also includes a component relative to industrial processing activities. Given the specific objective of the work – to assess the impact of climate change – attention has been focused on the phase of production of the raw materials that supply this industry. Where relevant, however, indications have been provided also as regards the work phases relative to the processing of raw materials, their transportation and consumption.

- Agriculture and climate change are characterized by a complex cause-effect relationship. Through the activity itself, agriculture produces significant volumes of greenhouse gases, the prime culprits for climate change. At the same time, however, it is affected by the negative impacts in terms of reduced productivity and increased food safety risks. Solutions able to interrupt this vicious cycle can currently be traced to two macro areas: re-localization of agricultural production and innovation in agrifood management and practices.

- Agriculture accounts for the production of approximately 33% of all annual greenhouse gas emissions worldwide[7]. It may be seen from the scientific data available that agrifood activities contribute moderately to the production of carbon dioxide, but more considerably to the generation of nitrous oxide and methane, due to the activities connected with animal husbandry, rice growing and – partly – soil fertilization[8].

- The effects of climate change on agriculture concern three macro-areas:
  - Agricultural output: the Mendelsohn and Schlesinger model underscores how agricultural output measured in monetary terms is a function of the average annual temperature, the average daily precipitation on annual basis and the concentration of carbon dioxide in the air. As may be seen, one factor which increases agricultural productivity is related to the phenomenon known as carbon fertilization. An increase in CO_2 emissions not only raises the temperature of our planet and damages agriculture, but it also has a positive effect on agriculture itself by alleviating the adverse effects related to overheating. Despite this, the drop in worldwide agricultural output will be at a level of almost 190 billion dollars per year and, even in the presence of carbon fertilization, world annual agricultural production would decrease by almost 40 billion dollars.
  - Safety of the food chain: the repercussions on food safety expected as a result of climate change mainly involve increased difficulties in the management of water resources and the faster spread of disease and contamination of agricultural products and foodstuffs.
  - Social security: the main critical/conflict situations for society connected with climate change concern: the availability and use of natural resources; economic damages

6 *The ecological footprint concept was developed in the first half of the 1990s by ecologist William Rees of British Columbia University and later elaborated, applied and widely diffused internationally by Mathis Wackernagel, currently director of the Ecological Footprint Network. Starting in 2000, the WWF regularly updates calculations of the ecological footprint in its biennial Living Planet Report, utilizing data prepared by the Ecological Footprint Network*

7 *Source: World Resources Institute, Database*

8 *Source: W. Cline, Global Warming and Agriculture, Centre for Global Development, 2007*

and risks for the **coastal cities** and their **infrastructures**; the increase of **territorial disputes; migratory phenomena** linked to worsening living conditions; situations of instability and **misgovernment** with respect to the response to the **growing needs of the populations**; tension linked to **access** and **control** of **energy resources**; pressures on international governance.

- With regard to the strategies for reducing the impact of the agrifood sector on climate change, it is possible to pinpoint a number of priority **objectives** to be attained in order to guarantee the environmental sustainability of agrifood production. Among these:
  - **to actively absorb and store the carbon** in the vegetation and in the soil;
  - **to reduce the emissions of carbon dioxide**, and of **methane** deriving from the production of rice, the raising of livestock and combustion, and also of those of **nitrous oxide** deriving from the use of inorganic fertilizers.
- The practices that, at the moment, appear to guarantee the achievement of these objectives, may be divided into three **macro-strategies**[9]:
  - Management of the **agricultural land**;
  - Management of the **grazing land** and **optimization of breeding farms**;
  - Recovery of **degraded areas** and **protection of forests and grasslands**.
- For the purpose of implementing the strategies described, the economic parties (farmers, owners of forests etc,), consumers and all the other categories involved may request support and incentives of various kinds. Some examples of these, of particular importance, are listed below: Sustainable Food Laboratory, Amazon Fund, Regional Greenhouse Gas Initiative, New Zealand Sustainable Land Management and Climate Change Plan, BioCarbon Fund - World Bank, Global Ecolabelling Network.
- The **Climate Foodprint** measures the environmental impact generated by the production and consumption of food. The concept of Climate Foodprint is part of that of the Carbon Footprint and, finally, of the Ecological Footprint. The production and consumption of food generates an environmental impact in terms of CO_2 emissions (Carbon Footprint) and in terms of demands on the Earth's ecosystems (Ecological Footprint). Hence, the type, the composition, and the quantity of food which is produced and consumed has a significant effect on both the total quantity of CO_2 emissions, and consequently on the Carbon Footprint, and on the human demands placed on nature in terms of the ratio between the consumption of resources and the Earth's capacity to (re)generate them.
- In this perspective, the impact in terms of CO_2 emitted and ecological footprint left by the two main types of diet currently consumed in the Western world has been analysed and assessed: the **North American diet** (characterized by a significantly high consumption of meat and a growing consumption of sweet foods and foods containing a high concentration of sugars and fats) and the **Mediterranean diet** (characterized mainly by the consumption of carbohydrates, fruit and vegetables). Briefly:
  - a person following the **North American diet leaves a 26.8 m² Ecological Footprint** and releases approximately **5.4 kg of CO_2** into the atmosphere each day.
  - a person following the **Mediterranean diet**, leaves a **12.3 m² Ecological Footprint** and releases approximately **2.2 kg of CO_2** into the atmosphere each day.
- An approach to food that has the capacity to integrate the various elements of the diet in a balanced way, as is the case of the Mediterranean diet, in addition to responding to requirements for health and physical well-being, also demonstrates all of its worth by taking environmental impact into account, particularly in terms of contribution to the mitigation of the climate change phenomenon. This has been demonstrated empirically by the results of the application of the **food pyramid model** developed by the Italian Ministry of Health.

RECOMMENDATIONS

In our view, there are six areas for action:

1. Promote and spread the use of objective environmental impact indicators that are simple and can be communicated at all levels;
2. Encourage economic policies and a system of fair, effective incentives/disincentives;
3. Re-localize crops, reduce incidence of zootechnical activities, protect forests;
4. Encourage technological innovation and promote sustainable agricultural policies (best practice);
5. Promote transparent communication policies (up to green labelling);
6. Promote eco sustainable life styles and diets.

9 The evidence and the considerations expressed in this paragraph are chiefly based on the contents of the following publications: IPCC, "Mitigation of climate change", 2007, Chap.8; Smith, P., D. Martino, Z. Cai, D. Gwary, H.H. Janzen, P. Kumar, B. McCarl, S. Ogle, F. O'Mara, C. Rice, .J. Scholes, O. Sirotenko, M. Howden,T. McAllister, G. Pan, V. Romanenkov, U. Schneider, S. Towprayoon, M. Wattenbach, and J.U. Smith, 2007a: "Greenhouse gas mitigation in agriculture", Philosophical Transactions of the Royal Society; Sara Scherr and Sajal Sthapit, "State of the world 2009 ", WRI, Chap. 3

Part A: scenario

1. CLIMATE CHANGE: TWO DIFFERENT APPROACHES

"The challenge of climate change, and what we do about it, will define us, our era, and ultimately, our global legacy"
Ban Ki-Moon
UN General Secretary

The profound structural transformations currently underway on a global level (population growth, accelerated economic development in some emerging countries, increase in energy consumption on a planetary scale, etc.) make necessary an increasingly careful evaluation of the **medium-to-long-term profile of sustainability of current social/economic development trends**. The pressure exerted on natural resources in various regions of the world is very strong and the concerns tied both to their more efficient use and containment of the most negative effects of the processes of economic growth are on the rise. Of particular concern are the effects of man's activity on the Earth's climate.

Over the last decade, climate change has come to the attention of the governments of the major industrialized countries and has become one of the most pressing issues on the international political agenda.

There are a number of definitions of "climate change", all of which are basically convergent. According to the UN's Intergovernmental Panel on Climate Change (IPCC), the phenomenon of **climate change** can be defined as *a statistically significant variation in the average status of the climate or its variability that persists over a long period of time (normally ten years or more), caused both by natural changes as well as human activity*.

According to the definition used by the United Nations Framework Convention on Climate Change (UNFCCC), climate change refers to a *change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods*.

As emerges clearly from the definitions formulated by the major international bodies concerned with this area, variation from the normal climate trend may be caused by two major factors, one connected with **natural variability**, and the other directly or indirectly traceable to **human activity**.

The possibility that there could be different causes behind climate change phenomena has given rise to **two different schools of thought**: one approach to climate changes (that proposed by the main international institutions) sees man and the influence of his activity on nature as the principle cause of climate change processes, and the other approach which, on the contrary – and in direct contradiction to the first one – strongly maintains the connection between natural phenomena (and their intrinsic variability over long periods) and climate change while not attributing to human activities a predominant role in the changes in progress.

Determining whether climate changes are, or are not, induced by human activity is crucial for defining whether or not exists the possibility of implementing corrective action for the changes observed.

As is well known, positions about this are not unified. While the IPCC declares it is certain that the warming seen over the last century is provoked by human activity (emissions of carbon dioxide and other greenhouse gases), the NIPCC (the Nongovernmental International Panel on Climate Change comprised of an independent group of scientists who study climate), maintains that the cause can be identified in normal natural cycles.

Winner of the Nobel prize for chemistry, **Paul Crutzen**, who fully agrees with the "institutional" approach, has defined the current geological era "Anthropocene" (era of man): the dominant aspect of this era – which had its start in the early nineteenth century with the industrial revolution – is that of human activity and its enormous impact on the environment.

Freeman Dyson – noted emeritus professor at Princeton's Institute of Advanced Studies – is, on the contrary, one of the most prominent opponents of the anthropogenic theory of climate change. According to Dyson (advocate of the theory supported by all scientists who do not accept the "institutional" approach), climate changes over centuries-long cycles and its changes have not yet been understood at a level that would make it possible to clearly and unequivocally identify a connection between human activity and observable climatic phenomena.

Despite the unquestionable authority of some exponents of the "non-anthropogenic" view, we feel there are **two valid reasons for choosing** (as we have done) **to approach the issue of climate change from the basis of an "anthropogenic" approach**:

- First of all, **international scientific consensus for an anthropogenic interpretation of the evidence of climate change seems very diffuse.** Studies conducted to-date by major international institutions and leading research bodies include among their authors the most authoritative international experts in this field and they are based on in-depth, scientifically tested analysis.
- Secondly, climate change is a real, significant and global phenomenon which impacts in a more or less direct way on numerous fundamental areas of existence, from the environment to the economy, health and social issues. **Taking on this phenomenon in an active way**, evaluating the impact of human activity on the environment (whether this plays a predominant or secondary role in the causes which contribute to climate change) **seems to be the only viable approach, including from the standpoint of the future, to attempt to contain the effects of this phenomenon on life and human activity**.

1.1 Main evidences of climate change

"Scientists have spoken with a single voice. The situation is grim. Urgent action is needed because the situation is desperately serious. Any delay could push us past the tipping point beyond which the ecological, financial and human costs increase dramatically. Scientists tell us that that the measures required to prevent a catastrophe are both doable and affordable. All we need is the resolve to act. [...] The Universal Declaration of Human Rights, adopted 59 years ago, established the inalienable human right to "liberty, justice and peace". Today, climate change represents the primary threat to these values and the cause of human development.[1]

Ban Ki-moon,
Secretary General of the United Nations,
December 10, 2007

Scientific consensus regarding the origins and causes of climate change is widespread and consolidated on a worldwide level, both internal and external to the Intergovernmental Panel on Climate Change (IPCC)[2]. Direct observations gathered to-date confirm that the change underway is undeniable and that the evidence and impact already observable today will become even more evident in the future.

The most recent report from the IPCC,[3] significantly improved from the previous one[4] thanks to progress made in understanding climate-related phenomena and changes in time and space, states in particular that:

- "**Warming of the climate system is unequivocal**, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice and rising global average sea level."
- "Most of the **increase observed in average global temperatures** since the mid-20th century is *most likely*[5] due to the **increase observed in concentrations of greenhouse gases of anthropogenic origin**." This represents a new result from the conclusions of the previous report because it underscores that the responsibility for human activity in the alteration of temperature equilibriums of the climate system is increasingly evident.

The evidence and scenarios presented in the report raised considerable concern, above all for the potential implications for world ecosystems, populations and economic sectors that depend on the climate conditions in which they find themselves.

Among the key evidences that emerged on a global level, were the following phenomena:

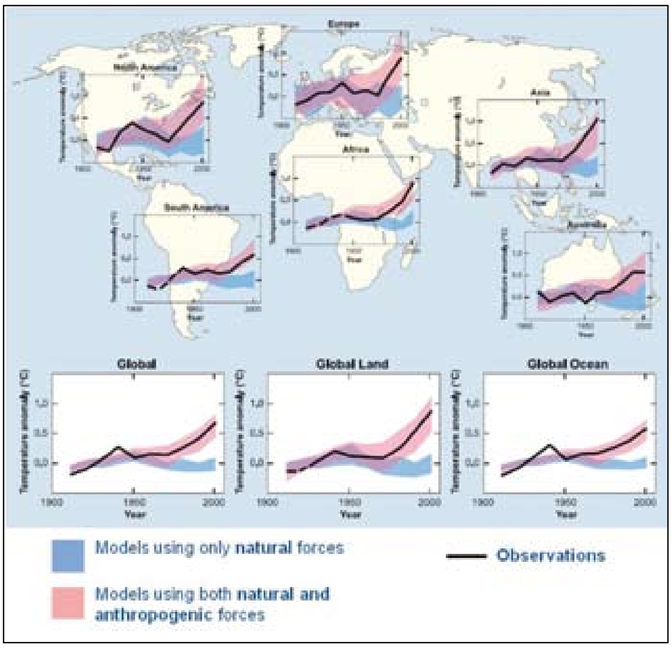
A. overall increase in **temperature** on a global scale;
B. melting and resulting decrease of land and marine surfaces covered by **ice**;
C. rise in the **sea level**;
D. variation in regional **precipitation** levels and its intensity, as well as an increase in the frequency of "extreme" phenomena (flooding, drought, etc.).

These changes have brought about an increase loss of biodiversity and have placed particular stress on land and marine ecosystems.

1 Remarks at the UN Development Programme (UNDP) event on the Human Development Report, December 11, 2007
2 The IPCC was formed in 1988 by the World Meteorological Organisation (WMO) and the United Nations Environment Programme (UNEP) with the purpose of providing policymakers with a scientific analysis of the technical-scientific and social-economic literature available regarding climate changes, their impact, adaptation and mitigation. 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. The primary activity of the IPCC consists of producing regular scientific assessment reports on findings related to the field of climate and climate changes. The assessment reports, which reflect analysis and evaluation of international scientific consensus of results pertaining to climate change, are reviewed by experts. In recent years, the work of the IPCC has been approved by leading scientific organizations and academies throughout the world
3 "Fourth Assessment Report: Climate Change 2007", IPCC, 2007
4 "Third Assessment Report: Climate Chance 2001", IPCC, 2001
5 In IPCC jargon, "most likely" indicates a 90-95% probability

natural forces (highlighted in light blue) are not sufficient to explaining the average warming trend observed (black line). The latter coincide with the trends simulated in the models that take into consideration both natural and anthropogenic forces (highlighted in pink).

Figure 3. Recorded variations in temperatures on a global level and by continent



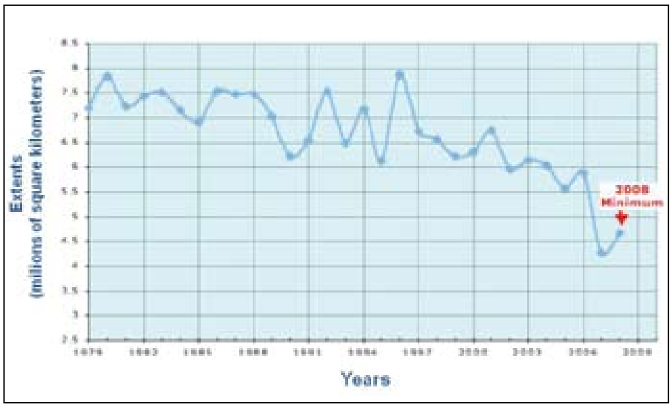
Source: "Fourth Assessment Report: Climate Change 2007", IPCC, 2007

B. Melting and contraction of glaciers and snow cover

The melting and contraction of glaciers represent one of the main proofs of the change currently underway and is the example most often used to capture the attention of public opinion and decision makers.

Alpine glaciers and snow cover have diminished on average in both hemispheres. Satellite monitoring performed since 1978 shows that the average annual extent of Arctic marine glaciers has decreased by 2.7% per decade with greater reduction during summer months (7.4% per decade).

Figure 4. Minimum annual extent of Arctic marine glaciers, 1979-2008

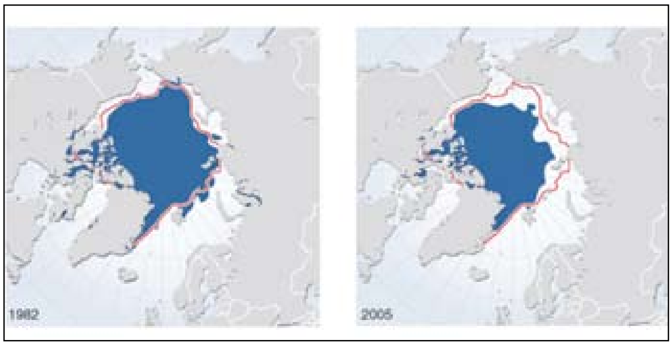


Source: NSIDC Sea Ice Index (http://nsidc.otg/data/seaice_index/archives/index.html); ARCUS

Starting in the 1980s, surface temperatures of the Arctic permafrost layer increased by as much as 3 °C, with a resulting reduction in snow cover of 5%. Since the year 1900, in the Northern Hemisphere, the maximum area covered by seasonal glaciers decreased approx. 7%, with a diminution of over 15% in spring.

Compared with 1979 levels, the extent of the ice cap on the Arctic Sea has decreased by 20%. Figure 5 compares the extent of the Arctic ice cap in September 1982 (maximum recorded since 1979) and 2005 (minimum for the period 1979-2005). The glacial extent in September 1982 was 7.5 million km^2, while in 2005 it was only 5.6 million km^2, a difference of 25%.

Figure 5. Glacial extent of the Arctic Sea, 1979-2005. The red line indicates the median minimum extent of the ice cover for the period September 1982-2005



Source: (NSIDC); "Global Outlook for Ice and Snow", UNEP, 2007

From 1979 to 2007, melting of the ice cover of Greenland increased 30% on its western side, with record melting recorded in the years 1987, 1991, 1988, 2002 and 2007. Specifically, data from JPL Gravity Recovery and Climate Experiment[12] show that Greenland lost approx. 150-200 cubic kilometers of ice per year between 2002 and 2005.

12 Jet Propulsion Laboratory - California Institute of Technology - NASA

The highest melt level, reached in 2007, increased a further 10% over that of 2005, making this the largest amount ever observed from the start of satellite readings in 1979.[13]

In terms of European glaciers, it has been estimated that since 1850 (the year of the greatest extent) to 1970, on average, they have lost 35% of their surface area and approx. 50% of their volume. The exceptionally hot summer of 2005, alone, resulted in a loss of 10% of the residual mass of glaciers in the Alps.[14]

C. Rise in the sea level

Analysis and monitoring of the variations involving sea level have taken on considerable relevance, especially in terms of the potential impact on populations settled in coastal areas and islands.

According to the latest IPCC report, the average sea level worldwide has increased at an average rate of 1.8 mm per year between 1961 and 2003. The rate of growth was higher during the period 1993-2003: approx. 3.1 mm per year.

On a global level, the estimated total rise over the 20th century was 0.17 m.

There are two main reasons for the increase in sea level: increase in temperature of the oceans and melting of terrestrial glaciers. Since 1993, the increase in ocean temperature accounts for approx. 57%, with the shrinking of glaciers and the ice cap for approx. 28%.

Figure 6. Variation in sea level, past trends and recent readings

Source: Colorado University and NASA / NOAA Satellite and Information Services, January 2009

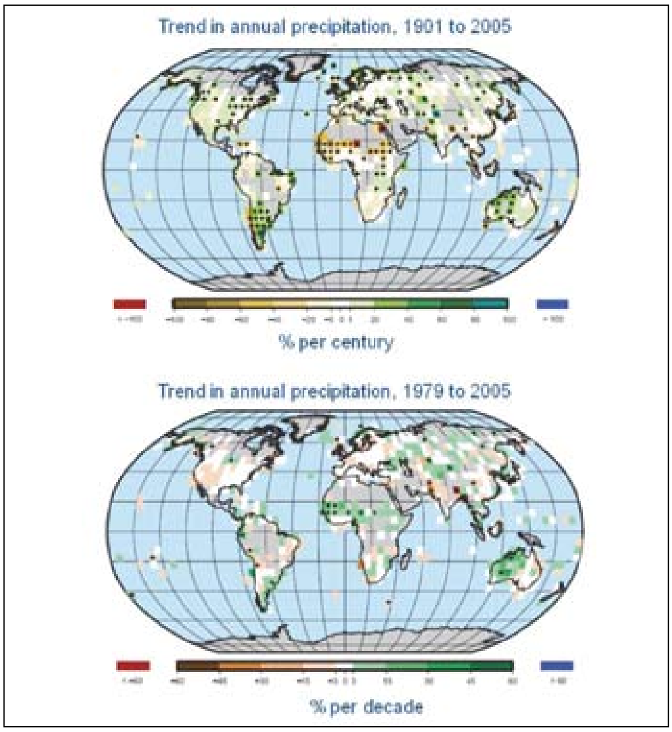
According to NASA satellite monitoring between 1993 and 2008, there has been an average rise in sea level of 4-5 cm, most of which concentrated in the east equatorial Pacific, North Atlantic and between New Zealand and the Tasmanian Sea.

It should also be noted that the increase of CO_2 concentrations in the atmosphere has generated a gradual increase in the acidification of the oceans and bodies of water, with resulting negative effects on the very existence of marine ecosystems.

D. Precipitation

Despite the fact that there is significant variability in terms of geographical area and time frames, and although for some regions only limited data is available, significant increments have been observed for the period 1900-2005[15] in the eastern areas of North and South America, in Northern Europe and in Northern and Central Asia. On the contrary, a diminution has been noted in countries in the sub-tropical area (between the 10th and 30th northern latitudes).

Figure 7. Annual precipitation: trend. Graphic at the top shows trend over 1901- 2005 (% per century), the graphic below shows trend over 1979-2005 (% per decade) - (the percent variation refers to the average of the period 1961-1990[16])



Source: "Fourth Assessment Report: Climate Change 2007", IPCC, 2007

Starting in the 1970s, the decrease and geographical variation in precipitation levels, combined with an increase in temperatures, has caused longer and more intense periods of drought, especially in tropical and sub-tropical areas. A trend towards drought has been noted in the Sahel, Mediterranean, southern Africa and parts of southern Asia.

13 University of Colorado: http://www.colorado.edu/news/releases/2007/481.html; http://earthobservatory.nasa.gov
14 "Global Outlook for Ice and Snow", UNEP, 2007; C. Carraro et al., "Gli Impatti dei Cambiamenti Climatici in Italia", Ed. Ambiente, 2009
15 On the basis of a long-term trend
16 The areas for which it has not been possible to provide reliable trends, due to lack of data, are marked in grey. The minimum number of years required to calculate a trend value is 66 over the period 1901-2005, while for the chart for the years 1979-2005, the number required is 18. Significant trends in the range of 5% are indicated with a black +

In Europe, over the 20th century, total annual precipitation in northern regions has increased by 10% to 40%, while in southern regions, there has been a decrease of over 20%.

Variation in pluviometric regimes and the hydrologic cycle overall also has significant consequences on those factors which govern ecosystems and on the increase in the frequency and intensity of extreme meteorological phenomena (hurricanes, floods, long periods of drought). Among the most recent are:

- Drought – central and southwest Asia 1998-2003: The precipitation level for the period 1998-2001 was, on average, 55% below the long-term average. The drought conditions over this period were the worst in 50 years. In Iran, for example, in June 2000, a period of 30 consecutive months without precipitation was recorded;
- Drought - Australia 2002-2003: The period of drought recorded in these two years was particularly serious because of the heat wave which accompanied it;
- Floods - Europe, Summer 2002: In Germany, an all-time record of 353 mm of rainfall in 24 hours was registered.[17] According to the WHO, flooding during this period caused the deaths of over 100 people in Germany, Russia, Austria, Hungary and the Czech Republic, with monetary losses in the range of 20 billion dollars.[18]

1.1.1 Impacts of Climate Change in Italy

From analysis of the last 200 years taken from a number of observatories and weather stations, the CNR[19] has identified a number of factors that can be traced to climate change in Italy.

Temperature: Over the last two centuries, average annual temperatures on the Italian peninsula have risen by 1.7 °C (equal to 0.8 °C per century), with maximum increase during winter. The most significant contribution to this increase has been in the past 50 years, during which the increase was around 1.4 °C. The rate of growth of average temperatures in Italy was almost double that of the global average.

Glaciers: As noted previously, the Alps have lost over half of their mass and the Italian Alps are no exception to this. In fact, of the 335 glaciers monitored over the period 1980-1999, it was noted that the percentage of advancing glaciers has decreased by 66% in 1980 to 4% in 1999, while those retreating rose from 12% to 89%.[20]

Sea level: Following an initial phase of gradual rise analogous to that observed on a global level, anomalies in growth rates also appeared in the Mediterranean. Especially over the last 30 years, the level has remained stationary or has even shown evidence of decreasing. This anomalous trend has been caused by an increase in evaporation (due to global warming) and by the simultaneous decrease in water supplied from rivers (due to a fall in precipitation levels and increase in use of river water).

Precipitation: Overall precipitation levels have decreased about 5% per century throughout the country, with increased reductions in the spring (ca. 9%). The most marked reduction involved central-southern regions where it reached 15% in the last century. The total number of rain days dropped by approx. 6 days per century in northern regions and by approx. 14 days in central and southern regions. This diminution was also noted above all over the last 50 years. The overall trend noted in all regions of Italy was an increase in precipitation intensity and a decrease in duration. Especially over the last 50 years, snowfall has also decreased by up to 10%.

Desertification: The areas which risk desertification amount to over 1/5 of Italy's surface area and, specifically, over 40% of southern areas (CRA et al. 2007). Currently is at risk of desertification:

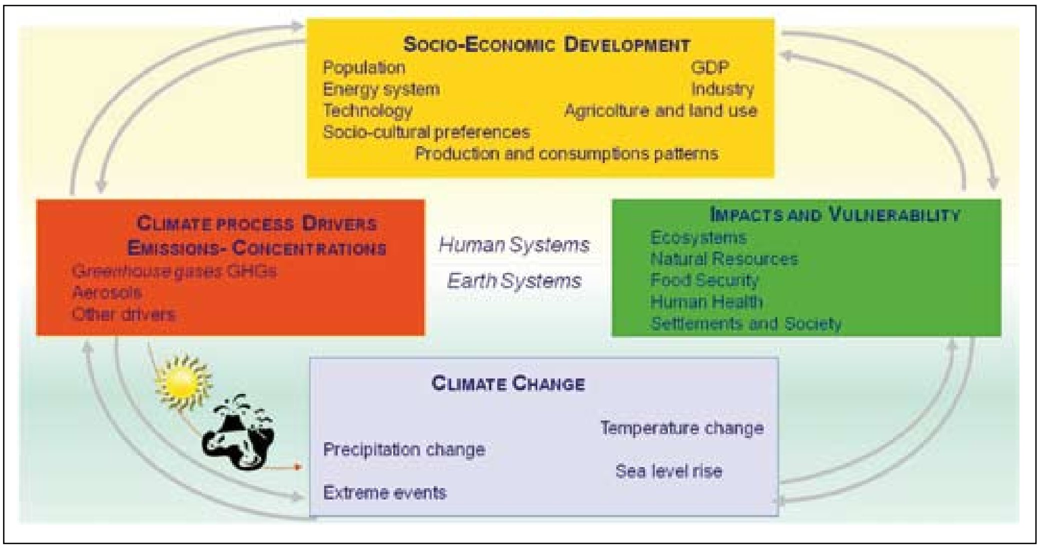
- 60% of the area of Apulia;
- 54% of the area of Basilicata;
- 47% of the area of Sicily;
- 31.2% of the area of Sardinia[21].

1.2 Causes of climate change

There seem to be many forces that have a direct or indirect impact on climate on a global scale. One of the schematic frameworks used to evaluate factors that influence climate change is presented below.

17 "Fourth Assessment Report: Climate Change 2007", IPCC, 2007
18 EM-DAT - Emergency Events Database, http://www.emdat.be/; "ALLUVIONI: Effetti sulla Salute e Misure di Prevenzione", WHO, 2002
19 M. Brunetti et al., 2006
20 Tibaldi 2007; "Cambiamenti climatici e strategie di adattamento in Italia. Una valutazione economica", C. Carraro et al., 2008
21 ENEA - Progetto Speciale Clima Globale, 2006; "Cambiamenti climatici e strategie di adattamento in Italia. Una valutazione economica", C. Carraro et al., 2008

Figure 8. Climate change schematic framework



Source: The European House-Ambrosetti re-elaboration from "Fourth Assessment Report: Climate Change 2007", IPCC, 2007

Emission and concentration of greenhouse gases and aerosols, together with the conditions (presence and utilization) of **the Earth's green resources** (forests and land) are factors which appear to influence the terrestrial climate in the most relevant and direct way.

There are also numerous macro factors with an indirect influence on climate, through their effect on the elements mentioned above: rise in population over recent decades, increase in world production and increase in energy demand and food consumption.

1.2.1 Greenhouse gas emissions

All recent scientific findings indicate a **significant increase in greenhouse gas emissions**, partly due to natural causes and partly to human activity.

According to the IPCC, changes in atmospheric concentration of greenhouse gases (GHGs) and aerosols (very small particles, such as nitrates, dust particles, etc.), in land cover and solar radiation, are capable of altering the energy equilibrium of the climate system, thus creating serious imbalances.

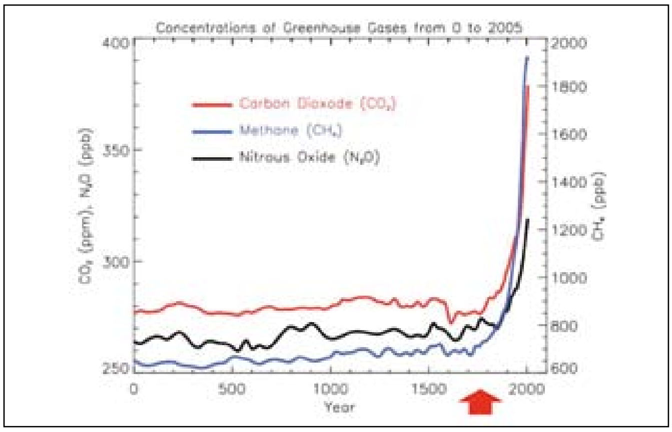
On this point, in the conclusions of its 4th Summary Report on Climate Change, released in 2007, the IPCC noted that:

- since the pre-industrial period, global emissions of greenhouse gases have **increased steadily. They increased of 70% between 1970 and 2004**;
- The global atmospheric concentration of greenhouse gases – carbon dioxide, methane and nitrous oxide being the primary ones – has increased significantly and, currently, **exceeds pre-industrial levels by 35%**.

The main greenhouse gases that absorb infrared radiation, thus contributing to climate change, are:

- **Carbon dioxide** (CO_2), the most common GHG, created by fossil fuels utilized for transport, heating and cooling systems and by industry. Deforestation and reduction of plant cover emit CO_2 through plant decomposition, thus limiting the natural process of its absorption;
- **Methane** (CH_4), the second most common gas, one of whose units corresponds to 21 units of CO_2, it is emitted via agricultural and zootechnical activities, decomposition of organic waste and biomass combustion. Methane is also released through natural processes in swamps, marshes, lake sediment, etc.;
- **Nitrous oxide** (N_2O), one unit of which corresponds to 310 units of CO_2, it is released through synthetic fertilizers and combustion of fossil fuels;
- **fluorinated gases** (HFCs, PFCs, SF_6), one unit of which corresponds to 600-23,900 units of CO_2, they are generated by refrigeration and air conditioning systems and other industrial processes. Natural processes emit only a limited amount of these types of gas.

Figure 9. Atmospheric concentration of the main GHGs, 0-2005



Source: "Fourth Assessment Report: Climate Change 2007", IPCC, 2007

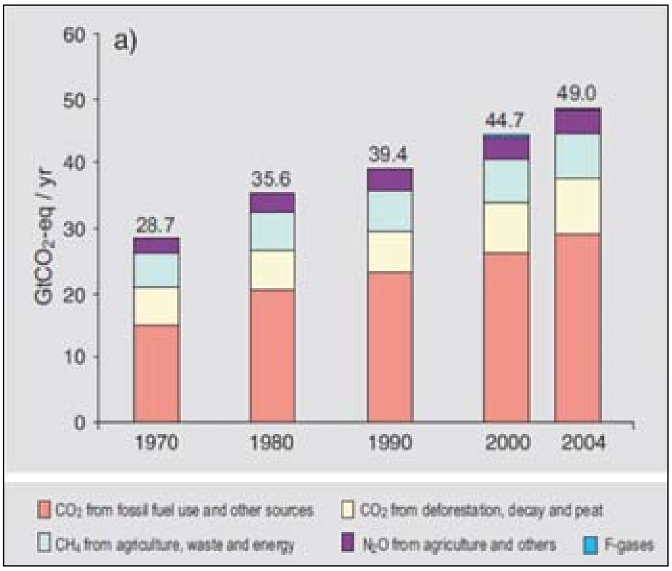
Anthropogenic activities contribute to climate change by altering the terrestrial atmosphere in terms of **quantity and chemical composition** of greenhouse gas, aerosol and cloudiness. These gases, interacting with the sun's radiation and infrared radiation from the Earth, alter the thermal balance of the planet: from the start of the industrial era, the primary net effect of the increment of the concentration of these gases can, in fact, be identified in terrestrial warming.

What are the primary causes for the increase of greenhouse gas concentration in the atmosphere? In its most recent report on climate change, the IPCC underscores that evidence is growing regarding the impact of the human factor on the causes of global warming. Compared with the third IPCC report, understanding of anthropogenic influence on climate has improved, leading to definite conclusions that are "very high confidence".

The increase in greenhouse gas, that was noted with the start of the industrial era (around 1750), has been attributed in almost all studies on this issue to be significantly due to human activity. The impact these activities have had on climate over the years is held to be considerably more important than that caused by natural change (related to the sun, volcanoes, etc.):

- From 1970 to 2004, greenhouse gas emissions caused by human activity have increased by 70%;
- Over the period under consideration, annual CO_2 emissions have increased approx. 80%, going from ca. Gt (gigatons = billions of tons) to 38 Gt;
- The rate of growth in $CO_{2\text{-eq}}$ [22] emissions was much higher over the years 1995-2004 (0.92 $GtCO_{2\text{-eq}}$) than during the period 1970-1994 (0.43 $GtCO_{2\text{-eq}}$).

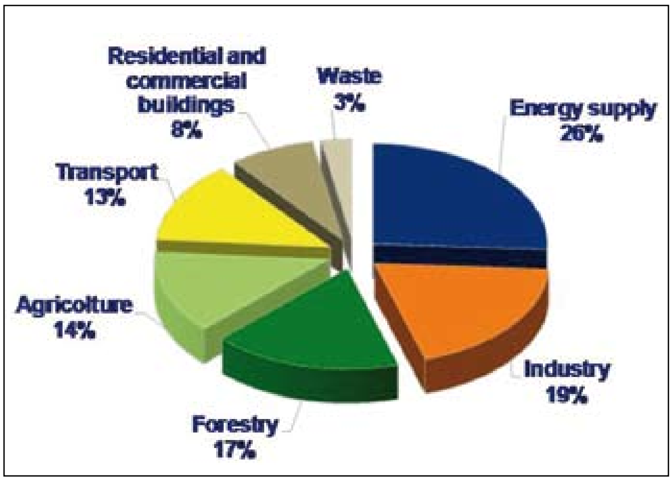
Figure 10. Annual global anthropogenic emissions of GHGs, by type of gas 1970-2004



Source: "Fourth Assessment Report: Climate Change 2007", IPCC, 2007

During this period (1970-2004), **the most significant amount of greenhouse gas** (CO_2, CH_4, N_2O, HFCs, PFCs, SF_6) **was generated by activities related to energy supply, transport** and, in general, to those that were **industry-related**. In 2004 – as can be seen in the figure below that analyzes the share by sector of global anthropogenic emissions – energy supply amounted to over 25% of all emissions.

Figure 11. Global anthropogenic emissions of GHGs, by sector, 2004



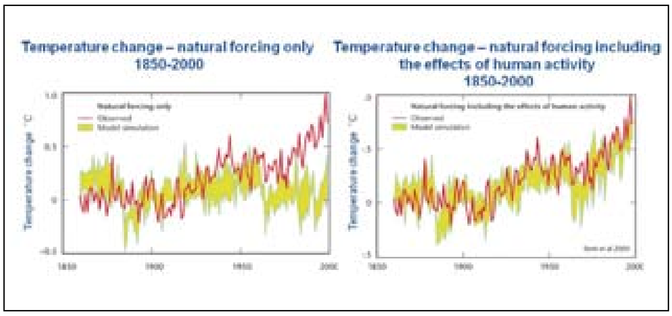
Source: The European House-Ambrosetti re-elaboration based on the "Fourth Assessment Report: Climate Change 2007", IPCC, 2007

The **main effect** of the increase in the concentration of greenhouse gas can be seen, therefore, in the increase in terrestrial temperature. Again in this case, the IPCC estimates that the impact of human activity is absolutely significant:

- The net average global effect of human activity from 1750 was the cause of warming with a radiative forcing of +1.6 Wm^{-2};
- The radiative forcing of CO_2 increased 20% from 1995 to 2005, the largest positive increase recorded in any decade, at least in the last 200 years.

As a term of comparison, it is estimated that changes in solar radiation from 1750 have produced a radiative forcing of +0.12 Wm^{-2}.

Figure 12. Temperature change: natural causes and of anthropogenic origin



Source: http://www.metoffice.gov.uk

The scientific evidence summarized briefly above would seem to point to greenhouse gas -and the significant increase in its emission into the atmosphere – as being the primary factor in the destabilization of the terrestrial climate.

As mentioned at the beginning of this chapter, coupled with the dizzying increase in the concentration of these gases, are

22 *$CO_{2\text{-eq}}$ is the universal unit of measurement used to indicate the Global Worning Potential (GWP) of each of the 6 greenhouse gases. It is used to evaluate the impacts of realising (or avoiding the release of) different greenhouse gases*

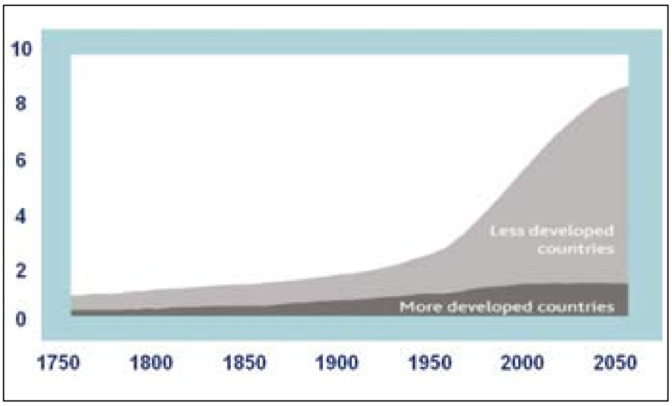
nonetheless a number of factors that are demographic, economic and social in nature. The next section will provide a brief summary of the key aspects.

1.2.2 Factors impacting on the increase of greenhouse gas emissions

The increase in world population that has been seen over the 20th century (from under 2 billion people in the early 1900s to over 6 billion currently) has generated enormous pressure on natural resources on a global scale and has led to an increase in exploitation of the land for agricultural use (only partially offset by technological and production advances that over the century has made it possible to significantly boost yield levels per cultivated hectare) and world water resources (regarding this, see the Position Paper on Water Management produced by the Barilla Center for Food and Nutrition in March 2009).

If we look to the future, the phenomenon of increasing population appears to be an indispensable factor to be considered carefully in relation to its effects on greenhouse gas emissions. In fact, the growth trend shows no sign of stopping and current estimates speak of a world population that could be 9 billion inhabitants by 2050.

Figure 13. World population (in billions)



Source: The European House-Ambrosetti re-elaboration based on data from UN, World Population Prospects, 2007

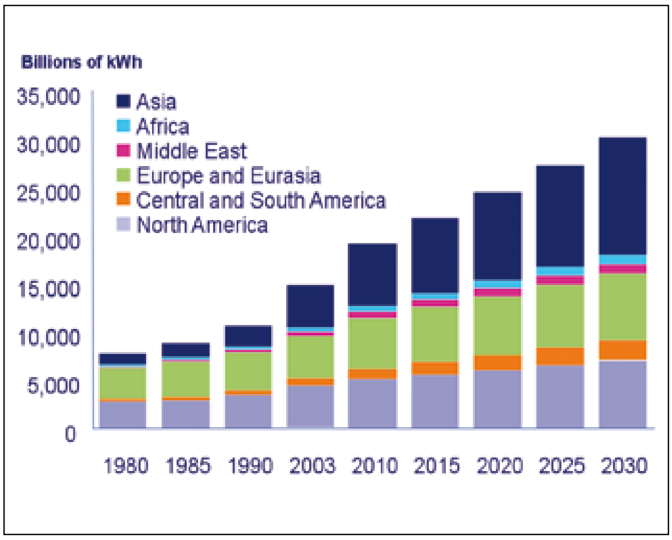
The increase in world population has gone hand-in-hand with the increase in demand for goods and services and, therefore, world production, with a resulting increase in greenhouse gas emissions tied to industrial activity (see the previous section for quantification of the impact of this activity on global emissions). Again, here, the trend shows no indication that it will stop, at least not in the long-term, and it is expected that in 2050 the world will be 4-5 times richer than at the current moment.

The increase in population and the increase in world production, linked to an increasingly consumer-based lifestyle and definable as "energy intensive", have caused a noticeable **increase** in **world energy demand**.

To satisfy this demand, use has been made primarily of non-renewable energy sources basically tied to the extraction and refining of petroleum. This activity has a highly-negative impact on the environment since it is the primary cause of greenhouse gas emissions into the atmosphere on a worldwide level.

Once again here, forecasts for the future do not seem to be reassuring in terms of impact of human activity on the environment. Global demand for energy is, in fact, growing at an increasingly rapid rate, especially due to the contribution of emerging countries in Asia.

Figure 14. World energy demand, 1980-2030



The geographical division of world consumption shows that the relative weight of consumption from areas such as North America (Canada and the United States) and Europe continues to decrease, against absolute and relative growth in all other areas, Asia in particular. This phenomenon is the result of different growth trends: much higher than the average in emerging areas in Asia, and much lower in already-industrialized areas, in Europe and North America.

It has been estimated that **world energy demand will increase by 45%** between now and the year 2030 (average annual increase of 1.6%). It is believed that non-OECD countries, especially China and India, will account for **87% of this increase**[23].

1.3 Potential future scenarios

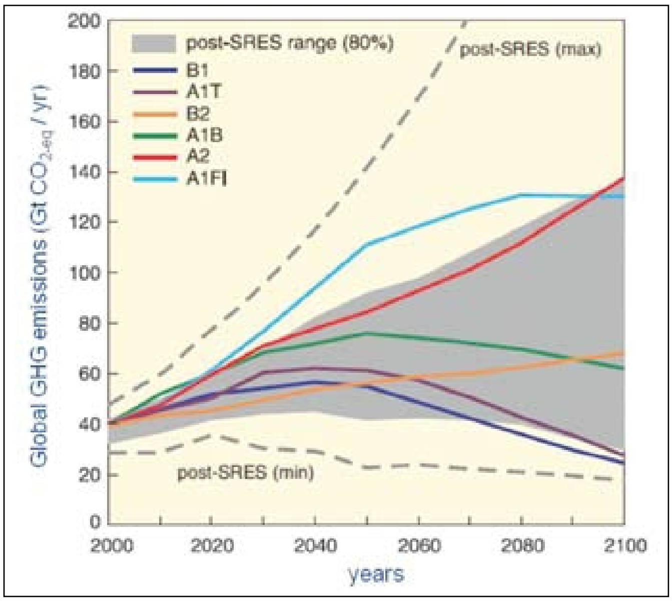
The most recent IPCC report confirms that future climate changes do not only involve rising temperatures, but also cause changes in the entire climate system with serious repercussions on ecosystems and human activity.

23 Source: IEA

However, the forecast impact must be considered together with future demographic, economic and technological developments, above all when the estimates involve a long-term scenario. The potential developments of these factors, as mentioned, interact with the physical transformations in the atmosphere and have been described and summarized by the IPCC in four related groups of scenarios:

- A1 scenarios: assumes a world characterized by a very rapid increase in population reaching its maximum level towards mid-century and then beginning to decline; rapid economic growth; rapid introduction of innovative and more efficient technologies. This group of scenarios develops along three distinct lines which provide alternative directions in technological change of the energy system, from intense use of fossil fuels (A1F1) to non-fossil energy sources (A1T), or balanced use of the various sources (A1B).
- A2 scenarios: depict a very heterogeneous world characterized by continuous population growth, slow and more fragmented economic development essentially on a regional basis, and very fragmented technological changes that are slower compared with other scenarios. The main characteristic of this group of scenarios is self-sufficiency and preservation of local identity.
- B1 scenarios: describe a population trend similar to that of the A1 scenario group, but with a rapid transformation of economic structures towards an information and service economy, with reductions in the intensity of materials and introduction of clean technologies that make more efficient use of resources. These scenarios emphasize the development of global solutions for environmental, social and economic sustainability, including from a more equitable perspective.
- B2 scenarios: depict a growing population trend, but at rates lower than those in the A2 scenarios. The economic growth forecast is at an intermediate rate and the technological changes more diversified and less dynamic compared to scenarios B1 and A1. This group of scenarios, especially oriented towards environmental protection and social equity, emphasize a world oriented towards sustainability and adoption of local and regional solutions.

Figure 15. Level of global GHG emissions in the IPCC's various SRES (Special Report on Emission Scenarios)[24] 2000-2100



Source: "Fourth Assessment Report: Climate Change 2007", IPCC, 2007

The scenarios outlined by the IPCC forecast a rise in global GHG emissions[25] including a range of 9.7 to 36.7 million tons of $CO_{2\text{-eq}}$ between 2000 and 2030.

These scenarios predict that **fossil fuels will maintain their dominant position in the global energy mix to 2030 and beyond**. As a result, CO_2 emissions deriving from energy consumption will increase by 40%-110%, between 2000 and 2030.

Starting from these considerations, the simulation models indicate that phenomena generally in line with those already observed[26] will be noted:

A. Increase in **temperature**;
B. Melting and decrease of the land and marine surfaces covered by **ice**;
C. Rise in the **sea level**;
D. Variation in the **pluviometric regime (precipitation)**.

A. Increase in temperature

Correlating exactly greenhouse gas emission levels hypothesized in the IPCC scenarios to the average increase in global temperatures is very complex because science has no certain knowledge of the sensitivity[27] of the climate system.

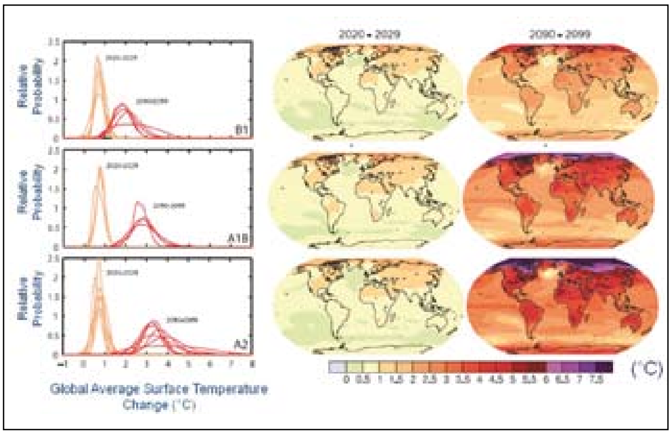
24 The area highlighted in grey represents the 80th percentile of the scenarios published subsequently to IPCC's SRES (post-SRES); the dotted line highlights the complete range of post-SRES. For additional information, please refer to the Fourth Assessment Report: Climate Change 2007, IPCC, 2007
25 Forecast increases over the baseline
26 This section will present only a brief summary of the main phenomena. For additional information, please refer to the Fourth Assessment Report: Climate Change 2007, IPCC, 2007
27 Sensitivity is defined as long-term average global warming following doubling of CO_2 concentrations of approx. 278 ppm compared with pre-industrial levels

Nonetheless, according to the most recent IPCC report, warming forecasts for the various emission scenarios define as the "best estimate" for the low scenario (B1) an increase of 1.8 °C and the best estimate for the high scenario (A1F1) 4 °C by the end of the 21st century.

Specifically in terms of Europe, the scenarios estimate an increase in average temperatures between 2.0 °C and 6.2 °C, therefore, values decidedly higher than the world average.

The forecast rise in average temperatures that involve above all southern Mediterranean countries (and, as a result, the central-southern areas of Italy) will cause increasingly frequent heat waves and marked decrease in precipitation.

Figure 16. Forecast changes in temperature in the first part (2020-2029) and second part (2090-2099) of the 21st century on the basis of three different SRES (variations hypothesized compared with average levels recorded during the period 1980-1999)



Source: "Fourth Assessment Report: Climate Change 2007", IPCC, 2007

B. Melting and decrease of ice and snow cover

In line with what has been observed to-date, all forecast scenarios indicate a further melting of terrestrial and marine surfaces covered by permanent or seasonal ice.

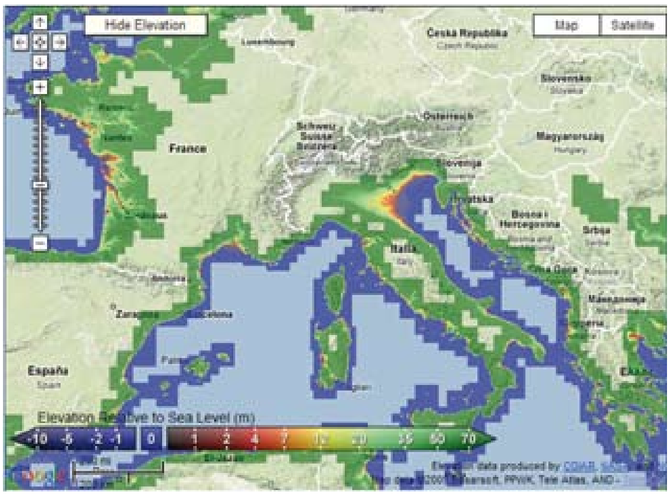
According to some forecasts, towards the end of the 21st century, Arctic marine ice will almost completely disappear[28].

C. Rise in the sea level

In terms of average global sea levels for the period 2070-2099,[29] they hypothesize a rise of between 0.09 and 0.88 meters with a rise in levels even higher in Europe and specifically in the Mediterranean area.[30]

According to the ENEA, the rise in the level of the Mediterranean Sea could remain between 18-30 cm for the year 2090. The main problems for coastal areas will consist of erosion and coastline instability.

Figure 17. Areas most vulnerable to a potential rise in sea level - Italy, 2100



Source: Google, Sea Level Rise Explorer based on data from NASA, CGIAR (Consortium for Spatial Information)

D. Precipitation

Although they still possess high levels of uncertainty, climate simulation models for the 21st century all forecast an across-the-board increase in precipitation at higher latitudes and a decrease in some sub-tropical regions and mid-latitudes.

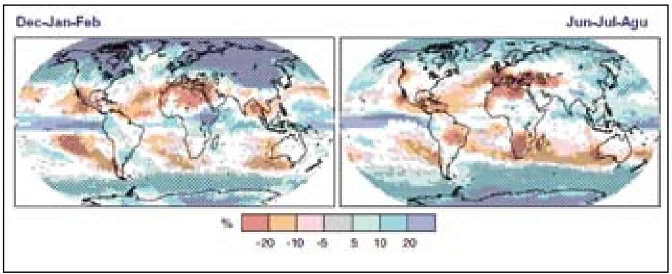
The changes in precipitation forecast indicate that they will increase in high latitudes (e.g., North America) and diminish drastically (up to approx. 20% by 2100) in sub-tropical regions.

For Europe, in northern areas, an annual increase of about 1-2% per decade is forecast, while for southern areas, reductions of about 5% are foreseen.

Forecasts also indicate that the paths of cyclones outside tropical areas will move towards the poles, with resulting variation in the structure of winds, precipitation and temperature.

28 *At the end of the summer season*
29 *Compared with the climate period 1961-1990*
30 *This is predicted in the event of the collapse of the Atlantic Meridional Overturning Circulation (MOC). Source: IPCC 2007; "Cambiamenti climatici e strategie di adattamento in Italia. Una valutazione economica", C. Carraro et al., 2008*

Figure 18. Forecast changes in precipitation patterns, 2090-2099 (with respect to the period 1980-1999)



Fonte: "Fourth Assessment Report: Climate Change 2007", IPCC, 2007

The scenarios outlined are unquestionably worrying. In order to prevent consequences that are irreversible and particularly risky for natural and human systems, scientists agree that immediate joint action must be taken.

Specifically, action should be taken regarding GHGs emissions in an attempt to limit warming **to "safe" levels which, under current conditions, have been set at within +2 °C**[31].

Higher warming levels, often defined as "points of no return", will have "highly destabilizing" effects that dangerously interfere with systems, sectors and regions.

Figure 19. Future implications for climate change according to various global warming hypotheses in a range of sectors

	1,5-2,0 °C	2,0-2,5 °C	> 2,5 °C
Ecosistems and biodiversity	Rising number of species face extinction (0-15% of the existing species); extensive damage to coral reefs	Significant losses in flora and fauna (especially in Southern Africa australe and Northern Australia)	Extinction risk for 20-30% of plant species and existing animals; Amazon rainforest losses (20-80%)
Food	Falling crop yields in many areas, particularly developing regions. Possible rising in some high latitude regions	-5% production of wheat, mais (India) and rice (Cina); Losses in the agricultural sectors in insular regions	Falling yields at a global level
Coasts	Rising intensity of storms, forest fires, droughts, flooding and heat waves	Growing damages	Growing damages
Health	Increasing burden from infectious diseases caused by the changed distribution of some disease vectors	Growing damages	Growing damages
Water	Decreasing water availability for several million people: -80% of Himalayan glaciers	Increasing number of people exposed to water shortages	2 milioni di persone esposti al rischio di maggiori carenze idriche
Sea Level	Increasing risk of Greenland's glaciers melting ; Sea level rise for 0.3-1.2m per century	Sea level rise of 0.5m within 2100	Sea level increase of 2-7m Possible significant losses of the western part of the Antarctic glaciers

Source: The European House-Ambrosetti re-elaboration based on the "Fourth Assessment Report: Climate Change 2007", IPCC, 2007

1.4 Economic evaluation of the impact of climate change

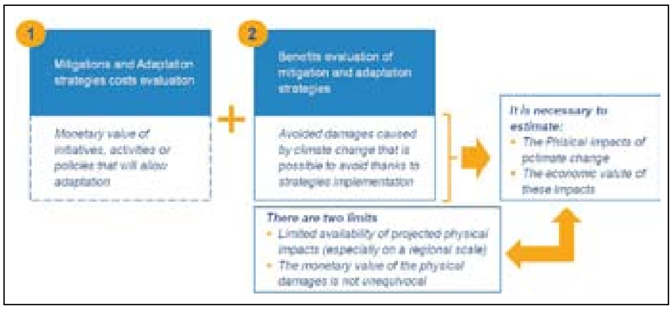
Climate change has a direct impact on the environment and, as a consequences, generates repercussions on the economy and society as a whole.

The economic and social costs (drop in wealth) tied to climate change not only have direct impact, but can also trigger others, such as prevention (costs to lessen the impact) and adaptation of the population to a new environmental context (adaptation costs).

Despite the obvious difficulties in calculating it, economic impact is the most effective tool for measuring and understanding this phenomenon.

Some international bodies and research groups have utilized models for evaluating economic and social impact (current and future) caused by climate change.

Figure 20. Reference framework for evaluating economic impact



Source: The European House-Ambrosetti based on data taken from Cambiamenti climatici e strategie di adattamento in Italia. Una valutazione economica, C. Carraro, et al., 2008

These models reference a common framework that form the basis of methodologies developed for various specific contexts. In fact, the various analyses of this issue are based on common elements and were performed using a calculation method that includes elements related both to calculation and forecast areas (e.g., sea and ocean levels, energy use, impact on agriculture, water availability, impact on health, the ecosystem and biodiversity and natural phenomena), as well as calculation tools, such as the discount rate method, time and geographical horizon, cost/benefit analysis and strong/weak point approach.

Although open to criticism and debate in terms of method and results, economic evaluation of the impact of climate change is a tool that can assign a measure of value to the phenomenon of climate change and the policies to be implemented. In other words, it could be defined a litmus test for damage caused to the environment and efficacy of environmental protection policies.

The tables below provide an overview of the results of the studies pertaining to alleviating the effects of climate change

31 This data is the result of recent IPCC evaluations and recent studies on this topic (costs for preventing climate change) and the results of studies pertaining to adapting to the effects of climate change (costs for adapting to climate change).

Figure 21. Cost and investment forecasts required for alleviating the effects of climate change

Studies	Estimates
Stern Review	1.000 billion $ a year
OECD (2008)	350 – 3.000 billion $ a year
UNFCCC (2007) (United Nations Framework Convention on Climate Change)	200 – 210 billion $ a year
IEA (2008) (International Energy Agency)	400 – 1.100 billion $ a year
World Bank (2006)	30 – 160 billion $ a year (only for developing countries)

Source: The European House-Ambrosetti elaboration of existing studies

Figure 22. Cost and investment forecasts required for adapting to the effects of climate change

Studies	Estimates
World Bank (2006)	4 – 37 billion $ a year
Oxfam (2007) (Confederation of 13 non-governmental organization)	8 – 33 billion $ a year
UNFCCC (2007) (United Nations Framework Convention on Climate Change)	28 – 67 billion $ (to 2030)
UNDP (2008) (United Nations Development Program)	86 billion $ a year (from 2016)

Source: The European House-Ambrosetti elaboration of existing studies

1.4.1 Costs of action and cost of inaction

Exist reliable solutions that can be implemented to respond to the problem of climate change on the Earth. Total worldwide greenhouse gas emissions are expected to rise by 37% by the year 2030 and 52% by 2050.

If proper action is not taken, the consequences will be dramatic. One billion people will live in areas where water is scarce and premature human deaths caused by the presence of ozone in the troposphere will quadruple.

The OECD predicts that economic growth will double compared with current levels by the year 2030. To counteract the negative effects of CO_2 emissions, the actions taken will cost approx. 2% of the growth in world GDP, considering a 12% increasing in emissions by 2030, as opposed to the 37% forecast.[32] This global cost will be less if countries work together.

In terms of the business sector, the IPCC estimates that if companies paid a price between 10 and 20 euros per t/CO_2 (tons of CO_2) emitted, this would be sufficient to meet the emission reduction terms established.

Figure 23. Intervention policy costs to the business sector

Manufacturing activities	Average product price rise to offset a tax of 20€/tCO_2 in order to maintain companies profitability unchanged
Cement	59.4%
Concrete/Cement	14.5%
Iron, steel and ferroalloys	4.3%
Coke oven products	3.0%
Industrial gases	2.7%
Other inorganic basic chemicals	2.4%
Textiles	2.1%
Fertilizers & nitrogen compounds inc. ammonia	2.0%
Aluminium	2.0%
Paper	2.0%
Rubber	1.6%
Refined petroleum products	1.1%
Household & sanitary goods	0.9%
Copper	0.7%

Source: EU ETS Impacts on profitability and trade, 2007

However, this price increase would have negative effects on business which would see their profit margins fall, and partially on the consumer who would be faced with price increases for certain goods and services.

In terms of international economic growth, on the other hand, a rise in temperature would cause a noticeable drop in GDP growth.

Figure 24. Impact on GDP of a temperature increase of 2.5 °C[33] (in percentage)

Countries	Total	Agriculture	Other vulnerable markets	Coastal	Health	Non-markets	Settlements	Catastrophic impact
United States	-0.45	-0.06	0	-0.11	-0.02	+0.28	-0.1	-0.44
China	-0.22	+0.37	-0.13	-0.07	-0.09	+0.26	-0.05	-0.52
Japan	-0.5	+0.46	0	-0.56	-0.02	+0.31	-0.25	-0.45
OECD Europe	-2.83	-0.49	0	-0.6	-0.02	+0.43	-0.25	-1.91
Russia	+0.65	+0.69	+0.37	-0.09	-0.02	+0.75	-0.05	-0.99
India	-4.93	-1.08	-0.4	-0.09	-0.69	-0.3	-0.1	-2.27
Other high-income	+0.39	+0.95	+0.31	-0.16	-0.02	+0.35	-0.1	-0.94
High-income OPEC	-1.95	0	-0.91	-0.06	-0.23	-0.24	-0.05	-0.46
Eastern Europe	-0.71	-0.46	0	-0.01	-0.02	+0.36	-0.1	-0.47
Other middle-income	-2.44	-1.13	-0.41	-0.04	-0.32	+0.04	-0.1	-0.47
Other lower middle-income	-1.81	-0.04	-0.29	-0.09	-0.32	+0.04	-0.1	-1.01
Africa	-3.91	-0.05	-0.09	-0.02	-3	-0.25	-0.1	-0.39
Other low-income	-2.64	-0.04	-0.46	-0.09	-0.66	-0.2	-0.1	-1.09

Source: Assessing the impacts of climate change, OECD, 2009

Specifically in terms of Italy, evaluation of the costs that Italy will bear for exceeding the limits set in the Kyoto Protocol, leads to an estimate of 3.6 million euros per day; this is equivalent to an annual cost of 1.3 billion euros. Therefore, since January 2008, the green debt that has been accumulated totals 1.85 billion euros, for comparison purposes, equal to the annual GDP of the Province of Enna, the construction of the BreBeMi Highway and six times the funds allocated in 2007 for health research.

32 Source: Environmental Outlook, OECD 2008

33 "Coastal" referes to territories losses caused by coastal drowning - "Non-market time use" refers to the impact of climate change on activities connected with leisure time. "Settlements" refers to those cities and natural and cultural treasures that cannot be moved elsewhere

Figure 25. Forecast of the costs for Italy following overrunning the limits of the Kyoto Protocol

Italy's main problems	Green Debt effects
Low growth	The accumulated Green Debt is equal to the **annual GDP of the Province of Enna**, or **half of the annual GDP of the Province of Aosta**
Inadequate/low infrastructure equipment	The accumulated **Green Debt** is **higher than the cost of the realization of the BreBeMi motorway** (included in the Corridor V), or like the cost of the realization of the Milan's East ring road
Low investments in R&D	The accumulated **Green Debt** is **six times higher that the health research fund** given by the Ministry of Labour, Health and Social Policies in 2007

Source: The European House-Ambrosetti re-elaboration based on data from Kyoto Club, 2009

The table below summarizes the main effects of climate change in Italy on the basis of the country's geographical characteristics.

Figure 26. Economic impacts of climate change in Italy

Alps Regions	Areas at risk of desertification	Coastal areas and marine resources	Hydro-geologic system
• In a 2 °C temperature increase scenario, skiing activities will be possible only in 60% of the currently available infrastructure on the Italian side of the Alps → average economic losses for 35 billion € • Average changes in the tourist expenses caused by the climate change (% difference compared to a situation without climate change): -10.2% in 2030 and -10.8% in 2090 → average profitability decrease included between 0.3% and 15.7% to 2030	• Productivity losses due to a higher soil erosion in arid areas: degrade of pasturelands, non-irrigated and irrigated lands • Damages increase for the higher number of fire • GDP from agriculture sector average annual losses between 2% and10% • → Applying to Italy other studies on desertification losses, is possible to estimate an average annual cost included between 60 and 412 million dollars (related to an area of 16,500 km^2 considered at risk of desertification)	• Significant economic impacts due to the possible increase of coastal flooding, which could affect 2.5 million people in Europe every year (A1FI IPCC scenario) → national studies are still incomplete and are mainly based on qualitative effects rather than quantitative • Negative impacts related to coastal erosion phenomenon, with damages on tourism activities • Negative impacts for fishing activities related to the negative impacts on biodiversity	• It is estimated that between 1998-2002 Europe experienced more than 100 floods, with at least 25 billion € losses due to damages • Italy, from 1939 to 2004, experienced 28 floods which have caused 23.7 billion $ damages: increase probability of these phenomenon is one of the climate change effects and cause of negative economic impacts • Negative impacts caused by landslides and hydro-geological instability

Source: The European House-Ambrosetti re-elaboration from "Cambiamenti climatici e strategie di adattamento in Italia. Una valutazione economica", C. Carraro et al., 2008

1.5 Emergence of a renewed public environmental awareness

In order to analyze public awareness of the issue of climate change, data from Eurobarometer, a survey undertaken by a number of specialized institutes for the European Commission, have been analyzed.

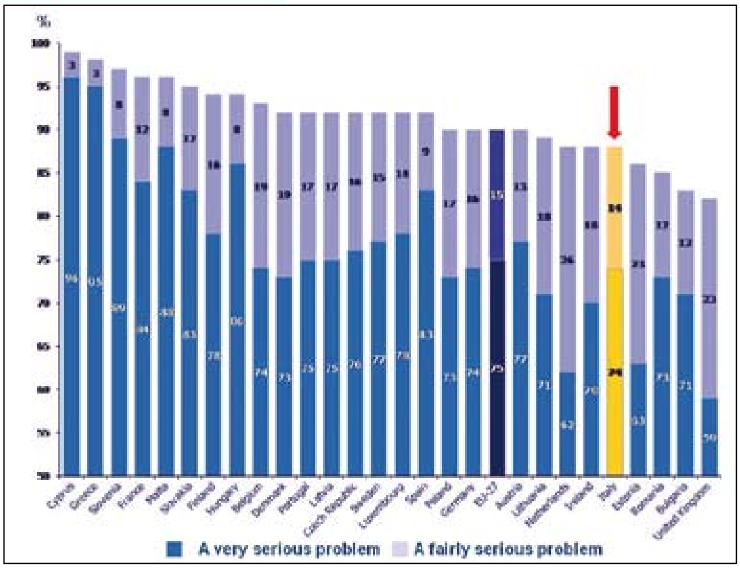
The most recent survey[34] found that:

- Approx. **75%** of those interviewed from the EU-27 area **believe climate change to be a very serious problem** (as opposed to only 7% of those interviewed who consider it a not very serious problem);
- **78%** of those interviewed from the EU-27 area **believe that environmental problems have a direct effect on their daily lives**;
- **75%** of those interviewed from the EU-27 area would be **willing to purchase eco-friendly products, even if they cost more** than other analogous products on the market;
- **96%** of those interviewed from the EU-27 area believe that, aside from any economic consideration, **protecting the environment is fundamental**;

Examining this data on a nation-by-nation basis, we discover that 9 people out of 10 interviewed in Greece and Cyprus perceive climate change as a "very serious" problem. On the contrary, English and Estonian do not consider climate change in the same way. In these countries, in fact, more than 1 citizen out of 10 responded that "it is not a serious problem".

In Italy 74% of the population consider climate change a very serious problem and 14% a fairly serious one. Only 11% of the population believe that it is not a serious problem.

Figure 27. Percentage of European citizens who believe that climate change is a serious problem[35]



Source: The European House-Ambrosetti re-elaboration based from Eurobarometer, "Europeans' attitudes towards climate change", European Commission, March 2008

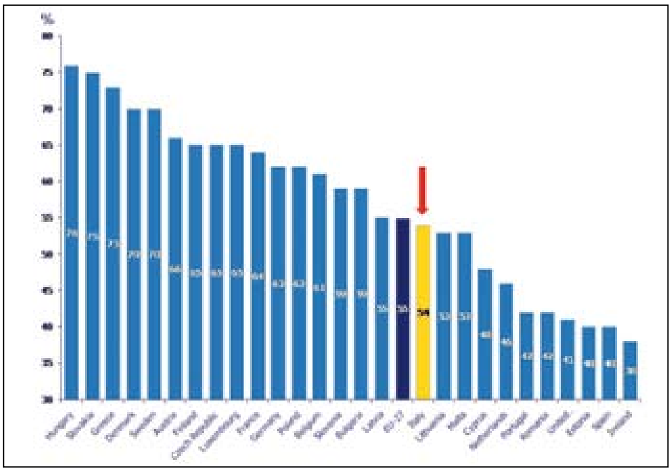
34 *Eurobarometer: "Europeans' attitudes towards climate change"; "Attitudes of European citizens towards the environment", European Commission, March September 2008*

35 *To the question about the level of seriousness of climate change, European citizens interviewed had the option of answering: "very serious", "somewhat serious", "not serious", "no opinion"*

Questioning European citizens about the **causes of climate changes**, we note that 55% are aware of the impact caused by CO_2. 30% believe the impact is of marginal importance, while the remaining 15% of the population has no opinion.

Hungarians, Slovakians and Greeks are convinced that CO_2 has a **significant impact** on processes that cause climate change. On the contrary, the Dutch, Britons and Irish believe that CO_2 emissions have only marginal impact.

Figure 28. Percentage of European citizens who believe that CO_2 emissions are responsible for climate change[36]



Source: The European House-Ambrosetti re-elaboration based on "Europeans' attitudes towards climate change", Eurobarometer, March 2008

The majority of Europeans believe that industry, government, citizens or the EU are doing enough to fight the climate change underway. Specifically, three citizens out of four (76% of the European population) are openly critical of industry.

The action taken by the EU is the area least known (25%), but the percentage of those interviewed which has "no opinion" about it is the highest.

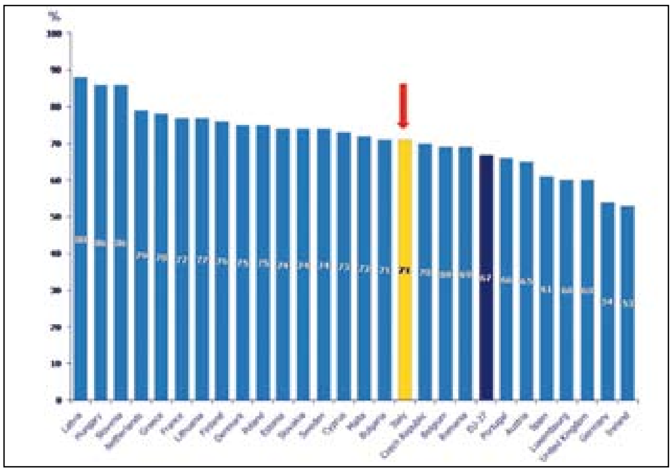
Figure 29. Players involved in the fight against climate change

	Industry	Citizens	Governments	EU
Not doing enough	76%	67%	64%	58%
Doing about the right amount	14%	23%	24%	25%
Doing too much	2%	2%	4%	3%
Don not know	8%	8%	8%	14%

Source: The European House-Ambrosetti re-elaboration based on "Europeans' attitudes towards climate change", Eurobarometer, March 2008

67% of those interviewed believe that citizens are not doing enough to combat climate change. This percentage reaches a level of nearly 90% in eastern countries. Germans (41%), Luxembourgers (31%) and Britons (30%), on the other hand, consider their contribution to be equitable[37].

Figure 30. Percentage of European citizens who believe that citizens are not contributing enough in the fight against climate change



Source: The European House-Ambrosetti re-elaboration based on "Europeans' attitudes towards climate change", Eurobarometer, March 2008

Among the **measures adopted** for fighting the changes underway, the ones cited most often by those interviewed were:

- waste recycling (76%);
- reducing energy consumption in their own homes (64%);
- reducing water consumption in their own homes (55%);
- reducing consumption of disposable products (40%).

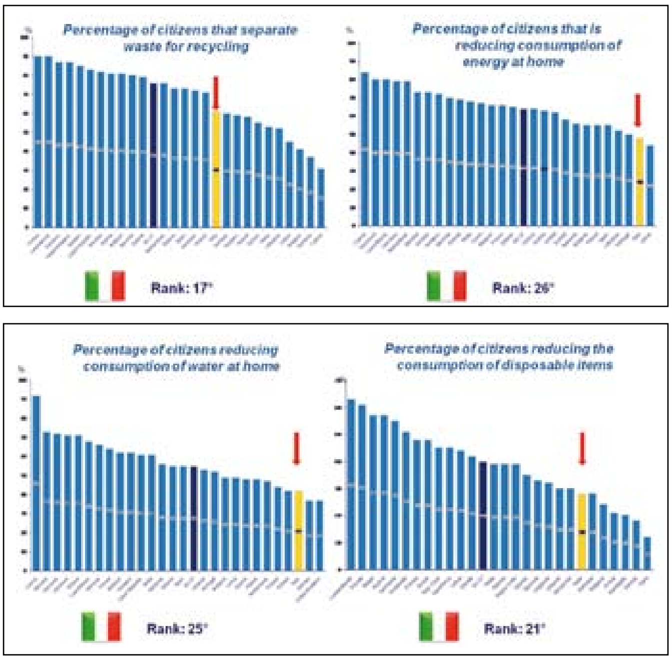
These four measures share a number of common characteristics: they are simple to implement, do not involve additional costs and make it possible to save.

Although to a lesser degree, changes in behavior in the transport sector have begun to represent a significant part of actions taken (28%), as has the purchase of local and seasonal products (27%).

36 *The question was posed in the following terms: "Emission of CO_2 has only a marginal impact on climate change?". The chart shows the percentage of people that does not agree with the statement*

37 *In the survey, an equitable contribution is defined as "the right amount"*

Figure 31. Actions taken by European citizens to fight climate change



Source: The European House-Ambrosetti re-elaboration based on "Europeans' attitudes towards climate change", Eurobarometer, March 2008

European awareness of environmental issues is not a new phenomenon. Despite the fact that the type of questions posed in the survey to citizens has changed over time, making it impossible to perform a direct comparison, a trend can be traced for two types of topics which, between 1986 and 1995, have remained virtually unchanged:

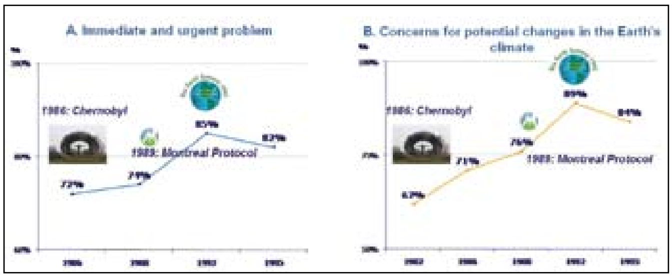
- the urgency of the problem of environmental protection ("immediate and urgent", "a problem for the future", "it is not a problem");
- the knowledge of the potential changes in the terrestrial climate caused by carbon dioxide.

Considering the evolution of the answers with the major events occurred during the period (Figure 32), it can be seen that the attention of European citizens towards the environment has evolved following and in line with (for example) the:

- Chernobyl incident;
- Entry into force of the Montreal Protocol;
- Rio Summit (Rio de Janeiro, Brazil. June 3-14, 1992), the most well-known international conference on environmental issues.

Reduced attention to environmental issues during the years 1994-1995 is probably due to media and international organizations focus of on terrorism[38].

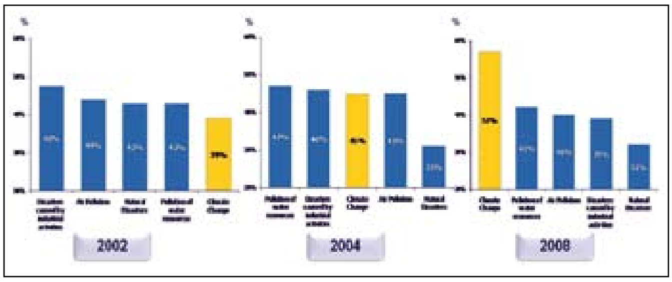
Figure 32. Changes in awareness: 1986-1995



Source: The European House-Ambrosetti re-elaboration of data from Eurobarometer, "Europeans and the Environment", 1982-1995

Subsequently, in surveys conducted in 2002, 2004 and 2008, perception of climate change as a source of preoccupation for potential generated impact on the environment rose from 5th to 1st position.

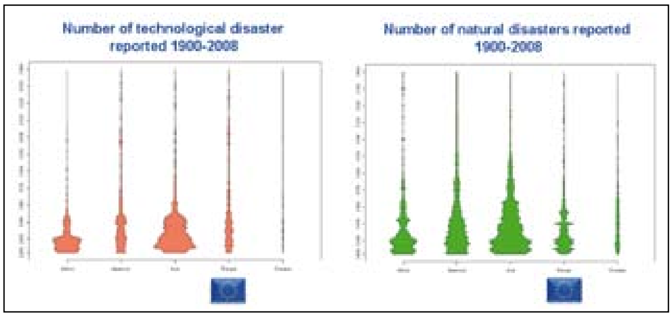
Figure 33. Changes in perception of European citizens regarding certain factors of risk for the environment, 2002, 2004, 2008[39]



Source: The European House-Ambrosetti re-elaboration of data from Eurobarometer, "Europeans and the Environment", 1982-1995

As can be seen in Figure 33, in the period in question, attention towards industrial and natural disaster remained particularly high. This is because, as can be seen in the figure below (Figure 34), the last decades of the 1900s and the first years of the 21st century were characterized by a greater frequency of these phenomena.

Figure 34. Trends in the incidence of industrial and natural disasters, 1900-2008



Source: EM-DAT data Emergency Events Database

38 1994 marked the signing of the UN Declaration on measures to combat terrorism; in addition, during 1995, there were two major attacks, one in the Tokyo subway and the other in the Paris Métro

39 Note: The total is more than 100% because multiple responses were allowed for the questions asked

Following the tsunami which hit the Indian Ocean in 2004 and Hurricane Katrina which, in 2006, hit the United States, the mass media began to connect these natural catastrophes with climate change. In addition, many scientists who, until that time, had been somewhat skeptical, began to consider the role of man in global warming..

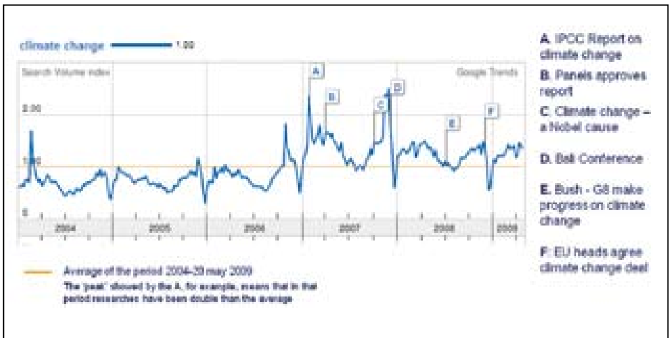
2007 was the year that saw climate change emerge as the key issue in international debate. On October 12th of that year, the UN body assigned to study climate change, the IPCC, together with former US Vice President Al Gore, were awarded the Nobel Prize for Peace. The award dedication read:

"for their efforts to build up and disseminate greater knowledge about man-made climate change, and to lay he foundations for the measures that are needed to counteract such change"

In December of the same year, during the summit of the thirteenth UN Climate Change Conference (COP 13) held in Bali, the international community created the basis for defining a new strategy against global climate change.

The Nobel Prize and the echo of the Bali Conference sanctioned the growing importance of the debate which continues to involve the international community and, at the same time, the growing attention of public opinion for the potentially catastrophic consequences of climate change.

Figure 35. Average global traffic for the phrase "climate change" on the Google search motor[40]



Source: Google Trends, May 2009

2. THE CARBON FOOTPRINT AND ECOLOGICAL FOOTPRINT

2.1 The Carbon Footprint

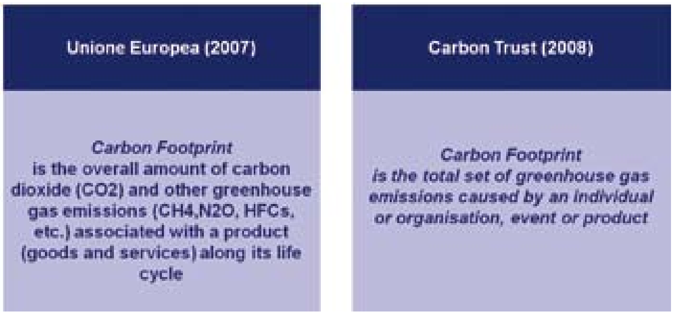
2.1.1 Introduction and definition of the Carbon Footprint

The term "Carbon Footprint" (CF) is spreading rapidly in the media throughout the world because the issues tied to climate change have taken on major relevance in international political debate.

Despite the growing spread of the term, there isn't a comonly accepted definition of Carbon Footprint, nor on how it should be calculated[41].

Recently, both the European Union[42] and the Carbon Trust[43] have attempted to define the concept of Carbon Footprint in a tangible and comprehensive manner on the basis of scientific studies carried out in recent years.

Figure 36. Definition of carbon footprint adopted by the EU and the Carbon Trust



Source: European Union, Joint Research Centre Institute for Environment and Sustainability, 2007; Carbon Trust, 2008

As can be seen, the two definitions are very similar and the current trend in theoretical scientific literature (as well as in empirical studies) is to adopt one of these two definitions.

For example, and in line with the definitions provided by the EU and Carbon Trust, some activities responsible for the increase in greenhouse gases are:

- electrical energy production;
- fuel consumption (petroleum, diesel fuel, methane, naphtha, etc.);
- burning of waste products;
- heating and cooling of air and water;
- mining;
- use of fertilizers in agriculture;
- crop cultivation and animal husbandry;
- irrigation of fields;

40 *Note: The scale is based on the average search traffic for this term. The "Y" axis is the numerical scale. "1" represents the index of the average number of searches during the period under examination*
41 *Wackernagel M., Rees W.E., "Our Ecological Footprint - Reducing Human Impact on the Earth", New Society Publishers Gabriola Island, Canada, 1996*
42 *European Union, Joint Research Centre Institute for Environment and Sustainability, 2007*
43 *Carbon Trust, 2008 (www.carbontrust.co.uk) . Note: Carbon Trust is a private agency with public ains established in 2001 by the english government. The Carbon Trust mission is to accelerate the move to a low Carbon Economy*

- use of means of transportation for personal travel;
- manufacturing;
- lighting of public and private places;
- pharmaceutical production;
- organizing events, concerts and demonstrations.

However, alternative definitions of Carbon Footprint do exist and have been adopted by international research bodies, sector researchers, political institutions and private companies.

Figure 37. Alternative definitions of carbon footprint

Source	Definition
British Petroleum	It represents the amount of carbon dioxide emitted due to human beings daily activities
Energetics	It is the total amount of CO_2 direct and indirect emissions produced by human activities
Environmental Technology Action Plan (ETAP)	It is a measure of the impact of human activities on the environment in terms of the amount of greenhouse gases produced, measured in units of carbon dioxide
Global Footprint Network	It is the demand on biocapacity required to sequester (through photosynthesis) the carbon dioxide (CO_2) emissions from fossil fuel combustion
Grub & Ellis	It is a measure of the amount of carbon dioxide emitted through the combustion of fossil fuels
Parliament Office of Science and Technology (UK)	A 'carbon footprint' is the total amount of CO2 and other greenhouse gases, emitted over the full life cycle of a process or product. It is expressed as grams of CO2 equivalent per kilowatt hour of generation
Carbon Trust (definizione del 2007)	It is a methodology to estimate the total emission of greenhouse gases (GHG) in carbon equivalents from a product across its life cycle from the production of raw material used in its manufacture, to disposal of the finished product (excluding in-use emissions).

Source: The European House-Ambrosetti review of recent scientific literature publications

As can be seen in the table above, carbon footprint varies from total CO_2 emissions alone generated by human activity or use of fossil fuels, to all greenhouse gases in CO_2 equivalents, i.e., conversion of greenhouse gases into CO_2 traceable to the entire manufacturing and consumption process of a product or service and the biocapacity required to absorb CO_2 emission equivalents through photosynthesis.

The various interpretations of the carbon footprint concept continue to co-exist and it does not seem that there are any data or scientific results that would lead to definitive preference of one definition over another.

In fact, on a scientific level, the conversion of greenhouse gases CH_4, N_2O, SF_6, HFCs and PFCs into CO_2 equivalents gives rise to some strong criticism because:

- the emissions data for these gases are not very reliable;
- as can be seen from their chemical equations, these gases are not formed by carbon molecules and, as a result, are not perfectly comparable to CO_2 equivalents.

For these reasons, the Carbon Footprint differs appreciably between the various bodies and organizations that measure it[44].

Once again, from a scientific standpoint, there is no commonly-shared methodology for Carbon Footprint conversion in terms of the square meters of earth required to absorb total emissions. In fact, the total CO_2 produced is measured in terms of kilograms and tons and there is no conversion between these units of measure into square hectares, meters and kilometers.

Introducing conversion rates between greenhouse gases and carbon dioxide and between the latter and square meters of earth increases uncertainty about the measurement of the Carbon Footprint which loses its specifically "carbon" identification to become more a "Climate Footprint" indicator.

Even if a common definition of Carbon Footprint doesn't exist, and neither a univocal interpretation and calculation methodology, the European Union and the Carbon Footprint proposals on this regard are generally recognized.

CO_2 emissions are measured through the **Life Cycle Assessment** (LCA) that is a standardised and internationally recognized methodology. The Life Cycle Assessment evaluates the environmental burdens associated with a product life cycle[45].

The technical guidelines used to developed the Life Cycle Assessment have been set by the *International Organization for Standardization* (ISO) and the European Commission, with the support of the *Joint Research Centre - JRC*[46].

Figure 38. Coefficients for converting greenhouse gas into CO_2 equivalents

Greenhouse Gases	Chemical Formula	GWP100
Carbon Dioxide (CO_2)	CO_2	1
Methane (CH_4)	CH_4	21
Nitrous Oxide (N_2O)	N_2O	310
Hydro Fluorocarbons	HFCs	124 – 14.800
Sulphur Hexafluoride	SF_6	22.800
Perfluorocarbons	PFCs	7.390 – 12.200

Source: European Commission, European Platform of Life Cycle Assessment

Specifically, after having determined the levels of gases emitted throughout the product life cycle, the carbon footprint is calculated utilizing specific indicators such as the Global Warming Potential (GWP). **The GWP represents the effect of the individual greenhouse gas to climate change over a period of 100 years.**[47]

2.1.2 Why measure the Carbon Footprint?

There are two major reasons why the Carbon Footprint is measured:

44 *Energy Information Administration - EIA, World Research Institute - Climate Analysis Indicator Tool, Carbon Dioxide Information Analysis Center, United Nations Framework Convention on Climate Change*

45 *European Environmental Agency, "A Life Cycle Assessment", 1998*

46 *Source: http://lca.jrc.ec.europa.eu*

47 *Definition provided by the Intergovernmental Panel on Climate Change. For GWP data, the conversion coefficients proved by the EU were utilized*

- to contain and manage current emissions with the goal of reducing them in the future in conformity with established environmental policies;
- to distribute and present the data to public bodies and private companies.

From this standpoint, what is essential for governments and supranational bodies, first of all, is to quantify total emissions, subdividing them by source of greenhouse gas emission (transport, electricity, oil combustion, agriculture and industrial processes) and, secondly, determine and identify the priorities and opportunities for reducing them.

For private companies, data for greenhouse gas emissions can be used for marketing purposes in order to present themselves to their increasingly environmentally-sensitive customers as "carbon neutral" and, as a result, present their products as more sustainable than those of competitors.

A carbon neutral company is one with a net carbon footprint equal to zero. To reach a "zero emission" level, a company must find a balance between emissions into the atmosphere from their daily business operations, and subtracting an equivalent amount of greenhouse gas from the atmosphere.

This balancing can occur in the following ways:

- reducing emissions within the company;
- producing amounts of energy from renewable sources (wind, biomass, hydro-electric) equal to energy from non-renewable sources used in the production process;
- utilize financial tools (carbon offsetting) to buy/sell "emissions permits" which certify that a given amount of energy was produced using renewable sources.

Once again in this case, because CO_2 **is not the only substance that impacts on climate change, in this context the term "climate neutral" may also be utilized.**

There are two carbon markets, one compliance-based and the other voluntary. The compliance market is based on the fact that companies, governments and other economic entities **buy "emission permits" to meet the emission limits imposed on them**. In 2007, EU Emission Trading Scheme established itself as the main market of reference for greenhouse gas emission trading. Over **37 billion euros[48] in certificates were bought on this market, equivalent to approx. 2,109 billion tons of CO_2.**

The voluntary market, on the other hand, is based on the fact that individuals, companies and governments **buy certificates to mitigate their own greenhouse gas emissions** deriving from the use of transport vehicles, consumption of electrical energy and from other sources. In 2007, over **190 million euros in certificates were bought on this market, equivalent to approx. 42 million tons of CO_2.**

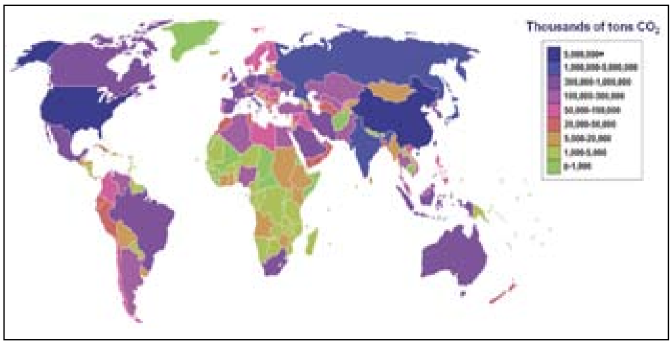
The precondition for trading of emission permits certificates is measurement of greenhouse gas emissions, i.e., measurement of the Carbon Footprint.

2.1.3 Quantitative data for the carbon footprint

In the world as a whole, the United States and China are the countries which emit the most greenhouse gases, with values exceeding 5 billion tons of CO_2 equivalent.

Taken together, the US, China and Europe represent 55% of world emissions of greenhouse gas. If Russia, India and Japan are added, this percentage exceeds 70%.

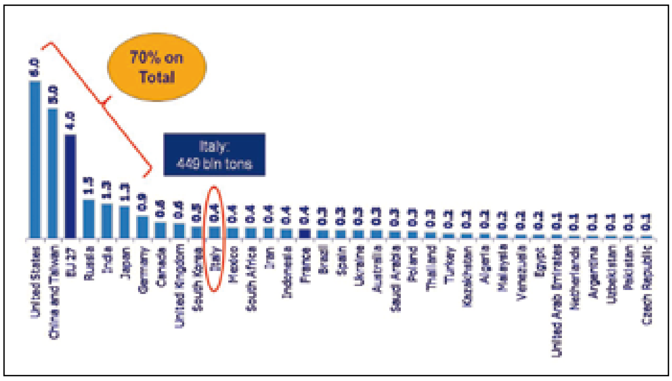
Figure 39. Annual emissions of greenhouse gas in various countries



Source: World Research Institute, Greenhouse Gas Data and International Climate Policy - Climate Analysis Indicator Tool, 2008

Within this context, Italy is in tenth place in the world for absolute emissions of greenhouse gas.

Figure 40. Top-ranking countries in greenhouse gas emissions, in thousands of tons



Source: World Research Institute - Climate Analysis Indicator Tool

48 *The European House-Ambrosetti elaboration based on data from The World Bank, State and Trends of the Carbon Market, Washington, 2008*

In terms of per capita emissions, however, Italy is 46th in the world[49]

Figure 41. Per capita greenhouse gas emissions, in tons

Source: World Research Institute – Climate Analysis Indicator Tool

In analyzing the data relating to the increase in emissions between 1990 and 2006, it emerges that China, the United States and India are the countries most responsible for the increase in greenhouse gas emissions on a worldwide level.

The worldwide change in emissions over the period between 1990 and 2006 was 7.5 billion tons of CO_2 equivalent, of which 5.3 were accounted for by China, India and the United States which, therefore, are **responsible for 70% of the world increase in greenhouse gas emissions over the last 16 years**.

Figure 42. Changes in greenhouse gas emissions for the period 1990 to 2006

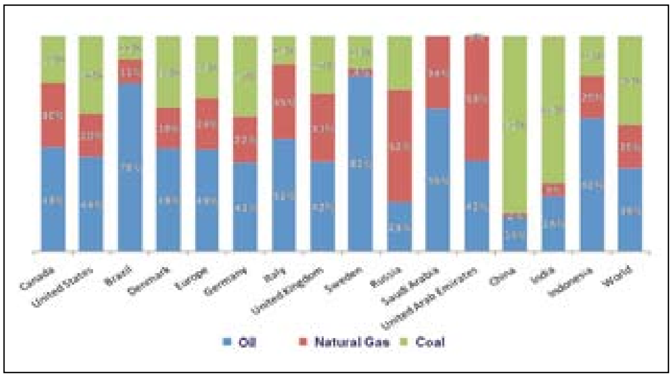
Country	Changes in emissions 1990-2006 (in million tons)	Emission changes in % '90-'06
World	7,512	+35%
China	3,724	162%
USA	874	17%
India	710	122%
South Korea	271	111%
Iran	269	133%
Saudi Arabia	216	104%
Japan	193	18%
Taiwan	182	153%
Thailandia	161	192%
Australia	147	55%
South Africa	143	47%
Brazil	140	59%
Canada	139	29%
Spain	136	57%

Country	Changes in emissions 1990-2006 (in million tons)	Emission changes in % '90-'0
Mexico	133	44%
Indonesia	129	85%
Turkey	106	82%
Malesia	98	151%
Singapore	83	144%
Vietnam	74	430%
United Arab Emirates	70	89%
Argentina	60	58%
Egypt	59	64%
Pakistan	59	87%
Italy	52	13%
France	49	13%
United Kingdom	-19	-3,2%
Germany	-131	-13,3%
Russia	-352	-17%

Source: The European House-Ambrosetti re-elaboration based on data from the Energy Information Administration

One of the major causes linked to the significant increase in emissions in China and India is the concerted economic development they have undergone over the last twenty years, and the prevalent use of **coal** which, **despite technological advances, remains the fossil fuel which emits the most CO_2**.

Figure 43. Energy mix for some countries in 2006



Source: The European House-Ambrosetti re-elaboration based on WRI and EIA data

2.1.4 Potential solutions to reduce greenhouse gas emissions

Changes in the energy mix, renewable sources and improvements in energy efficiency represent the main solution for reducing greenhouse gases[50].

Just consider that a **medium-to-small office consumes 15,000 KWh of electricity each year**, equivalent to emitting 6.5 tons of CO_2 into the atmosphere. Potential solutions include:[51]

- use of wind power. In fact, there currently exist many possibilities for installing wind power systems. Energy production levels are 1 KW for micro wind generators and up to

49 The European House-Ambrosetti re-elaboration based on WRI and EIA data. Those nations with fewer than 100,000 inhabitants were excluded from the ranking. If these countries were also taken into consideration, Italy would be in 59th place. The countries excluded were: Gibraltar, the Virgin Islands, Dutch Antilles, Faroe, Nauru, Pierre and Miquelon, New Caledonia, Guam, Greenland, American Samoa, Bermuda, Antigua and Barbuda, and the Cayman Islands

50 "World Energy Outlook", Energy Technology Perspectives, EIA, 2008

51 Carbon Trust, Renewable energy sources, 2006

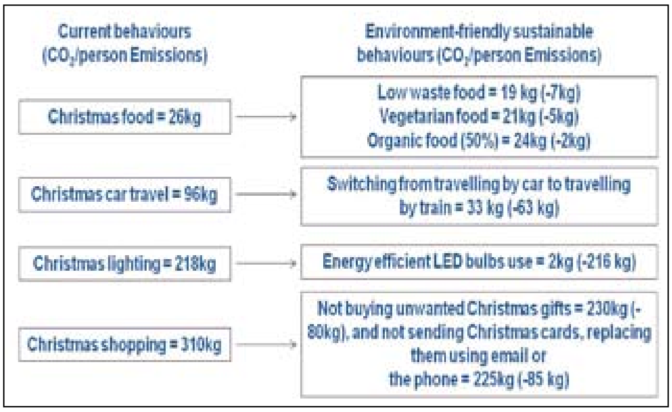
3 MW for turbines. Under normal circumstances, a 6 KWh wind turbine comprised of a rotating blade and a generator produces over 15,000 KWh per year, i.e., the energy requirements for an office;

- use of solar power. Solar panels can be installed on building roofs or ground supports. Energy production depends on a number of factors, including the sun's rays, light spectrum, temperature, etc. A typical solar panel system generates 1.5-2 KW peak per 10-15m^2 of surface area. Under normal circumstances, an office with a surface area of 40m^2 in solar panels on the roof produces over 20% of its annual energy needs.

In addition to renewable energy sources, "more restrained" energy choices also help our planet.

For example, during the **Christmas season** (December 24-26th), **food consumption, travel, purchase of presents** and public and private Christmas **lights produce approx. 650 kg of CO_2, equivalent to 6%-7% of the annual CO_2 emissions of an average European**. Adoption of environment-friendly sustainable behavior would reduce total CO_2 equivalent emissions from the current 650 kg per person to approx. 280 kg per person.

Figure 44. Examples of environment-friendly sustainable behavior



Source: Stockholm Environment Institute, The Carbon Cost of Christmas, 2007

In addition to these specific provisions during the Christmas season, the adoption of other more environment-friendly sustainable behavior (which would also translate into direct monetary savings for citizens), would result in an overall decrease in emissions of around 30%.

Some examples of this type of behavior include:

- setting the thermostat so that heating is shut off at night and when no one is in the house → 440 kg of CO_2;
- installing double-glazed windows → 350 kg of CO_2;
- insuring that windows and doors in the home provide good insulation → 650 kg of CO_2;
- purchasing class A appliances → 210 kg of CO_2;
- turning off room lights when they are not needed → 270 kg of CO_2;
- replacing incandescent bulbs with low-consumption ones → 250 kg of CO_2;
- only running the washing machine with a full load → 45 kg of CO_2;
- only boiling the actual amount of water required for hot drinks → 25 kg of CO_2;
- torn-off water while brushing teeth → 3 kg of CO_2;
- utilizing reusable shopping bags → 8 kg of CO_2;
- only printing documents actually required → 7 kg of CO_2;
- purchasing cars with low fuel consumption → 660 kg of CO_2;
- checking that tire pressure is correct → 140 kg of CO_2.

Annual per capita emissions in Europe are approximately 10 tons. **Adopting these measures** would produce a **reduction of 30% in greenhouse gas emissions**, equivalent to 3 tons per capita, and would also have unquestionable benefits for the family budget.

2.2 The Ecological Footprint: global results, international comparisons and future scenarios

The Ecological Footprint is a statistical measure that compares human consumption of natural resources with the ability of our planet to regenerate them. This index **measures the biologically productive area (of sea and land) required to produce the resources consumed by man and to absorb the waste generated.**[52]

In calculating the Ecological Footprint, **six major types of land are taken into consideration**:

- **cropland**: arable surface area utilized for production of food and other goods;
- **grazing land**: land used for raising animals;
- **forest**: land used for production of wood and paper;
- **built-up land**: land used for housing development, industrial areas, service areas, transport infrastructure, etc.;
- **fishing ground**: marine surface area used for growth of fishing resources;
- **energy land**: forest area required to absorb the carbon dioxide produced by the use of fossil fuels.

A common measure is applied to these various surfaces and each is weighted proportionally on the basis of its worldwide average productivity. Specifically, to calculate the Ecological Footprint for a **range of types of consumption**, the amount of each good consumed is compared (for example, wheat, rice, corn, grains, meat, fruit, vegetables, root vegetables, legumes, etc.) with a yield constant expressed in kg/ha (kilograms per hectare). The result of the equation is a surface area.

52 The Ecological Footprint concept was developed in the first half of the 1990s by ecologist William Rees of British Columbia University and later elaborated, applied and widely diffused internationally by Mathis Wackernagel, currently director of the Ecological Footprint Network. Starting in 2000, the WWF regularly updates calculations of the Ecological Footprint in its biennial Living Planet Report, utilizing data prepared by the Ecological Footprint Network

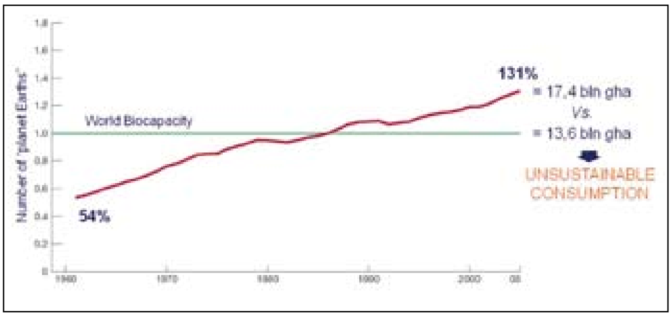
To calculate the impact of energy consumption, it is converted into equivalent tons of carbon dioxide and this calculation is made taking into consideration the amount of forest area required to absorb the amount of tons of CO_2 involved.

The sum of these various components provides the "equivalent area" required to produce the amount of biomass utilized by a given population, measured in "global hectares" (gha).

As can be seen in the figure below, in 1961, humanity used just 54% of the overall capacity of the Earth, while in 2005 (the most recent year for which figures are available), this figure was 131%. This means that mankind is consuming more environmental resources (equivalent to 17.4 billion global hectares each year) than it should (13.6 billion global hectares, which represents the global capacity of the biosphere). In other words, mankind is drawing on its own natural capital.

Humanity has been in a situation of ecological overshoot starting from the mid-1980s and this situation would appear to be unsustainable given that it implies a progressive impoverishment of the planet that could challenge man's consumption levels in the near future.

Figure 45. Ecological Footprint of mankind, 1961-2005

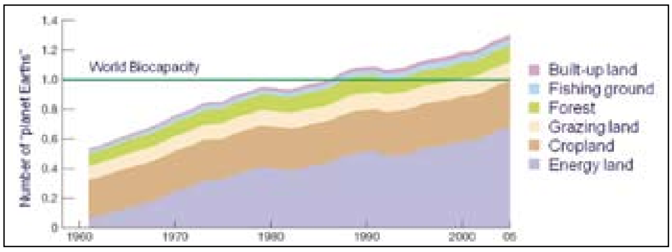


Source: The European House-Ambrosetti re-elaboration based on the Ecological Footprint Network, 2009 and WWF, 2008

Currently, therefore, mankind would need 1.3 planet Earths to sustain its consumption and absorb its waste (this means that the Earth needs approximately one year and four months to regenerate the resources consumed by man in a year and absorb the waste produced). Using the Ecological Footprint, we can estimate "how many planet Earths" will be needed to sustain humanity in a given lifestyle. For example, if the world's entire population lived according to the lifestyle of an average American, humanity would need over 4.5 planet Earths. If the lifestyle adopted were that of the average of Italians, 2.3 planet Earths would be required.

Analyzing the weighted values of the components of the 2005 global Ecological Footprint (Figure 46), the quantitatively most significant component is that of the carbon footprint, followed by cropland and grazing land. The carbon footprint is the only component that has grown significantly over the years, rising from very modest levels in the 1960s to approx. 68% of global biosphere capacity in 2005.

Figure 46. Ecological Footprint of mankind by component, 1961-2005

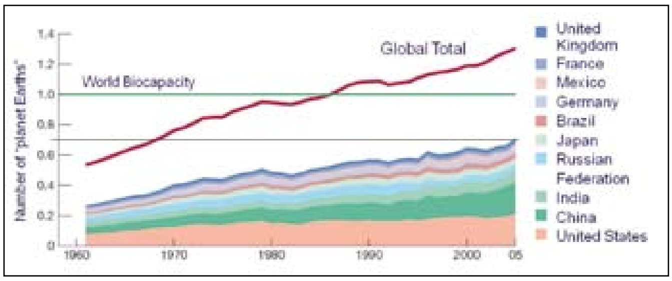


Source: The European House-Ambrosetti re-elaboration based on the Ecological Footprint Network, 2009 and WWF, 2008

From the standpoint of individual countries (Figure 47), the United States and China represent the two countries with the largest Ecological Footprint, equal to approx. 21% of the Earth's capacity. The performance of the former is due, above all, to having one of the highest per capita levels in the world, while for the latter it is due to the size of its population. In third place is India with an index of approx. 7%. Italy, on the other hand, consumes 2.1% of the global capacity of the biosphere.

It should be noted that China is also the country with the fastest growth in the value of its Ecological Footprint over the last 40 years and that the top 10 countries are responsible for consuming about 70% of the global capacity of the entire biosphere.

Figure 47. Ecological Footprint of mankind by country, 1961-2005

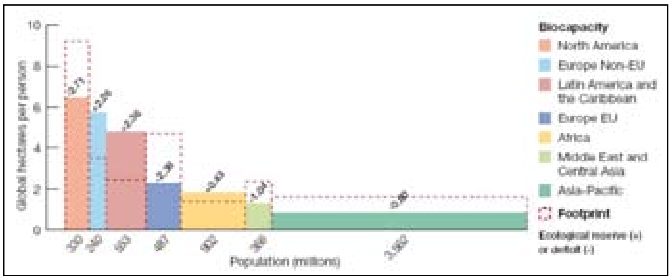


Source: The European House-Ambrosetti re-elaboration based on the Ecological Footprint Network, 2009 and WWF, 2008

Looking at the Ecological Footprint on a per capita basis, the average global level is 2.7 global hectares, compared with per capita biosphere capacity of 2.1 global hectares. As a result, the ecological deficit is 0.6 hectares per person.

Nonetheless, major differences are found between geographical areas and countries. The figure below shows the deficit regions (North America, European Union, Middle East and Central Asia, Asia and the Pacific) and those in surplus (European countries not part of the EU, Latin America and the Caribbean, and Africa), with the world population resident in these areas also given.

Figure 48. Biocapacity and Ecological Footprint of mankind by region, 2005

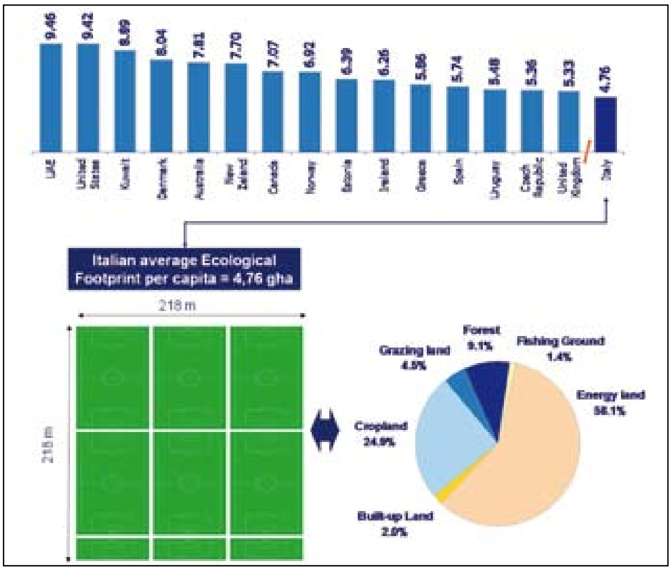


Source: The European House-Ambrosetti re-elaboration based on the Ecological Footprint Network, 2009 and WWF, 2008

The countries with the highest per capita Ecological Footprint are the **United Arab Emirates and the United States**. Among the top 15 countries are also some **northern European countries** (such as Denmark, Norway, Estonia and Ireland) and southern Europe (Greece and Spain). **Italy, on the other hand, is in 24th place**, with an Ecological Footprint of **4.76 global hectares per person**.

On average, the Ecological Footprint of each Italian represents an area which, if imagined as a flat surface, would be equivalent to **a square of over 218 meters per side, equal to 6 soccer fields**. Taking into consideration the various components of the Ecological Footprint, this surface should be seen as covered for 1.4% by the sea, 9.1% by forests, 24.9% by cropland, 4.5% by grazing land, 2% by built-up areas (cities, roads, infrastructure) and a full 58.1% of the area covered by the forests required to absorb carbon dioxide.

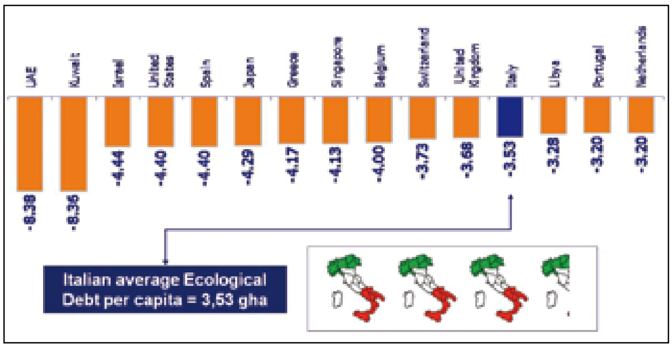
Figure 49. Per capita Ecological Footprint (global hectares), 2005



Source: The European House-Ambrosetti re-elaboration based on the Ecological Footprint Network, 2009

To **evaluate consumption sustainability for each country**, the value of the per capita Ecological Footprint must be compared with that of the biocapacity of the entire nation, which varies in relation to available resources. The figure below shows the top 15 countries by **ecological deficit** and **Italy is found in 12th position**, with 3.53 global hectares per capita. As a result, **more than "3 Italys" would be needed to satisfy the country's level of consumption**.

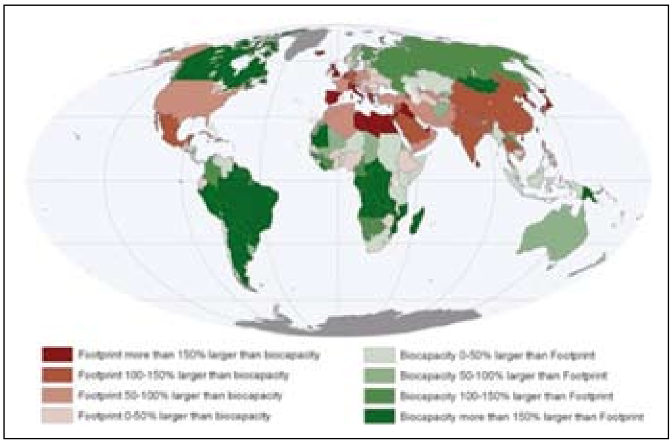
Figure 50. Per capita Ecological Deficit (global hectares), 2005



Source: The European House-Ambrosetti re-elaboration based on the Ecological Footprint Network, 2009

On a global level, distinction may be made between **debtor countries** (which use more resources than what are available within their own national boundaries) and **creditor countries** (Figure 51). Increase in pressure involving availability of resources on a worldwide level could cause this factor to emerge on a geopolitical level, with a very significant impact on the competitiveness and well-being of each country.

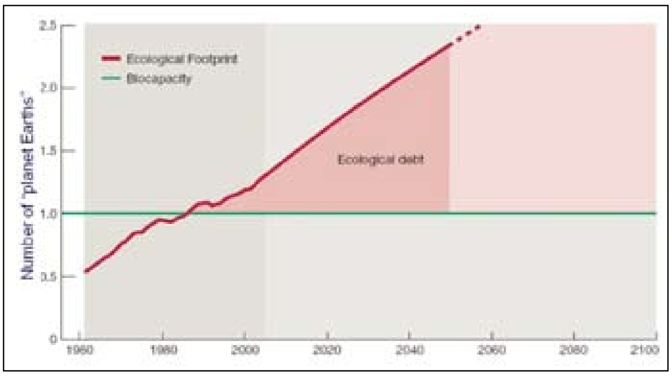
Figure 51. World map of debtor countries and creditor countries on the basis of the Ecological Footprint



Source: The European House-Ambrosetti re-elaboration based on the Ecological Footprint Network, 2009 and WWF, 2008

To conclude, it is also interesting to take a look at **future scenarios** for growth of the Ecological Footprint. Applying the economic and demographic growth estimates (prepared by the UN), CO_2 emissions (prepared by the IPCC) and consumption (prepared by the FAO), the scenario developed by the Ecological Footprint Network for 2050 indicates that **humanity will face such a large ecological deficit that two planet Earths will be needed to sustain consumption levels and absorb the waste generated**.

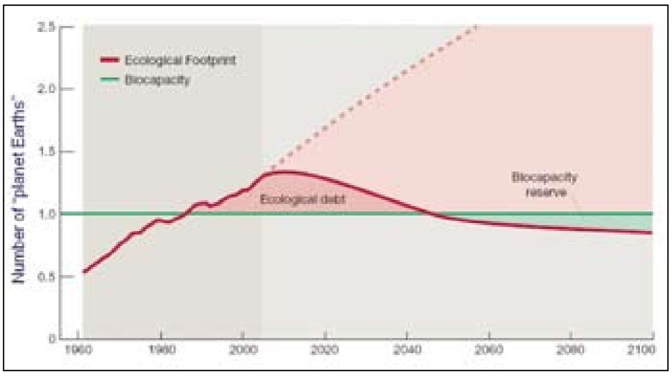
Figure 52. "Business-as-usual" scenario and ecological deficit



Source: The European House-Ambrosetti re-elaboration based on the Ecological Footprint Network, 2009 and WWF, 2008

The figure below shows the possibility for **rapid transition towards the creation of a biological reserve** with a gradual reduction in the global Ecological Footprint from current levels. This route calls for the application of a **range of** coordinated and complementary **strategies** aimed to: **change lifestyle habits and reduce consumption; reduce emission and increase efficiency and productivity** in human activity (involving agriculture, industry, transport, etc.) through investments in new technologies and modern infrastructures.

Figure 53. Scenario for a return to sustainability



Source: The European House-Ambrosetti re-elaboration based on the Ecological Footprint Network, 2009 and WWF, 2008

The European Union considers the Ecological Footprint a **useful indicator for assessing and communicating progress on the EU's Sustainable Use of Natural Resources Strategy**[53], that has been set in 2005 (that strategy recognises that using resources more efficiently is crucial for the economic development of the EU, for the European environment, and for a positive role of the EU in the world). In fact, the Ecological Footprint, for which further improvements in data quality, methodologies and assumptions are required, has been selected by the EU with few other indicators to evaluate Member States environmental impact.

3. THE INTERNATIONAL POLICY SCENARIO

A large part of this document has been dedicated to summarising the main scientific evidence regarding the changes that are occurring in climate equilibrium and their possible causes. This section highlights the fact that **climate change** represents one of the main **environmental, social** and **economic** threats to our planet.

Whilst there is no absolute certainty regarding its causes, the international scientific community across the board tends to agree with the theory that climate changes are significantly **affected by human activities**. This conviction, which is shared by most Governments, has triggered an international negotiation process – still underway – which aims to reduce global emissions of greenhouse gases.

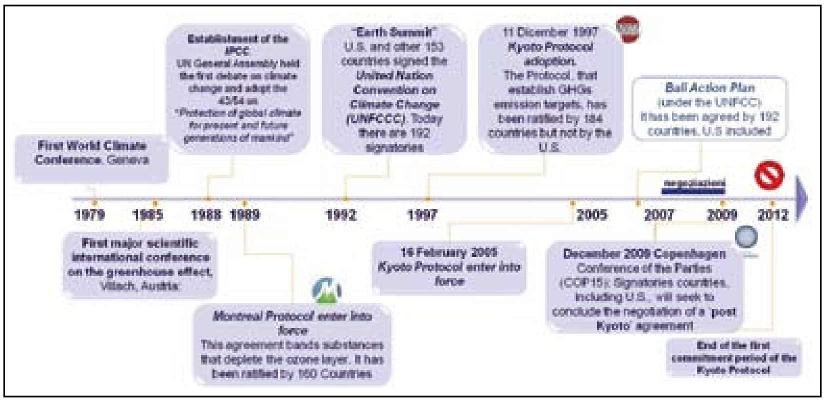
Needless to say, these negotiation processes represent an extremely complex diplomatic challenge without precedent in history, given the considerable differences that exist in terms of emissions and pro capita income between all countries. Accordingly each government needs to protect its own specific interests.

Yet there is no alternative to the diplomatic process. The inter-government meetings currently underway represent the only way forward for lowering emissions enough to manage to overcome the problem.

It is no longer possible to postpone attaining tangible goals set as the result of negotiations, particularly because some greenhouse gases have very long life cycles in the atmosphere – some even lasting thousands of years – and a present day cut in emissions would only bring slow improvements, given the tendency of the negative effects to be protracted through the long term in line with a principle of inertia.

53 Potential of the Ecological Footprint for monitoring environmental impacts from natural resource use. Analysis of the potential of the Ecological Footprint and related assessment tools for use in the EU's Thematic Strategy on the Sustainable Use of Natural Resources". Report to the European Commission, DG Environment, May 2008

Figure 54. Timeline of international measures



Source: The European House-Ambrosetti re-elaboration based on various documents

Whilst international negotiations on climate change officially got underway 30 years ago (in 1979) when the first "World Climate Conference"[54] was called – which closed with the approval of a solemn declaration with which all the world's governments were asked to take steps to prevent any interference of human activities on natural climate progression – it was only in the '80s that the various political players used negotiations for the first time as a means of implementing binding joint agreements for tackling climate problems.

On 22 March 1985, the Vienna Convention for protecting the ozone layer was ratified, followed by the Protocol of Montreal regarding the reduction of substances that are harmful for atmospheric ozone.

Thanks mainly to the considerable support given by then-President of the United States, Ronald Regan, and the participation of over 190 countries, the Protocol defined a programme which, in the years immediately after, made it possible to reduce production of chlorofluorocarbons (CFCs) drastically, along with other substances used in refrigerating appliances, aerosols and fire-resistant agents. From the peak which was recorded around the '90s, production of CFCs will actually be reduced to zero around the year 2010.

In literature, the Montreal Protocol is defined as the most successful environmental agreement in the world, and as the model which should inspire the way future climate negotiations are conducted.

Leaving aside the analysis of past diplomatic activities, the real starting point of the international negotiation process concerning climate change was actually the so-called "Earth Summit" staged in Rio de Janeiro in 1992 by the United Nations. It resulted in the *United Nations Framework Convention on Climate Change – UNFCCC*. Approved on 9 May 1992, it came into force as an international law in 1994. The Agreement was signed and ratified by virtually every country worldwide[55]. To this day it still represents the cornerstone of attempts to counter global warming and all its consequences.

Officially speaking the document sets out to:

*"(...) **obtain the stabilisation of atmospheric concentrations of greenhouse gases, taking them to such a level that they prevent dangerous anthropogenic interference with the climate system**. This level of stabilization should be reached in a period of time that enables the ecosystems to **adapt** in a natural way to climate changes so that the **food production system for the world's population is not placed at risk** and, lastly, is such that it enables the **socio-economic development of the world to continue in a sustainable manner** (..)"*[56].

In addition, the Convention sets two fundamental principles[57] which have since gone on to become reference points for all the subsequent international negotiations held on climate change:

1. Principle of common but differentiated responsibility. For all countries, it establishes the responsibility for the consequences of one's behaviour on the climate and the world's environment. Yet this responsibility differs from one country to another, both for historical reasons and with regard to the socio-economic development conditions, and the present-day capacity for "upsetting the balance of the world's environment"[58].
   This principle, which guided the adoption and implementation of commitments and obligations by the various countries involved, involves industrialised countries taking the initiative in the battle against climate change and tackling its consequences by playing a more important role than developing countries.
2. Principle of equity. This is divided into three aspects. First and foremost it should be seen in terms of all countries participating in defining the strategies and decisions to be taken

54 At the end of the Conference all the world's governments were invited to "avoid potential climate changes generated by man which might have negative repercussions on humanity's welfare". Another outcome of the conference was the adoption of a Worldwide climate research programme (WCRP) to be supported by the Worldwide Meteorological Organization (WMO), the United Nations' Environment Programme (UNEP) and the International Council for Scientific Unions (ICSU)

55 The agreement was ratified by 192 countries. Source: http://unfccc.int/2860.php

56 Art. 2 "United Nations Framework Convention on Climate Change", United Nations, 1992

57 Art. 3 UNFCCC: "The Parties should protect the climate system for the benefit of present and future generations of humankind, on the basis of equity and in accordance with their common but differentiated responsibilities and respective capabilities. Accordingly, the developed country Parties should take the lead in combating climate change and the adverse effects thereof"

58 Art. 3 "United Nations Framework Convention on Climate Change", United Nations, 1992; A. Pasini et al., "Kyoto e dintorni. I cambiamenti climatici come problema globale", 2006

(.."*equitable and balanced representation of all Parties within a transparent system of governance*"). It should also be viewed in terms of the cooperation between various countries to implement the decisions adopted as agreed (.."*the need for equitable and appropriate contributions by each of these Parties to the global effort regarding that objective*"). Lastly, equity is taken as the agreement on the priority to be attributed to the decisions and their implementation for safeguarding future generations (.."*The Parties should protect the climate system for the benefit of present and future generations of humankind*"..)[59].

The Convention identified 3 groups of countries that should have followed its provisions:

- **Annex I**, namely the members states of the OECD in 1992 and countries with economies in a transition (the Russian Federation, the Baltic States and Central-Eastern European countries);
- **Annex II**, namely the member states of the OECD in 1992;
- **non-Annex I**, namely the group of remaining countries (so-called developing countries).

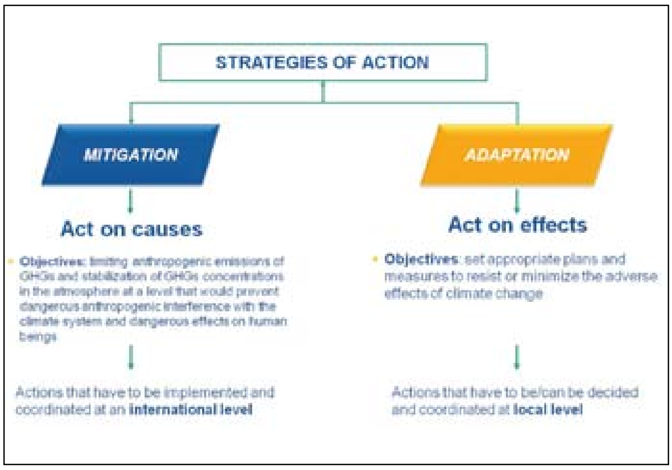
This classification, which is still used in international negotiations, constitutes one of the most tangible ways of implementing the outlined principles, making it possible to adopt different courses of action by homogenous groups of countries.

For the UNFCC, tackling the common risks means, in particular, adopting **two specific strategies**: the strategy defined as "**mitigation** of climate changes" and the "**strategy for adapting** to climate change".

The **mitigation strategy** aims to act on the **causes** of climate change, particularly on reducing and stabilising emissions and the concentration of greenhouse gases in the atmosphere that come from man's activities. The success of this strategy requires global and therefore international action.

The **adaptation strategy**, on the other hand, aims to act on the **effects** of climate change by drafting plans, programmes, actions and measures that minimise the negative consequences resulting from climate change. These should be such that reduce the territorial and socio-economic vulnerability to damage, whether effective and/or potential, resulting from climate change. The intrinsic nature of this strategy means that its implementation calls for coordinating measures to be carried out on a local level.

Figure 55. Strategies for mitigating and adapting



Source: The European House-Ambrosetti re-elaboration based on various documents

During the Convention, the fact that mitigation and adaptation should be taken as complementary rather than alternative strategies was underscored on a number of occasions.

Owing to its legislative nature, the Convention does not establish which actions are to be implemented and by whom in detail, nor does it establish the deadline required. This operative implementation is handed down to other legally binding operative instruments.

3.1 The Kyoto Protocol

The **Kyoto Protocol** fits into this context as the next step in countering the consequences of climate change. It is a **legally binding instrument** both for industrialised countries and those whose economy is in a transition phase.

The Kyoto Protocol, adopted on 11 December 1997 at the end of the third plenary session of the Conference of Parties (COP3)[60], indicates the international objectives for **reducing greenhouse gas emissions**, considered the main culprits for the global warming of the planet and consequently the changes occurring in the world's climate.

The Kyoto Protocol commits industrialised countries as well as those with an economy in a transition phase to reduce emission levels of the main greenhouse-effect gases produced by human activities between 2008 and 2012 (known as the *commitment period*) by **5.2%** overall[61] compared to 1990 figures.

59 A. Pansini et al., "Kyoto e dintorni. I cambiamenti climatici come problema globale", Franco Angeli, 2006

60 In 1994, after the UNFCC had become effective, the delegations of the contracting countries decided to meet annually for the Conference of the Parties (COP), defined as being the decision-making body which checks that the UNFCCC is applied. The Kyoto Protocol was adopted at the end of the COP 3 held in Kyoto, Japan. In the course of the 2 previous COPs, the "Parties" had not managed to reach an agreement on how to implement the general commitments indicated in the Rio Convention (UNFCCC)

61 The amount of annual emissions for 1990 (or 1995 for countries with an economy in a transition phase) is defined as "baseline"

There are six greenhouse gases taken into consideration by the Protocol[62]:

- carbon dioxide (CO_2);
- methane (CH_4);
- nitrous dioxide (N_2O);
- hydrofluorocarbons (HFC);
- perfluorcarbon (PFC);
- sulphur hexafluoride (SF_6).

The average overall reduction 5.2% **was not divided evenly throughout all the countries**. In fact for the countries of the European Union the overall reduction was set at 8%[63], for the United States 7% and for Japan 6%. Instead of reduction only stabilisation was required for the Russian Federation, New Zealand and Ukraine. Countries that, on the other hand, can increase their emissions are Norway by up to 1% Australia by up to 8% and Iceland by up to 10%.

Figure 56. Target of reduction of emissions according to the Kyoto Protocol

Countries	Ratified Kyoto Protocol	Emission Target (%)
EU-15	Yes	-8%
Belarus	Yes	-8%
Bulgaria	Yes	-8%
Czech Republic	Yes	-8%
Estonia	Yes	-8%
Latvia	Yes	-8%
Liechtenstein	Yes	-8%
Lithuania	Yes	-8%
Monaco	Yes	-8%
Romania	Yes	-8%
Slovakia	Yes	-8%
Slovenia	Yes	-8%
Switzerland	Yes	-8%
United States	No	-7%
Canada	Yes	-6%
Hungary	Yes	-6%
Japan	Yes	-6%
Poland	Yes	-6%
Croatia	Yes	-5%
New Zealand	Yes	0%
Russian Federation	Yes	0%
Ukraine	Yes	0%
Norway	Yes	1%
Australia	Yes	8%
Iceland	Yes	10%

Source: Kyoto Protocol, United Nations, 1998

The Protocol also establishes the best instruments for implementation, and the methods of implementation. As a result the reduction in emissions (mitigation) can be put into practice with:

- **intervention on a national scale** to reduce emissions;
- **interventions that involve the international community** (known as "flexible mechanisms").

The interventions listed by the Protocol which can be adopted on a national scale include the following: improving the energy efficiency in important sectors of the national economy; protecting and improving mechanisms for removing and collecting greenhouse gases; promoting forms of agriculture that are geared towards sustainability; research, promotion and development of renewable energy forms and technologies for capturing and isolating carbon; the progressive reduction or gradual elimination of market imperfections, tax incentives, fiscal exemptions and subsidies that go against the aims of the Convention.

The "flexible" mechanisms introduced by the Kyoto Protocol are:

- the *Joint Implementation* of the reduction objectives by industrialised countries and with an economy in a transitional phase (Annex I);
- the *Clean Development Mechanism* which addresses cooperation between industrialised countries and with an economy in a transitional phase and developing countries;
- *Emission Trading*, namely the trade in emission quotas.

These mechanisms are summed up in the following table:

Figure 57. The flexible mechanisms of the Kyoto Protocol

Mechanisms	Descriptions
Joint Implementation – JI (art. 6)	Allows a country with an emission reduction or limitation commitment under the Kyoto Protocol (Annex I) to **earn emission reduction units** (ERUs) from an **emission-reduction or emission removal project** in another Annex I country, each equivalent to one tonne of CO_2, which can be counted towards meeting its Kyoto target
Clean Development Mechanism – CDM (art. 12)	Allows a country with an emission-reduction or emission-limitation commitment to **implement an emission-reduction project in developing countries**. Such projects can earn saleable certified emission reduction (CER) credits, each equivalentto one tonne of CO2, which can be counted towards meeting Kyoto targets
International Emission Trading – IET (art. 17)	Allows countries that have emission units to spare - emissions permitted them but not "used" - **to sell** this excess capacity **to countries that are over their targets**. Thus, a new commodity was created in the form of emission reductions or removals. Since carbon dioxide is the principal greenhouse gas, people speak simply of trading in carbon. Carbon is now tracked and traded like any other commodity. This is known as the "carbon market"

Source: The European House-Ambrosetti re-elaboration from "Kyoto Protocol to the United Nations Framework Convention on Climate Change", United Nations, 1998

The measures stipulated by the Protocol[64] also include the so-called "sinks", namely the storage of carbon by the agro-forestry sector. In practice this "mechanism" stipulates that emissions and absorption of CO_2 and other greenhouse gases resulting from the formation of new forests (*afforestation, re-*

62 All GHGs are converted into equivalent units of carbon dioxide (CO2eq) using conversion factors linked to the greenhouse effect (or warming power) that each gas has

63 This target, through the so-called Burden Sharing Agreement was subsequently divided between the various Member States

64 Articles 3.3 and 3.4 of the Protocol. Article 3 in particular states: "The net variations in greenhouse-effect gases, with regard to emissions from sources and from absorption sinks resulting from human activities directly linked to the change in destined usage of lands and forests, only with regard to forestation, reforestation and deforestation after 1990". Source: "The Kyoto Protocol: Convention on Climate Change", United Nations, 1998 *forestation*[65]) and the conversion of forests into other forms of soil use (deforestation), carried out after 1990, can be calculated in the national balances of emissions and absorptions of greenhouse gases.

Under point 3.4 the Protocol then states that it is possible to calculate emissions and absorption of greenhouse gases related to additional human activities. The activities listed are as follows:

- *"Forest management"*
- *"Cropland management"*
- *"Grazing land management"*
- *"Revegetation"*

Each country may therefore decide to include one or more of the four above-mentioned activities in their balances, and accordingly calculate the variations in associated carbon stocks[66].

These activities are particularly relevant and their importance has increased over the course of time as it has become evident that through the use of the territory and afforestation, reforestation and control of deforestation it is possible to ensure that **conspicuous amounts of greenhouse gases are absorbed**.

Owing to problems involved in calculating the emissions caused by human activities and entering them in the inventory (such as those caused by forest degradation)[67], the activities set in place by the *sinks* (LULUCF activities in general) have been the subject of numerous debates[68] right since the adoption of the Protocol.

Nonetheless the Kyoto Protocol left many questions unanswered, above all those regarding the definition of criteria and methods for tangible application (and the application of the relevant mechanisms), which were therefore the object of subsequent meetings of the Parties. Only the agreement reached in Bonn and finalised in Marrakech (COP7) managed to define the methods for implementing key aspects more clearly.

The Protocol[69] which has been ratified by 184 countries (representing 63.3% of the total emissions of Annex I countries)[70] came into force on 16 February 2005, eight years after it was adopted. The withdrawal of the United States and Australia[71], the complexity of negotiations and Russia's hesitation were all responsible for the delay. The following figure summarises the positions of the various countries during the process of its adoption.

Figure 58. The position of the main Countries during the process of adopting the Protocol

Source: The European House-Ambrosetti re-elaboration based on various documents

In the event of non compliance with the obligations stipulated in the Protocol, the sanctions mechanism[72] does not actually involve any direct economic sanctions but instead sets out to facilitate, promote and reinforce respect for the commitments established in the agreement whilst at the same time guaranteeing the transparency and credibility of the system. In the event that the commitment to reduce emissions should not be respected, the Kyoto Protocol therefore states that the following sanctions are to be applied:

- **30% increase** of the amount of missing emissions compared to the objective to be reached, charged in addition to the obligations to be established during the second commitment period (post-Kyoto);
- **adoption of a plan of action** for respecting the goals;
- **suspending participation in the emissions trading scheme**.

In addition, in the event that the reduction commitments adopted in the *Burden Sharing Agreement* should not be complied with, the member countries of the European Union are subject to infraction procedures.

65 These activities are often referred to by the name LULUCF, namely Land Use, Land Use Change, and Forestry. Through the photosynthesis process, the plants store the carbon they absorb from the carbon dioxide in the atmosphere. Accordingly they can play an important role on reducing global warming linked to the greenhouse effect. The EUROFLUX gauging network has calculated that European forests represent an absorption sink capable of absorbing from 10 to 40% of carbon dioxide emissions linked to human activities in Europe. Source: European Commission. NOTE: the Joint Implementation and Clean Development Mechanisms include and take into consideration clauses for the implementation of LULUFC activities between the Parties

66 Article 3.4 states that, given the uncertainty surrounding the calculation of these figures and the need to provide results that are transparent and communicable, this decision will be applied in the second and subsequent fulfilment periods. One Party may apply it to its supplementary anthropological activities in the first phase of fulfilment on the condition that the aforementioned activities occurred after 1990

67 There are many problems involved in this instrument; as a result, for further information reference should be made to the website of the United Nation Framework Convention on Climate Change, http://unfccc.int/methods_and_science/lulucf/items/4129.php

68 Consider, for example, the discussion of the COP6

69 14 January 2009. - Source: http://unfccc.int/kyoto_protocol/status_of_ratification/items/2613.php

70 The Protocol does not involve commitments for developing countries, in line with the principle of equity

71 Australia ratified the Protocol in December 2007. It became effective in March 2008

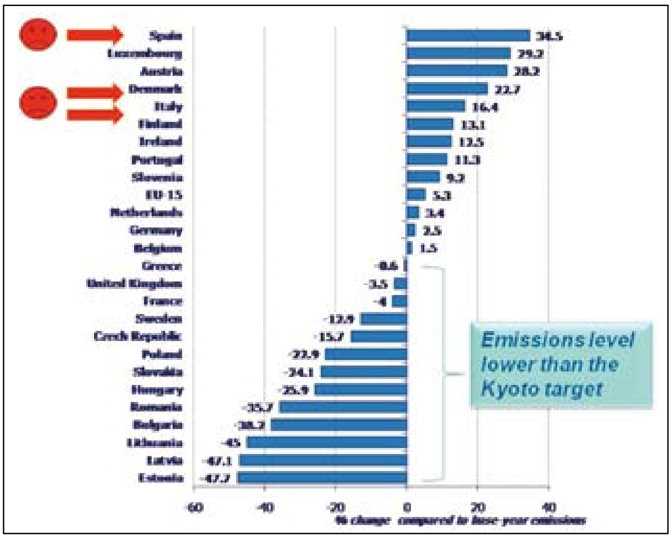
72 The sanctioning mechanism was defined during the process of implementing the Kyoto Protocol (decision 27/CMP.1)

Those countries which, according to the latest analysis by the EEA (*European Environment Agency*)[73] **will not manage to respect the pre-fixed targets and therefore risk being subjected to the Union's infraction procedures are: Spain, Denmark and Italy**.

In particular, with effect from 1st January 2008[74], it has been calculated that **Italy accumulates a debt of 47.6 euro a second each day** owing to the fact that it has not reached the Protocol's objectives. **By the end of 2008 we had reached 1.5 billion euro of annual debt by exceeding the target**[75].

With regard to the European Union (EU-15), on the other hand, it is estimated that the objective to reduce emissions by 8% as envisioned by the agreement will be respected by 2012. In addition, the adoption and implementation of additional measures would result in a further reduction of 3.3% compared to the base year (1990).

Figure 59. Gap between the results attained in 2006 and the targets of the Kyoto Protocol



Source: The European House-Ambrosetti re-elaboration taken from "Greenhouse Gas emission trends and projections in Europe 2008", EEA, 2008

3.2 Negotiations underway for defining the post-Kyoto strategy

In December 2007, during the thirteenth **Conference of the Parties** of the United Nations Convention on Climate Change (COP13) held in **Bali**, the international Community agreed upon a Plan of Action (known as the *Bali Action Plan*) and a *Road Map* **for drafting a global protocol to be implemented after 2012**, when the first "commitment period" of the Kyoto Protocol expires.

In adopting this road map, the Parties defined the issues and the schedule for the negotiations. This should guarantee a transition without any gaps between the current system and the future one. It is a vital condition for tackling the harmful effects of global warming effectively.

The international Community undertook to conclude the negotiations process no later than the **next session of the Conference of Parties** of the United Nations Convention on Climate Change which will be held in **Copenhagen** from 7 to 18 **December 2009**.

The Bali Action Plan stipulates the need to focus the attention on the **four** main issues, called the ***key building blocks***[76]:

- **Mitigation**: process for reducing emissions, to be implemented above all by increasing energy efficiency and the changeover to energy sources with a low CO_2 rate whilst limiting deforestation in developing countries;
- **Adaptation**: strategies for adapting the economic and production systems as well as human settlements themselves to the climate changes occurring, with an end to limiting the damage and seizing any opportunities. In particular, it would appear necessary to reinforce the measures taken to provide tangible responses to the immediate needs of developing countries, particularly the poorest ones[77];
- **Technological transfer**: transfer of the know-how and low-emission/non-polluting technologies from industrialised countries to developing nations with an end to supporting the mitigation and adaptation activities they get underway;
- **Financing**: introduction of international financing instruments for realising the aforementioned *building blocks*.

Moreover, the **main issues** currently being **discussed** (and which will constitute the content of the new climate agreement) are:

- **the legal status** of the new agreement;
- **the individual mid-term objectives for reducing emissions** of greenhouse gases for industrialised countries (2020);
- **the aggregate long-term objective for reducing emissions of greenhouse gases** for industrialised countries (2050);
- **the objectives for reducing emissions of greenhouse gases for developing countries** with a high rate of economic development (Brazil, India, China, etc.);

73 *"Greenhouse Gas emission trends and projections in Europe 2008", EEA, 2008*
74 *Start date of the commitment period of the Kyoto Protocol*
75 *For each tonne of CO_2 exceeded, a sanction price of 20 euro is estimated. Deed of the Chamber of Deputies dated 13 November 2008, session no. 085 http://banchedati.camera.it*
76 *COP13, December 2007 - Bali Action Plan Decision 1/CP.13, 2007; "Climate Change: Financing Global Forests", Eliasch Review, 2008*
77 *A crucial issue involved in recent agreements between the Parties was rendering the Adaptation Fund operative. This instrument is vital for helping developing countries to support the burden of the climate changes at hand. This fund, which was set up within the framework of the Kyoto Protocol for financing tangible projects and programmes for adaptation in developing countries will be financed through the 2% of credits generated by Clean Development Mechanism projects. The Fund will provide the poorest countries with an initial capital of 60-80 million dollars which could reach 300 million dollars by 2012. Source: "Climate Policy and Markets", Eni Enrico Mattei Foundation, 2008*

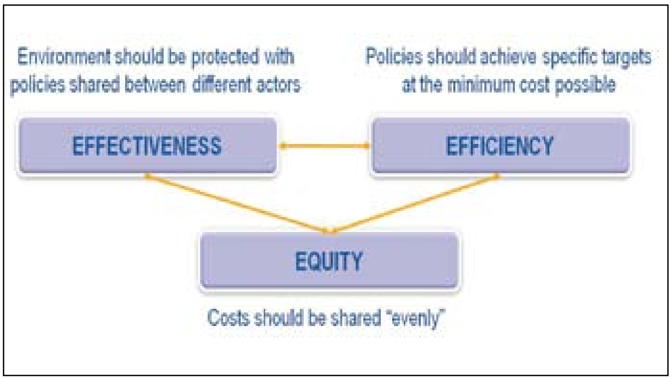
- **changing and improving the flexible mechanisms**;
- changing the regulations that govern the use, monitoring and calculation of **forestry activities**;
- **the inclusion of new greenhouse gases**, sectors and sources within the framework of applying the Kyoto Protocol;
- **technological financing and transfer to developing countries**.

In particular, one of the main "innovations" of the Bali Action Plan involves introducing measures to reduce emissions by developing countries. In addition, the plan involves bringing the international commitments of these countries into line with national development goals.

In fact the strategic plan also sets out a series of measures geared towards reducing emissions from the deforestation and degradation of the forests in these countries, whilst at the same time increasing investments for development and technology transfer.

Lastly, another important innovation involved in the Bali Action Plan, introduced under the subject of measures that can be geared towards activities for mitigating greenhouse gases, involves introducing the concept "*measurable, reportable and verifiable - MRV*". The interpretation and adoption of this concept by the post-Kyoto agreement will have significant implications for the effectiveness of the agreement where the stakeholders of developing countries are concerned, not to mention those in developed countries[78].

Figure 60. Key characteristics of the future international agreement



Source: The European House-Ambrosetti re-elaboration taken from "The Cost of Climate Change: sharing the burden", Enrico Mattei Foundation, 2007

The introduction to the final decision of the Conference of Parties of Bali, ("in order to reach the ultimate goal of the Convention, significant reductions in global emissions will be necessary") does not state the extent of the reductions from a quantitative standpoint, but instead underscores the **importance of taking urgent measures to counter climate change** (as indicated in the Fourth Assessment Report of the IPCC[79]) and more specifically recalls the need to respect, of the various scenarios for stabilising concentrations, the more conservative limit of **450 ppm**[80] (this level of concentration of greenhouse gases would make it possible to limit the increase in average global temperatures to around 2 °C).

To reinforce the existing mitigation measures, one of the subjects currently being discussed is the reduction of emissions from deforestation and the degradation of forests (REDD – *Reducing Emissions From Deforestation and Degradation*). This is a crucial issue if we bear in mind that deforestation is one of the main factors responsible for emissions of greenhouse gases[81]. According to the last report by the IPCC, the emissions caused by deforestation are responsible for around 20% of the total.

More generally, the negotiations session scheduled for June (1-12 June 2009) in Bonn[82], Germany, is vitally important not just because it will take place six months before the Copenhagen conference but above all because, for the first time, delegates will discuss the first real negotiation texts, bearing in mind the outcomes of the previous sessions and proposals presented by the Parties.

3.3 The strategies adopted by the European Union and other main countries

By playing a key role in the drafting of the two most important treaties – the United Nations Framework Convention on Climate Change in 1992 and the subsequent Kyoto Protocol in 1997 – the European Union has occupied the role of **leader region in the negotiation process and acts as a guide on a global level**.

During the course of the European Council held in March 2007 the leaders of the EU renewed a considerable commitment to an **integrated climate and energy policy** geared towards promoting sustainable development and countering climate change.

The strategic objective which the Union has set itself involves limiting the increase in the earth's average surface temperature to less than 2 °C higher than pre-industrial levels (a level which scientists increasingly consider the "maximum limit"). The Council also agreed on an objective to reduce emission by 30% compared to 1990 emissions in the event that an international agreement for the post-Kyoto period (2020) is concluded.

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78 Indeed the Bali Action Plan also applies this measure for developed countries. "Measurable, reportable and verifiable nationally appropriate mitigation commitments or actions, including quantified emission limitation and reduction objectives, by all developed country Parties, while ensuring the comparability of efforts among them, taking into account differences in their national circumstances". COP 13, December 2007 http://unfccc.int/files/meetings/cop_13/application/pdf/cp_bali_act_p.pdf
79 "Fourth Assessment Report: Climate Change 2007", IPCC AR4
80 For further information refer to the section in Annex III of the IPCC AR4
81 According to the latest IPCC report, the emissions caused by deforestation are responsible for around 20% of the total.
82 For more information refer to http://unfccc.int/meetings/sb30/items/4842.php

Nonetheless, in spite of the activities initiated by other countries and to underscore its own determination, the **European Union unilaterally committed itself to reducing its emissions by 20% compared to 1990's emissions by 2020**. This is with an end to reducing emissions by 60-80% by the year 2050.

This goal forms part of the ambitious European energy policy passed by Parliament last December and definitively approved last 6 April. In addition to the 20% reduction in greenhouse gases compared to 1990 figures, it also involves:

- **a 20% saving on energy consumption** compared to forecasted figures for 2020 **by improving energy efficiency**;
- **increasing quotas of the renewable energies used in the** total **energy consumption rate by 20%** by the year 2020;
- **reaching**, by 2020, **a quota of at least 10% of renewable fuels**, including biofuels, over the total consumption rate of petrol and diesel. This must be on the proviso that all biofuels – those produced inside the European Union as well as those that are imported- be produced in a sustainable manner[83].

The package also involves:

- **revising the EU system for trading greenhouse gas quotas** (known as the *European Union Emissions Trading Scheme* – EU-ETS): with effect from 2013 an auction system is planned for the purchase of emissions quotas, all proceeds from which will be used for financing measures to reduce emissions and adapt to climate change;
- **effort sharing** amongst Member States outside the EU-ETS to reduce carbon emissions;
- a regulatory framework for **developing and promoting technologies for capturing and storing carbon** (*Carbon Capture and Storage* - CCS).

This new integrated policy for energy and climate change is the precursor to the launch of a **new industrial revolution**, geared towards transforming the way in which we produce and use energy, as well as the types of energy that we use.

The aim of the Union is to become an **economy that is climate-compatible** based on a combination of technologies and energy resources with low carbon dioxide emissions.

The 20-20-20 package adopted by the EU might, however, affect its mid-to-long-term **competitiveness**, particularly in the event that other countries should decide not to adopt similar stringent measures for countering the climate change now underway.

One of the most keenly disputed topics prior to the final approval of the document did in fact involve the possibility of delocalisation of the manufacturing industry (so-called *carbon leakage*) owing to the introduction of more stringent targets, within the EU Emission Trading Schemes, and the unfavourable economic situation. The stand taken by certain countries of the European Union which are particularly aware of these issues resulted in certain changes being made to the package.

Figure 61. Changes to the legislative package

EU ETS: EXCEPTIONS

Manufacturing sectors at **risk of delocalization* (carbon leakage) will be granted 100% of their CO_2** emission credits free of charge. However, only the cleanest factories will be eligible, as the free permits will be distributed "at the level of the benchmark of the best technology available"

Non manufacturing sectors of: Italy, Austria, Finland, Denmark, Spain, Luxembourg, Portugal, Ireland, Slovenia, Cyprus and Sweden can use credits from CDM and JI in order to reach the 3% of total emissions

Industries that will **not risk carbon leakage will have to buy permits** for 20% in 2013 and to 70% in 2020 and reach 100% within 2025.

In case of adoption of an international agreement, the European Council will establish free grants quotes to sectors at risk.

(*) The European Council defined a sector at risk of delocalization (carbon leakage) if the introduction of mitigation strategies will lead to an increase of production costs higher than 5% of the value added and if it is exposed to international competition for more than 10% of its imports and exports.

Source: "Climate Policy and Markets", No. 6, Enrico Mattei Foundation, 2008

The International Energy Agency (IEA) has also analysed how competition is being distorted with the introduction of *Emission Trading Schemes* or *carbon taxes*[84].

With regard to the commitments adopted by other countries, to follow is a brief analysis of the main policies that are planned or have already been adopted.

THE UNITED STATES

The change in Presidency of the American administration saw an important move forward regarding climate change commitment, particularly seeing as the failure of one of the world's main greenhouse gas emitters to adhere to the Kyoto Protocol caused serious problems with its implementation.

In the course of the negotiations held in Bonn last April, the special envoy for climate Todd Stern officially announced "*the United States is back*" and that they seriously intend to make up for lost time in order to tackle the current climate emergency. In particular, during his speech he outlined two key commitments which the United States will be seeing through in negotiations: adoption of emission limits in the short and long-term (2050), and setting aside considerable funds for supporting de-

83 "The fight against climate change. The EU leads the way", the European Commission, 2008
84 For further reference see the document "Issues behind competitiveness and Carbon Leakage", IEA, 2008

veloping countries to help them plan and implement measures for adapting and encouraging reductions in emissions.

President Obama, in particular, stated that "*It is critical that we understand this is not just a challenge, it's an opportunity, because if we create a new energy economy, we can create five million new jobs, easily. It can be an engine that drives us into the future the same way the computer was the engine for economic growth over the last couple of decades*"[85].

In particular, Barak Obama declared his intention to invest 100 billion dollars in the next 10 years to:

- double energy production from alternative sources[86] in three years (stimulating the cycle of innovation and developing new networks or "smart grids"[87]);
- adopting and developing third-generation biofuels and sales of hybrid vehicles;
- modernising over 75% of public buildings;
- improving the energy efficiency of two million homes;
- etc.

A crucial aspect of these commitments will be their formal adoption before the international community.

CHINA

China, traditionally one of the countries least committed to the environment, has made an important about-turn by committing itself on various fronts. This is particularly important if we consider that 20%[88] of the world's greenhouse gas emissions come from China.

In 2005, as the unchecked development of China's industries placed visible signs of pressure on national environmental resources, the Government moved to lead the country towards a more sustainable form of growth. In fact 2005 saw it announcing 10 national energy savings programmes which will involve the most energy-hungry sectors, and a number of projects for improving energy efficiency involving the adoption and development of technological innovation, financial support and pilot projects.

In addition, in 2006 the Chinese Government announced a plan for reducing energy consumption per unit of national product by 20% by the year 2010 and adopted a law on renewable energy sources. In just a few years, the latter has already become a strategic industry.

However, in spite of the clear intentions of central Government, local authorities and industries are not working in the same direction owing to the lack of incentives and the arbitrary nature of the targets set.

MEXICO

Mexico has announced a 50% cut in 2002's level of emissions by the year 2050. This objective will be attained with energy efficiency measures and the implementation of an emission trading scheme by 2012.

BRAZIL

Brazil has announced its intention[89] to halve the deforestation rate by 2017 with an end to reducing the greenhouse gas emissions produced by these activities by almost 5 billion tonnes. There are also plans to adopt an energy efficiency plan which will set itself the goal of reducing electricity consumption by 10% by 2030, replacing obsolete fridges and freezers (1 million a year for 10 years) and reducing losses in the electricity distribution process, bringing it down to a rate of 1000 GWh a year for the next 10 years.

85 "It is critical that we understand this is not just a challenge, it's an opportunity, because if we create a new energy economy, we can create five million new jobs, easily. It can be an engine that drives us into the future the same way the computer was the engine for economic growth over the last couple of decades" – Barak Obama, 2008

86 Wind, solar and geothermal power to at least 50GW

87 The latest generation of electricity grids, capable of managing inconstant renewable sources and compensating them with traditional sources whilst optimising energy storage so it can be put into the grid when needed

88 Source: CAIT database, World Resource Institute. The figures refer to 2005 and do not include emissions related to land use change

89 National Climate Change Plan – PNMC signed in December 2008

Part B: climate change and the agricultural sector

"Agriculture and deforestation are major contributors to climate change, but by the same token farmers and forest users could become key players in reducing greenhouse gas emissions"

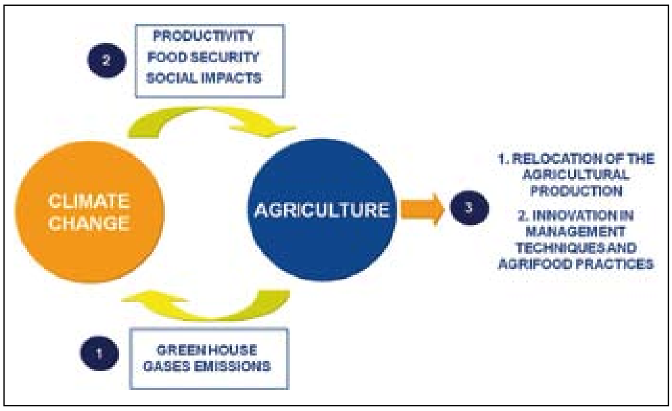
Alexander Müller
FAO Assistant Director-General

The agrifood chain includes also industrial transformation activities. Given the specific scope of the work - assess the impact of climate change - we have focused our work on the raw agriculture materials production phase. However, where considered relevant, we provide indications and information on the transformation, production, transportation and consummation phases.

4. CLIMATE CHANGE AND THE AGRICULTURAL SECTOR

Agriculture and climate change are characterized by a complex cause-and-effect relationship. The practice of agriculture produces significant volumes of greenhouse gases, the prime culprits for climate change. At the same time, however, agriculture is affected by the negative impacts of the climate change in terms of reduced productivity and increased food safety risks. Solutions able to interrupt this vicious cycle can currently be traced to mainly two macro areas: re-localization of agricultural production and innovation in agrifood management and practices.

Figure 62. The relationship between climate change and agriculture



Source: The European House-Ambrosetti elaboration

4.1 The contribution of the agricultural sector to climate change

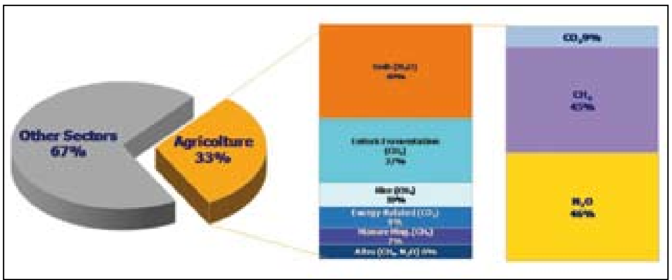
Agriculture accounts for the production of approximately 33% of all annual **greenhouse gas** emissions worldwide[90]. Of this share, 46% is **nitrous oxide** from working agricultural land and the use of energy, 45% is **methane emissions**, above all from animal digestive fermentation processes (27%), rice cultivation (10%) and management of organic fertilizers (7%); the final 9% comes from **carbon dioxide**. From the data, one can assume that agrifood activities account for a rather modest amount of carbon dioxide while animal husbandry, rice-growing and, in part, soil fertilization, generate more significant amounts of nitrous oxide and methane.

90 Source: World Resources Institute, Database

The agricultural contribution to the production of greenhouse gases worldwide has increased over the years: it has gone from 39 billion tons in 1990 to 49 billion in 2004, a 25.6% increase. For the most part, this increase can be attributed to the use of fertilizers, the development of animal husbandry, the production of sewage and the use of biomass for energy production.

As regards future scenarios, the IPCC envisages that, without corrective measures, by 2030 we will see a 35-60% increase in nitrous oxide and 60% increase in methane released by agricultural. Modifications in land use are mainly due to these increases.

Figure 63. The main greenhouse gases produced by the agricultural sector



Source: The European House-Ambrosetti elaboration based on W. Cline, Global Warming and Agriculture, Centre for Global Development, 2007

The Figure 64 shows the contribution of the agrifood sector to climate change. Among the data, it is worth noting the contribution the agrifood sector in terms of methane and nitrous oxide emissions, respectively, 49.3% and 82.5% of the total emissions. These two gases have a marked impact on climate change. In fact, one unit of these products corresponds, respectively, to 21 and 310 units of carbon dioxide.

More specifically, it is worth noting that agricultural soil is a major generator of nitrous oxide (75% of the total emissions), while animal husbandry and fertilizer management are mainly responsible for the methane emissions (35% of the total emissions). Again, as regards the agricultural sector, changes in use generate approximately 18% of the total greenhouse gases, mainly from deforestation.

Figure 64. Contribution of the agrifood sector to greenhouse gas emissions

Sector	Activity	Total contribution to GHGs emissions	Total contribution to carbon dioxide - CO_2	Total contribution to methane - CH_4	Total contribution to Nitrous Oxide - N_2O
Agrifood Sector	Soil	6.0%	-	-	75.0%
	Cattle/manure	5.1%	-	35.0%	2.5%
	Rice	1.5%	-	10.8%	-
	Other agriculture activities	0.9%	-	3.5%	5.0%
	Energy	1.4%	1.8%	-	-
	Totale	14.9%	1.8%	49.3%	82.5%
Land Use Change	Deforestation	18.3%	23.8%	-	-
	Afforestation	-1.5%	-2.0%	-	-
	Riforestation	-0.5%	-0.7%	-	-
	Crop management	2.5%	3.3%	-	-
	Others	-0.6%	-0.8%	-	-
	Total	18.2%	23.7%	-	-

Source: The European House-Ambrosetti elaboration based on W. Cline, Global Warming and Agriculture, Centre for Global Development, 2007

As regards the agricultural sector and its impact on climate change, one must note that the activity generating the greatest amount of greenhouse gases is deforestation. In fact, this practice annually generates 8,500 millions of tons of carbon dioxide equivalent[91], followed by land fertilization (2,100 millions of tons of CO_2 equivalent) and emissions of gases coming from cattle digestion (1,800 millions of tons of CO_2 equivalent).

Figure 65. The main greenhouse gas emissions from agriculture

Agriculture Sector	ANNUAL EMISSION (millions of tons of $CO_{2\text{-}EQ}$)	GHGs EMITTED
Deforestation (peat included)	8.500	CO_2
Fertilization (manure and chemicals)	2.100	N_2O
Enteric fermentation	1.800	CH_4
Biomass combustion	700	CH_4 - N_2O
Rice production	600	CH_4
Cattle manure	400	CH_4 - N_2O
Others (for ex. irrigation)	900	CO_2, N_2O

Source: The European House-Ambrosetti re-elaboration based on "State of the World 2009", WRI, 2009

Deforestation, in the worldwide, is one of mainly causes of atmospheric greenhouse gas emissions. The world's forests are highly useful as they lock enormous amounts of carbon into the soil. It is estimated that this amount can reach around 500 billion tons[92].

An example of the negative impact deforestation has is the case of the peat forests in Indonesia. These forests stand out

91 The CO_2 equivalent ton is a unit of measure that makes it possible to weigh together the various greenhouse gas emissions having different effects on the climate.
92 Source: World Watch Institute, 2009 and Greenpeace, 2009

for their great carbon absorption capacity. The steady expansion of oil palm plantations is, however, significantly reducing the extension of these forests. It is estimated that each year at least 1.8 billion tons of greenhouse gases[93] are released through deforestation, decay and fires.

4.2 Climate change effects on the agricultural sector

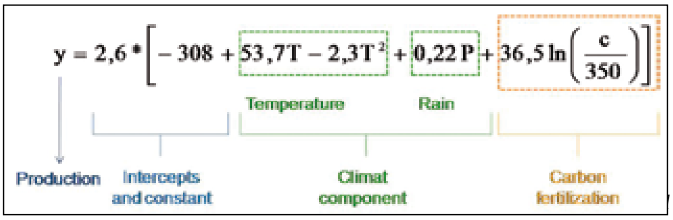
4.2.1 Impacts of Climate Change on agricultural productivity

There are **two main methodological approaches** for evaluating the impact of climate change on agricultural production:

- the **Ricardian approach**[94], which takes into consideration climatic conditions, precipitation levels and CO_2 concentration in the atmosphere as explicative elements in agricultural production (expressed in monetary terms);
- **crops models**: built on a database collecting informations on 18 countries, crop models are compatible with each other in 125 agricultural sites, each with different climatic, precipitation and solar radiation characteristics.

The first forecasting models prepared using the Ricardian approach were developed by Mendelsohn and Schlesinger in 1999 and subsequently updated and re-applied in specific geographical areas.

Figure 66. The Mendelsohn and Schlesinger model



Warming and Agriculture, Centre for Global Development, 2007

The **Mendelsohn and Schlesinger model** underscores how agricultural output measured in monetary terms (y) is a function of the average annual temperature measured in Celsius (T), average daily precipitation in millimeters on annual basis (P) and concentration of carbon dioxide in the air measured in parts per million (ppm).

As can be seen from the model signs, one factor which increases agricultural productivity is related to the phenomenon known as carbon fertilization.

An increase in CO_2 emissions not only raises the temperature of our planet and damages agriculture, but it also has a positive effect on agriculture itself by alleviating the adverse effects related to overheating. This positive effect is tied to the phenomenon of carbon fertilization.

CO_2 is an input into chlorophyllous photosynthesis which utilizes solar energy to convert carbon dioxide into oxygen and other organic components. The literature and a number of empirical studies performed in the lab and in small fields show a positive relationship between CO_2 concentration and agricultural productivity.

Even if the results obtained from empirical studies performed do not provide definitive results on the extent of the increase in agricultural productivity following an increase in CO_2 concentration, it is clear that high concentrations of CO_2 intensify the process of photosynthesis and closure of plant stomata with a resulting reduction in their loss of water.

More specifically, a number of laboratory studies have shown how wheat exposed to high concentrations of CO_2 (about 550 ppm) registered a 31% increase in yield. Nonetheless, in experiments run on fields in the open, the yield increase was between 7% and 11%.

In any case, the presence–or lack of presence–of carbon fertilization has a significant influence on future forecasts regarding the impact of planet overheating on agricultural production.[95]

The uncertainty tied to the effects of carbon fertilization on agricultural output is largely due to the fact that this is a recent phenomenon and still in an early stage[96].

In terms of crops models, on the other hand, the first models making this approach were developed by **Rosenzweig** in 1990 and subsequently updated and re-applied in specific geographical areas.

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93 Source: World Watch Institute, 2009 and Greenpeace, 2009

94 The Ricardian theory, which takes its name from David Ricardo, one of the leading exponents of classical economic theory, states that the only relevant difference in production between two countries is found in technological factors (all the other characteristics supposed to be identical between countries).

95 Source: The European House-Ambrosetti elaboration based on W. Cline, "Global Warming and Agriculture", Centre for Global Development, 2007

96 Provided below is a brief example that clarifies how the phenomenon of carbon fertilization is not something tied to the past or present, but rather a fact that involves the immediate future.

Current CO2 concentration levels are approx. 385 ppm.

$$\text{carbon fertilization} = \left[36{,}5\ln\left(\frac{385}{350}\right)\right] \rightarrow \text{Ln}(1.1)$$

The natural logarithm of 1.1 is 0.09.

$$\text{carbon fertilization} = [36{,}5\ln(1{,}1)] \rightarrow 0.09$$

$$\text{carbon fertilization} = [36{,}5 * 0{,}09] = 3{,}4$$

The impact of the phenomenon of carbon fertilization on agricultural output is limited: 3.4 is the dollar increment (reference year 1990) related to the agricultural output of a hectare of land if you count inflation, the future Capitalization of this value to the present day would lead to an estimate of an increase in production per hectare generated by carbon fertilization of approx. US$ 6.50-7.00

One of the most recent updates of the crops models was done by Rosenzweig and Iglesias in 2006.

It includes a database containing data for hundreds of crops in different countries around the world. This database is updated on the basis of results from the same types of crops over the years following changes in climate, precipitation levels and solar radiation.

The forecasts made using these models assume CO_2 concentration of 550 ppm over the long-term and three assumption of adaptation of the crops to changed climatic conditions:

- shifting of the phases of planting and harvesting by less than a month and increase in the use of current irrigation systems;
- shifting of the phases of planting and harvesting by more than a month and need to construct new systems of irrigation and planting of new types of crops;
- no adaptation.

From analysis of the results of studies performed, it was seen that Ricardian models and crops models applied in a range of contexts produce forecasts that are sometimes significantly different from each other.

The main reasons for this lie in the fact that crops models provide a lower variability rate (12%) than Ricardian models (28%). The main explanation for this is that crops models tend to be linear in terms of climate change, while Ricardian models are non-linear.

As a result, the two models were tested using different climate change scenarios with the goal of identifying the most reliable and statistically-consistent forecasts on the basis of specific model characteristics. Given the nature of the data contained in the database, the crops models produce forecasts that are not that reliable for geographical areas at latitudes different from those of the United States. The Ricardian models, on the other hand, were applied in specific contexts in the United States, Canada, Africa and India, while forecasts for other countries were made using a basic model.

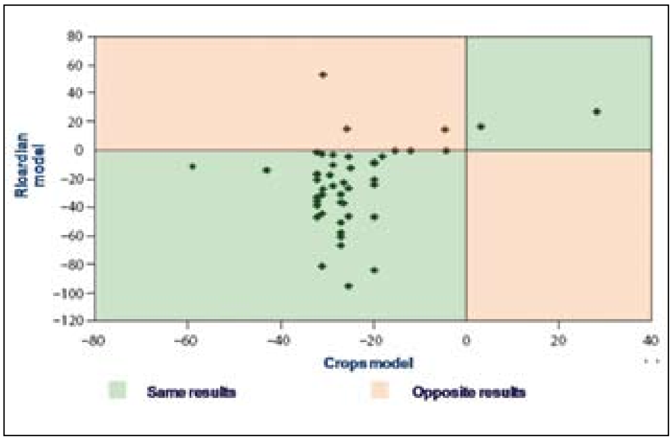
Figure 67. Temperature increase forecasts, 2070-2099

Study	Authors	Delta in Celsius degrees
German Climate Research Centre, European Centre Hamburg	Roeckner (1996) Zhang (1998)	+2.6 °C
UK Hadley Center for Climate Prediction and Research Coupled Model	Gordon (2000)	+3.0 °C
US Geophysical Fluid Dynamics Laboratory R-30 Resolution Model	Knutson (1999)	+3.4 °C
Japanese Centre for Climate System Research	Emori (1999)	+3.5 °C
Canadian Centre for Climate Modelling and Analysis	Flato e Boer (2001)	+3.6 °C
Australian Commonwealth Scientific and Industrial Research Organisation	Gordon e O'Farrel (1997)	+3.7 °C

Source: The European House-Ambrosetti elaboration of data from existing literature

Both the Mendelsohn and Schlesinger model (based on a Ricardian approach) and the Rosenzweig and Iglesias model, were tested using these various climate change scenarios which foresee a rise in temperature between 2.6 and 3.7 °C.

Figure 68. Percentage forecasts of the impact on production in 47 countries (without carbon fertilization)



Source: The European House-Ambrosetti elaboration of data from the Peterson Institute for International Economics

As can be seen, on a general level, the two models offer a high level of coherence and consistency in their forecasts, given that **in 95% of cases, provide results of the same sign**. In fact, only 3 countries out of 47 show an increase in production using Ricardian models and one a decrease in production using crops models.

Effects of overheating on agricultural output

On a worldwide level, India, Mexico, Australia and Brazil will be the areas hardest hit.

Figure 69. Impact on agricultural output as of 2080

	Delta production with no carbon fertilization	Delta production with carbon fertilization	Delta in monetary terms (base 2003)
Australia	-26.6%	-15.6%	-3.4<X<-2.1
Brazil	-16.9%	-4.4%	-4.9<X<-1.3
Canada	-2.2%	+12.5%	-0.4<X<+2.2
Europe	-9.4%	+4.1%	-6.7<X<+3.8
China	-7.2%	+6.8%	-15.3<X<+14.2
India	-38.1%	-28.8%	-50.4<X<-38.1
Mexico	-35.4%	-25.7%	-8.8<X<-6.4
Japan	-5.7%	+8.4%	-2.4<X<+3.6
Russia	-7.7%	+6.2%	-8.7<X<+3.8
US	-5.9%	+8%	-5.8<X<+8.1
World	**-15.9%**	**-4.2%**	**-186.5<X<-38.1**

Source: The European House-Ambrosetti elaboration of data from the Peterson Institute for International Economics

As seen in the table above, keeping the same agricultural surface, the drop in worldwide agricultural output will be at a level of almost 190 billion dollars per year. Even in the presence of carbon fertilization, world annual agricultural production would decrease by almost 40 billion dollars.

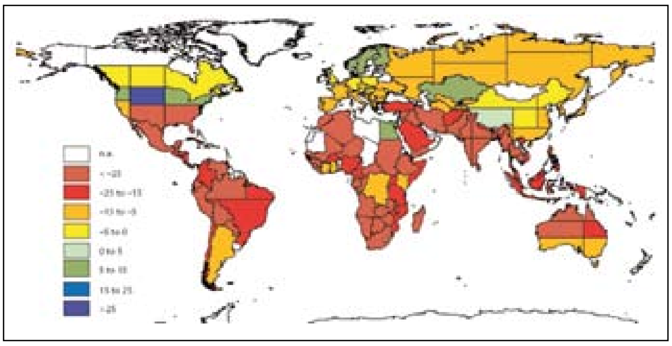
Figure 70. Impact on agricultural output as of 2080

	Delta production with no carbon fertilization	Delta production with carbon fertilization	Delta in monetary terms (base 2003)
Belgium	-6.7%	+7.3%	-0.2<X<+0.2
France	-6.7%	+7.3%	-2.3<X<+2.6
Germany	-2.9%	+11.7%	-0.5<X<+2.0
Greece	-7.8%	+6.0%	-0.7<X<+0.6
Italy	-7.4%	+6.5%	-2.4<X<+2.1
Netherlands	-7.0%	+6.9%	-0.7<X<+0.7
Portugal	-9.6%	+4.0%	-0.4<X<+0.2
Romania	-6.6%	+7.4%	-0.4<X<+0.5
Sweden, Norway, Finland	+10.9%	+27.5%	+0.9<X<+2.5
Spain	-8.9%	+4.8%	-2.7<X<+1.4
UK	-3.9%	+10.5%	-0.5<X<+1.3

Source: The European House-Ambrosetti elaboration of data from the Peterson Institute for International Economics

Italy risks depending of different scenario, a loss of almost 2.4 billion dollars per year in terms of agricultural output (in absence of carbon fertilization), while in the most positive case which takes into consideration the presence of carbon fertilization, there will be an increase in productivity of almost 2.1 billion dollars.

Figure 71. Impact on agricultural production as of 2080 without carbon fertilization

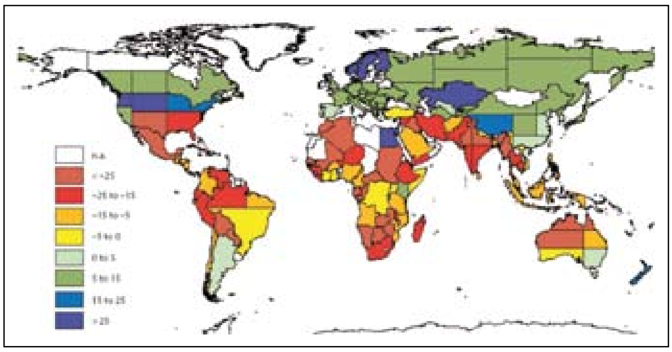


Source: The European House-Ambrosetti elaboration of data from the Peterson Institute for International Economics

In the absence of carbon fertilization, almost all countries will undergo a decrease in agricultural production, with the exception of Scandinavia and the areas near the Caspian Sea. Most heavily hit will be equatorial areas.

However, in the presence of carbon fertilization, the northern hemisphere will see substantial improvement, especially above the 35th parallel.

Figure 72. Impact on agricultural production as of 2080 with carbon fertilization



Source: The European House-Ambrosetti elaboration of data from the Peterson Institute for International Economics

4.2.2 Repercussions on the safety of the food chain

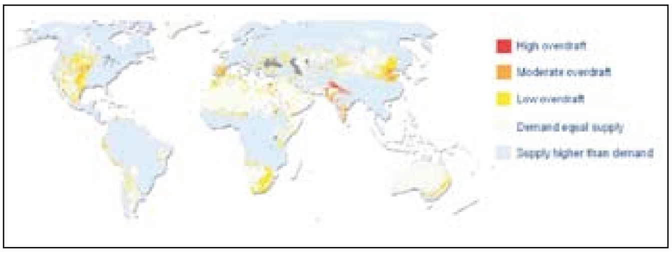
Climate change also has consequences on food security. The term food security indicates a situation in which all people have physical and economic access to sufficient, safe, and nutritious food to meet their dietary needs and food preferences for an active and healthy life[97]. The potential repercussions envisaged as a result of *climate change* mainly involve the **management of water resources, spread of disease and contamination of agricultural products and foodstuffs**.

A. Water Management. It is estimated that until 2030 agriculture will remain the main user of water resources[98]. It is assumed that currently about 80% of the agricultural surface worldwide uses rainwater while the remaining 20% is irrigated[99]. The crop yields are higher with irrigation and that irrigation accounts for 40% of the total agricultural production.

Climate change appears to lead to two main effects. In the northern hemisphere, the capacity of the rivers is expected to increase as will the overall amount of water available. The tropical and semi-arid areas (mainly the Mediterranean, eastern United States, South Africa and northeastern Brazil) will instead see a significant decline in their water resources[100]. At the same time, due to population growth, inefficient irrigation practices and growing competition for the use of water resources, it is estimated that a 15-35% use of water for irrigation will no longer be sustainable in the future[101]. As regards management practices to be implemented to improve water resource management, see *Position Paper "Water Management"* published by the Barilla Center for Food & Nutrition in March 2009.

97 *"Food Security exists when all people, at all times, have physical and economic access to sufficient, safe, and nutritious food to meet their dietary needs and food preferences for an active and healthy life" - World Food Summit, 1996*
98 *Source: "Facts and Trends – Water", World Business Council for Sustainable Development (WBCSD), 2006*
99 *Source: "Facts and Trends – Water", World Business Council for Sustainable Development (WBCSD), 2006*
100 *Source: "Climate Change 2007: Synthesis Report. Summary for Policymakers", IPCC, 2007*
101 *Source: "Facts and Trends – Water", World Business Council for Sustainable Development (WBCSD), 2006*

Figure 73. Use of water resources for agriculture



Source: "Facts and Trends – Water", World Business Council for Sustainable Development (WBCSD), 2006

B. Spread of disease and contamination in agricultural products and foodstuffs. It appears that changes in the climate and environmental conditions could lead to the spread of disease and contamination in agricultural products and foodstuffs, more than is seen today.

- **Bacteria, viruses and protozoan parasites**. Cholera is perhaps the best example of the potential climate change has to modify the dynamics behind pathogen transmission. One of the most significant effects of the high concentration of CO_2 is, for example, altering the acidity of the oceans. This phenomenon raises the pH of the water which, in turn, increases the potential to spread disease. Similar processes – facilitated by climate conditions with higher than average seasonal temperatures and high humidity – lead to the spread of some diseases, including salmonellosis and rotaviruses.
- **Zoonosis and zoological diseases**. Animals can transmit zoological diseases to man in several ways: by direct contact with diseased animals, through animal products, by various carriers and through consumption of contaminated food and water. In this regard, it has been shown that climate change increases the vulnerability of the animals, increases the availability of potential carriers and extends the carrier-related transmission cycles. All these consequences increase the proliferation of zoological diseases.
- **Toxic fungi and microtoxin contaminations**. Microtoxins are a group of highly toxic substances produced by moulds and which grow in a certain number of crops both before and after harvesting. Some of these toxins are particularly dangerous for man and their spread could be due to changes in climate conditions.
- **Toxic algae**. Recent years have seen a significant increase in the presence of the so-called *Harmful Algal Blooms*. These algae which are potentially hazardous for man, even indirectly. It appears that changes in the marine habitat – changes linked to climate phenomena – can create marine environments which are particularly favorable to the spread of such algae.
- **Environmental contamination and chemical residues in the food chain**. Extreme events such as floods and hurricanes tend to bring with them contamination related to chemicals. Higher water temperatures and more intense rainfalls increase the potential for water contamination by organic debris and chemical substances. Moreover, the use of pesticides contaminates agricultural soil and its products.

4.2.3 Scarcity of food resources and impacts on social security

Since the end of the Cold War, two fundamental changes have taken place in the world, linked to the concepts of peace and security on a global scale:

- on the one hand, conflicts involving whole countries have decreased, and it is now more **civil wars** and **internal conflicts** which hold the greatest risk for the maintenance of world peace;
- on the other hand, alongside political and military strife, other elements, like **poverty** and **environmental** risks, the availability and use of **natural resources** and **health**, are becoming significant risk factors for the development of conflicts.

The connection between climate change, the availability of natural resources and security is a subject of particular interest to the most important international organizations: among the many studies on the subject, one, in particular, is worth mentioning: the recent study on the subject by the United Nations Environment Programme, "*From Conflict to Peacebuilding. The Role of Natural Resources and the Environment*", published early in 2009, which focuses on a theme that has been debated for a number of years, in various forms.

The **European Council**, in December 2003, adopted the *European Security Strategy*, identifying among the **most serious global challenges in terms of security**, for the present and future, the competition **for natural resources** (mainly concerning water).

In particular, according to the European Council, the effects of climate change on the availability and allocation of natural resources will lead, in all likelihood, to an increase of the turbulence and migratory phenomena:

"The competition for natural resources that, in the next few decades, will be aggravated by global warming, will very probably produce ***upheaval*** *and* ***migratory phenomena*** *in several parts of the planet".*

In line with these forecasts, the **European Commission**, in the spring of 2008, acknowledged climate change as "**a dangerous multiplier capable of exacerbating all the other trends, tensions and existing factors of instability**".

As we have seen, international attention around this theme appears widespread, and the considerations of the European Commission help us to delineate the possible macro-effects of *climate change* in terms of security.

However, which specific risks appear most likely? All the international studies agree in general in identifying certain critical or conflict areas deriving (directly or indirectly) from *climate change*.

Following the reasoning set forth by the European Commission in its most recent document on "*Climate change and international security*", the following critical/conflict situations for society are connected with climate change:

- conflicts generated by the **availability** and **use** of the **natural resources**: the negative effects of climate change on natural resources (especially in terms of arable land and availability of water) appear likely to increase the probability of conflicts relative to the allocation of **resources as they grow more and more scarce, particularly in developing countries**;
- significant economic damage and risks for the **coastal cities** and their infrastructures: among the effects of climate change, as we have seen, are the rising levels of the seas and a significant increase of the problem of coastal erosion, creating a situation of serious **risk to the coastal population, from the standpoint of health and welfare, as well as economic considerations**;
- risks for the existence of entire portions of the territory and the increase of **territorial disputes**: climate change threatens the conformation and even the very existence of significant portions of the territory in many countries of the world; a consequence deemed highly probable is the increase of disputes concerning the definition of territorial and maritime frontiers, **especially where these frontiers act as watersheds between access and non-access to natural resources** located in border zones or even across borders;
- **migratory phenomena** linked to worsening living conditions due to climate change: this risk for security is one of those considered most likely and serious; climate change, directly – through the **greater frequency of extreme events** (heat waves, floods, hurricanes, ...) - as well as through the **reduction of natural resources available** (particularly in lower-income countries, in which the direct dependence of individuals on natural resources is very high) increases the probability that growing masses of people will be forced to move from their original homeland ("environmental migrants"), and acts indirectly on migratory movement through its negative effect on social conflict linked to the **allocation of natural resources as they grow scarcer**;
- situations of instability and ***misgovernment*** with respect to the response to the **growing needs of the populations**: the increased pressure on the availability and allocation of natural resources requires powerful government strategies by the institutions and political classes, in order to manage them without generating social conflict: **climate change generates new needs** (at the economic and social level), as well as new health and environmental problems, that **require new and adequate responses**: should the right answers not be forthcoming, the likelihood of social conflicts would increase exponentially, **especially in the "weaker" geo-political contexts**", such as those of many developing countries;
- tension linked to **access** and **control** of **energy resources**: climate change exasperates a situation of increasing demand for energy that has been growing rapidly in recent years; **the energy resources will become more and more precious** and cannot be expected to do anything but increase the likelihood of conflicts over their ownership and management, **especially when they are "shared" among several different economic/institutional owners** (such as hydrological basins that cross the borders of several countries, or mining and oil resources located in regions whose attribution is disputed by bordering countries) or in the case of resources located in **countries** that are **socio-economically unstable, and highly exposed** to the possible negative effects of **climate change**;
- pressures on **international governance**: the existence of some **countries that are relatively more responsible** for emissions of greenhouse gases, the main cause of the aggravation of climate change, and **countries that are relatively more seriously damaged** by the climate change could generate conflicts at the international level, exacerbating in some cases latent historical tension (one point of conflict could arise, for example, over the sharing of the costs for active operations of adaptation to climate change).

In support of the theory of the existence of a correlation between natural resources, climate change and security, there is **a particularly significant and "alarming" body of evidence**: it has been estimated that in the last 60 years at least **40%** of the conflicts arising within countries have been connected with the availability or use of natural resources.

According to the UNEP, in particular, **starting from 1990, at least 18 conflicts were generated/fueled by the exploitation of natural resources**.

Environmental factors often are not the only or main cause of the conflicts, but the exploitation of natural resources can be indicated as a highly relevant factor in all stages of their development, even *ex post*.

On the basis of a UNEP study, **conflicts associated with natural resources** have twice as much probability **of being repeated within the succeeding 5 years** as internal conflicts unrelated to natural resources.

4.3 Strategies for climate-compatible agriculture

4.3.1 Mitigation and adaptation

Agriculture and climate change are characterized by a complex cause-effect relationship: agricultural activity produces considerable volumes of greenhouse gases (see Figure 62), the main cause of climate change, but at the same time it suffers, as already shown, the negative impacts – in terms of productivity and food safety – of climate variations. For these reasons, the agrifood sector today is more central than ever to any strategy facing up to climate change.

In general, as already mentioned, the **intervention strategies** for dealing with and resolving the problems connected to climate change may be grouped into two main lines of action:

BOX 1

The case of Darfur

According to the *United Nations Environment Programme*, the development of recurring **droughts** and an increasing **population growth** are among the causes that drove Darfur into a spiral of violence that has caused, **since 2003, 300,000 deaths and over two million refugees**.

The UNEP has identified the climatic **variability** of the region, the **scarcity of water** and the **rapid loss of large portions of arable land** as the fundamental causes of the conflict.

Specifically:

- the excessive exploitation of pastureland and deforestation have led to a significant **depletion of the soil**;
- the lack of trees and vegetation has **reduced the defenses against encroaching sand dunes**;
- the shortage of rain has significantly **depleted water reserves** for the population and soil.

In such a situation, the population increase combined with the growth of demand for natural resources has **fueled the tension among farmers and other nomadic or herding populations**, in an area where **75% of the population depends directly on natural resources for its very survival**.

- **mitigation strategies**: with the power to act positively upon the causes, by seeking to reduce or stabilize greenhouse gas emissions. In the specific case of the agrifood sector, an example of this is the use of organic fertilizers, improved techniques for the breeding of livestock and the management of manure and the optimization of land management techniques for the purpose of absorbing and storing CO_2;
- **adaptation strategies**: with the power to act positively on the effects through plans, programmes and actions to minimize the impacts of climate change. An example of this is the revision and adaptation of the planting calendar and of the varieties sown, the transfer of the crops to other areas and the improvement of territory management techniques.

It is important to point out that, due to their complexity, the implementation of the intervention strategies is particularly difficult, especially in terms of coordination of the actions to be put into practice. In actual fact, in addition to skills and to technical, financial and administrative expertise, the planning and implementation of these actions requires, first and foremost, the political will to do so, both at a local and at an international level. This renders both the development of the strategies and their fulfillment an extremely challenging task.

4.3.2 What are the strategies for sustainable development in the agrifood sector?

The **three main objectives** to be attained in order to guarantee the environmental sustainability of agrifood production are[102]:

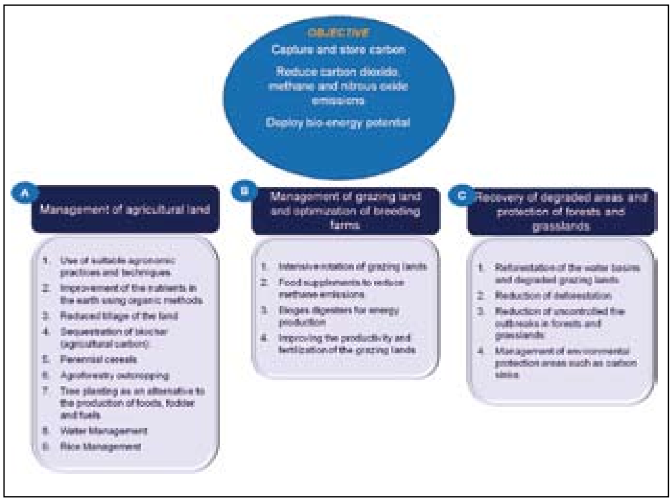
- **to actively absorb and store the carbon** in the vegetation and in the soil;
- **to reduce the emissions of carbon dioxide**, and of **methane** deriving from the production of rice, the raising of livestock and combustion, and also of those of **nitrous oxide** deriving from the use of inorganic fertilizers;
- to exploit the potential of ***bio-energy***, promoting forms of production that are not alternative to the agricultural use of the land, in order not to trigger disincentive mechanisms relative to production for food-related purposes.

With reference to the first points listed, it is important to point out how – from a scientific perspective – the **transfer from the atmosphere to the soil (and vice versa) of surface carbon**, a crucial element in the climate change process, feeds the life cycle of the Planet, provided that this movement is not altered by changes in the soil and by other factors. It is clear, therefore, that the ground and the activities connected with it play a fundamental part in the cooling process of the Earth. The utilization of the land, the type of use allocated to it, the choice of the crops to be cultivated, the practical management of each of them, are some of the factors that can both guarantee the stabilization of the climate and promote better production (in terms of quantity and quality) of food for the population.

The practices that, at the moment, appear to guarantee the achievement of these objectives, may be divided into three **macro-strategies**[103]:

A. Management of the agricultural land;
B. Management of the grazing land and optimization of breeding farms;
C. Recovery of degraded areas and protection of forests and grasslands.

Figure 74. The 3 strategies for reducing the impacts of climate change in the agrifood sector



The details of the aforementioned macro-strategies are provided below.

A. Management of the agricultural land

The soil is the Planet's third largest carbon sink. The organic substance present in the ground (coming from the living flora and fauna and from dead animal, plant and microbial materials) has the capacity to retain air and water within its surface, to supply nutrients for plants and fauna and to store the carbon in the soil. If the organic materials are managed efficiently, land enriched with carbon guarantees rich productive soil, without the need to resort to widespread use of chemical substances.

It is possible to **enrich the soil with carbon** through a number of practices which are outlined below:

- **Use of suitable agronomic practices and techniques**: agricultural land requires, first and foremost, special attention as regards its management. Numerous techniques and

102 *Source: IPCC, "Mitigation of climate change", 2007, Chap. 8; Sara Scherr and Sajal Sthapit, "State of the world 2009", Chap. 3*
103 *The evidence and the considerations expressed in this paragraph are largely based on the contents of the following publications: IPCC,*
- "Mitigation of climate change", 2007, Chap.8
- Smith, P., D. Martino, Z. Cai, D. Gwary, H.H. Janzen, P. Kumar, B. McCarl, S. Ogle, F. O'Mara, C. Rice, .J. Scholes, O. Sirotenko, M. Howden,T. McAllister, G. Pan, V. Romanenkov, U. Schneider, S. Towprayoon, M. Wattenbach, and J.U. Smith, 2007a: "Greenhouse gas mitigation in agriculture", Philosophical Transactions of the Royal Society
- Sara Scherr and Sajal Sthapit, "State of the world 2009", Chap. 3

practices may be successfully applied. Among these, the following are of particular interest: the use of perennial cereals, less tillage of the soil, land rotation, the use of arboreal crops. From the practical standpoint, dissemination of more detailed information on the most suitable and most efficacious practices is required. We shall examine the themes mentioned here in greater detail later;

- Improvement of the nutrients in the earth using organic methods: it is estimated that the use of nitrogenous fertilizers leads to greenhouse gas emissions of 2 billion tons[104]. Considering that nitrous oxide has a heating capacity 300 times greater than that of carbon dioxide, the potential damage that a chemical fertilizer can generate is clearly evident. On the other hand, adopting organic fertilizers (organic compost, green manure, dung, cover crops and intercropping methods) soil fertility management practices would enable the carbon to be absorbed from the atmosphere. For intensive cropping, this practice would appear to generate an increase in costs and labour, but this is not the case for other types of crops which can also benefit from better yields. Also the optimized use of inorganic fertilizers, to all effects and purposes indispensable, according to the *best practices* on the subject[105], can bring about considerable ecological advantages;
- Reduced tillage of the land: normally land is ploughed with the intention of improving the conditions of the seed bed. In actual fact, the tilling of the soil exposes anaerobic microbes to oxygen and suffocates aerobic ones by burying them, leading to the emission of carbon dioxide. The use of farming practices with the power to reduce the tillage of the land (such as leaving crop waste or mulch on the ground), promotes the absorption of carbon and reduces its emissions. Moreover, the non-tilling of the land has the advantage of reducing both labour and the use of fuels for farming machinery (with the benefit of lower production costs), of improving biodiversity and of promoting the cyclization of the nutrients. It is estimated that this practice can increase the yield of grain and soya crops by at least one third[106]. Recently, also due to the increase in the price of fuels, a sharp increase in land cultivated in this way has been observed;
- Sequestration of biochar (*agricultural carbon*): in order to enrich the soil with carbon, the decomposition of plant materials should take place in the subsoil. In certain areas of the world, especially in damp ones, this is not easy to achieve, if not thanks to a recent scientific discovery[107], through which *biochar* can be sequestered in the ground. *Biochar* (also known as agricultural carbon) is a natural nutrient composed of a fine grained soil with a high organic carbon content, produced by vegetable waste (forest residue, rice chaff, peanut shells, urban waste). This soil enriching solution, enables the soil to retain the carbon and to release the nutrients more slowly and gradually;
- Perennial cereals: plants have the characteristic of being able to capture energy and extract carbon from the atmosphere in order to produce biomass and their use appears to be efficacious in the prevention of climate change phenomena. Currently, two-thirds of the arable land available is cultivated with annual cereals[108], which involves a new tilling process each year and, as a consequence, continual emission of greenhouse gases. In contrast, perennial grasses maintain a dense mass of radical systems during growth, leaving a good quantity of biomass in the ground, as opposed to leaving pollutants in the atmosphere. Even though the issue is, from many points of view, still in its initial stages of development at the moment, the perennial plants available on the market are already numerous and derive from cereals (rice, sorghum and wheat), from some types of fodder and from oil plants (sunflower);
- Agroforestry outcropping: another way to retain carbon is through agroforestry. This consists of planting productive trees at the edges and within farmlands and grasslands. The species used could supply both products (fruit, nuts, medicines, fuels, wood etc.), and services for the farm business (nitrogen assimilation, wind protection, animal fodder, etc) and for the ecosystem (animal *habitat*, climate improvements, etc). The contribution of these plants reaches its maximum utility with *multistratified* agroforestry, which has the advantage of exploiting various ecological niches and therefore storing a greater volume of carbon;
- Tree planting as an alternative to the production of foods, fodder and fuels: in nature or, alternatively, as a result of genetic selection processes (domestication and commercial development) a number of tree varieties exist capable of replacing the annual crops of starch, protein, edible and industrial oils or animal fodder. Since one third of the cereal production is allocated to animal feeding, these plants could replace part of the animal fodder crops or contribute to the production of biofuels, thereby reducing the negative impacts of greenhouse gas emissions;
- Water Management: approximately 18% of the world's land is provided with a quantity of supplementary water, compared to the natural physiological dynamics, in the form of irrigation. In some areas of the World, irrigation could bring major benefits in the form of increased productivity. It is important, however, for the water to be managed carefully as it is a scarce resource;
- Rice Management: rice cultivation emits large quantities of methane, especially during the plant's growth phase. These emissions can be reduced through the application of specific management procedures, such as the reduction of the level of water present on the farmland during the plant's growth

104 Source: FAOSTAT, Statistical Database
105 Source: Uphoff et al., "Biological approaches to sustainable soil systems", 2006; International Fertilizer Industry Association, "Fertilizer Best Management Practices", 2007
106 Source: A. Calgeri, "No-tillage System in Parana State, South Brazil", 2001
107 Source: J. Lehmann, "Bio-Char Sequestration in Terrestrial Ecosystem - A review", 2006
108 Source: FAOSTAT, Statistical Database

phase, the reclamation of the lands during the pre-planting periods and the correct use of organic residue.

B. Management of grazing land and optimization of breeding farms

Over the last twenty years with the process of industrialization and distribution of wealth, the consumption of meat in the world has grown significantly[109]. This *trend* has led to an increase in large intensive animal breeding farms and the deforestation of large areas to be used as grazing land. It is, by now, universally acknowledged that livestock produces a large quantity of greenhouse gases, among which methane (from the fermentation of the food in the animal's rumen and from the storage of stable manure), nitrous oxide (from the denitrification of the soil and the surface of manure heaps and carbon (from crops, animals, microbial respiration, fuel combustion and deforestation). It is estimated that livestock is responsible for at least 50% of the agricultural emissions of greenhouse gases (approx. 7.1 billion tons; in this connection, just consider that a cow/calf couple produces more greenhouse gases in a year than a person covering 12,500 km by car[106]) and of land-use change (one of the causes of pollution). The medium-to-long term solution to this problem consists in reducing the consumption of meat and dairy products at a worldwide level. There are also in this case, however, optimum management techniques for limiting the most negative effects of the phenomenon:

- Intensive rotation of grazing lands: various research projects carried out[111] have demonstrated that if an intensive livestock rotation system is applied, the grazing lands can give sustenance to a larger number of animals, since this practice leads to excellent regeneration of the vegetation after grazing. Recent research conducted by the US Ministry of Agriculture[112] points out that the best way to reduce the greenhouse gas footprint of intensive livestock breeding farms is to improve the storage of carbon in the grazing lands, to use better quality fodder, to eliminate the storage of dung, to cover manure heaps, to increase the productivity per animal and, first and foremost, to use management-intensive grazing techniques;
- Food supplements to reduce methane emissions: the methane produced in the rumen of the animals is responsible for as many as 1.8 billion tons of greenhouse gas emissions[113]. With the aim of reducing this quantity, food supplements and innovative mixtures of feed have been developed and have succeeded in reducing its production by at least 20%. Unfortunately, however, at the moment this solution is not easy for the farmers to adopt, both due to its high costs and to the complex management system involved;
- Biogas digesters for energy production: breeding farms could be transformed into producers of green energy, through the innovative management of their waste products. For example, manure, one of the main forms of pollution, could become an alternative source of energy with the power to reduce the farm business's dependence on fossil fuels. This would be possible, for example, through the use of anaerobic biogas digesters. These devices are, in fact, able to break down the manure into methane/biogas and compost mud, where the former is burned for heating and for the production of electricity and the second can be used as a fertilizer;
- Improving the productivity and fertilization of the grazing lands: better productivity of the breeding farms is obtained also through efficient land management. To achieve this it is possible to use, for example, organic fertilizers and nitrogen or sustainable irrigation techniques which take into account issues such as water management and the use of energy. Also the use on the land of species of grassy plants can also help guarantee the high productivity of the grazing lands.

C. Recovery of degraded areas and protection of forests and grasslands.

Extensive deforestation, and the designation of ever increasing areas for annual crops and as grazing land has deprived the world of huge areas of vegetation. Initiatives to restore the vegetation, are beneficial actions which can often be implemented with minor economic expenditure. Among the practices that could help achieve the above goal, the following are worth considering:

- Reforestation of the water basins and degraded grazing lands: the scarce presence of vegetation on the land reduces the possibility to store the carbon and, first and foremost, to retain the rainwater in the ground. In a situation characterized by a world water emergency[114] and by climate change, the recovery of the plant covering of the river basins needs to be dealt with immediately;
- Reduction of deforestation: the World's forests and grasslands also act as an enormous carbon sink. It is estimated that the dimensions of the forests amount to 4 billion hectares while those of the grasslands amount to 5 billion hectares[115]. Forests and grasslands are known to have great carbon absorption and climate mitigation capacities. Deforestation activities lead, therefore, to an increase in greenhouse gases in the atmosphere and to a reduction in carbon dioxide absorption capacities. If we consider that between 2000 and 2005 alone, 7.3 million hectares per year of woodlands were lost, mainly to agriculture and infrastructures, and that through each hectare 217 to 640 tons of carbon were released into the atmosphere, we can begin to get the

109 The most significant case is that of China where the consumption of meat has more than doubled over the last twenty years and is expected to double again within 2030. Source: UNDESA
110 Source: Steinfeld H. et al, "Livestock's Long Shadow: Environmental Issues and Options", 2006
111 Source: C.L. Neely and R. Hatfield, "Livestock System"
112 Source: Al Rotz, "Grazing and the Environment"
113 Source: Steinfeld H. et al, "Livestock's Long Shadow: Environmental Issues and Options", 2006
114 Source: Barilla Center for Food & Nutrition, Position Paper "Water Management", 2009
115 Source: World Resources Institute, Earth Trends Information Portal

picture of the dramatic proportions of this phenomenon[116]. Hence, it is essential that deforestation be regulated at an international level and, at the same time, that the most suitable forms of incentive be devised (financial, property rights, certifications, etc.) for the owners of the woodlands, to encourage them to adopt suitable methods for protecting the areas. Among the possible solutions being assessed are the following:

- the Redd programme (*Reducing Emissions from Deforestation and Degradation*) for the reduction of emissions from deforestation and degradation plans, after 2012, to allocate economic funds to the sustainable management of forests, with a view to reducing greenhouse gas emissions[117];
- an alternative, but equally interesting, approach is that of the *Biodiversity and Agricultural Commodities Program of the International Finance Corporation*, which is committed to increasing the production of sustainable and certified products (soybeans, sugarcane, etc);
- a third method of intervention consists in guaranteeing property and use rights to local residents so that they might protect the forests in a sustainable manner;

- **Reduction of uncontrolled fire outbreaks in forests and grasslands**: biomass combustion is an important generator of carbon. In agriculture, in some cases, if controlled and of limited dimensions, it can be an advantageous factor for production. When however it is man himself who starts the fires in order to set up land settlements, large quantities of carbon emissions are generated and the flora and fauna suffer serious damage. It is, therefore, essential to protect the forests and grasslands using instruments capable of preventing arson. One practice could be to raise the awareness of the local communities, by offering incentives with the power to exert social control. This method has already been put into practice in Honduras and Gambia[118].
- **Management of environmental protection areas such as carbon sinks** (see paragraph entitled "The international policy scenario").

Also in the light of the above, it is important to underline how fully eco-friendly agricultural activities are strongly linked to training processes, the sharing of *best practices* and the transfer of scientific skills already acquired within consolidated operational procedures. In other words, the investment that should be made on a global scale is, first and foremost, that of a renewed realization of the impact that human activities in the agrifood sector actually have, and the promotion of instruments, logical procedures and practices to deal with the same.

4.4 Financing and incentives systems

The strategies described may require, for their realization, support and incentives of various kinds for the economic players (farmers, owners of forest lands, etc.), the consumers and all the other categories involved.

The instruments and mechanisms for providing these incentives and financing the implementation of the agricultural strategies and practices are numerous and varied. In general, these instruments are defined on the basis of the specific purpose and subject involved. They must also be linked to concrete, measurable goals. In this connection, the indicator currently most widely used is **the measurement of reduction of the impact of greenhouse gases**, as this is an extremely effective instrument in evaluating new technologies relative to agrifood production.

Hereafter we describe a number of interesting initiatives enacted by public and private entities, that have generated important benefits.

- **Sustainable Food Laboratory**[119]. This is an association of 70 enterprises and social organizations all over the world, that through a scientific team composed of researchers, enterprises and experts, identifies and provides incentives for the application of sustainable agricultural practices and verifies their application. In short, the goal of this association is to share knowledge and the concrete application of the solutions identified. The interesting aspect of this initiative is just the spread of information on the agricultural practices and crops with a high capacity for absorption of carbon, and the linked system of economic incentives for those agricultural producers who adopt and comply with the suggested quality standards.
- **Amazon Fund**[120]. With the goal of reducing emissions caused by deforestation and deterioration of the Amazon Rainforest, the *Amazon Fund* was created to collect financial resources to use in projects designed to combat deforestation and promote the conservation and sustainable use of the forest's resources. What makes this initiative interesting is the mechanism of collection and allocation of the funds based on the results achieved in reduction of emissions from deforestation. In practice, a board of scientists and experts certifies, by means of specific systems of calculation, the portion of emissions avoided by reducing the activities of deforestation. The organization is also distinguished for its close cooperation with the local authorities, with the Brazilian government, with the non-government organization *Amazonia Association* and with the *Brazilian Development Bank*.

116 Source: World Resources Institute, Earth Trends Information Portal
117 The Redd (Reducing Emissions from Deforestation and Degradation) programme is promoted by the United Nations in cooperation with FAO, UNDP and UNEP. The agreement was stipulated at the end of 2007 at the Bali Conference
118 Fao, "Community based Fire Management: Case Studies from China, The Gambia, Honduras, India, the Lao People's Democratic Republic and Turkey", 2003
119 Source: www.sustainablefoodlab.org
120 Source: www.amazonfund.org

- **Regional Greenhouse Gas Initiative**[121]. This initiative is promoted by a non-government organization created to support, develop and implement practices and strategies designed to reduce emissions of greenhouse gases in the 10 participating American states. What makes it interesting is that, to reduce emissions, the 10 states are using a market-based approach with relative exchange of "*cap-and-trade*" certificates. This is the first compulsory market in the U.S. in which states exchange shares of CO_2 emissions and the supply of electrical power.
- **New Zealand Sustainable Land Management and Climate Change Plan**[122]. The New Zealand government has shown itself to be particularly sensitive to the problem of climate change. It has therefore decided to establish a project for the spread of knowledge of the problem and its solutions, and commit itself to reduction of its own environmental impact. One of the initiatives promoted, that is particularly worthy of attention, is the definition of a five-year plan for the sustainable management of the territory and for climate change. Its intention is to promote the adjustment of agriculture and selviculture to climate change, through financial initiatives (about 175 million dollars have been made available over the 5 years) to be assigned to the operators in the agrifood sector and in the world of scientific research, and a quota system of emissions (*cap-and-trade*) to promote the application of ecosustainable behaviours and practices.
- **BioCarbon Fund - World Bank**[123]. The World Bank has established a fund to finance projects to promote the increase of sequester and conservation of the carbon in the forests and soil. The fund is distinguished by its public-private nature and by the success it has received in the stage of gathering funds, that have now reached 91.9 million dollars.
- **Global Ecolabelling Network**[124]. From the consumers' viewpoint, however, the trend is to provide incentives for developing ecosustainable behaviour through advertising campaigns promoted mostly by the associations to heighten awareness and communicate the message. The goal is to spread greater knowledge and awareness of the impact that the entire life cycle of agricultural and food products have (from the production to the consumer) on generating climate change. In this connection, one of the most effective instruments is the use of *Ecolabels*, which are labels that certify the use, by the producers, of practices of management and production that respect the environment. This instrument serves to inform the consumer of the environmental impact relative to the product purchased. It is, basically, a method of spreading information relative to the impacts that the individual consumer has on the environment, and consequently enable buyers to direct their choices on the basis of their own environmental sensitivity.

As we have seen, there are many instruments that can be used. Regardless of the type and promoting organization, the incentives and financing systems should be the means to ensure that the economic players apply the best practices of management, production and distribution of agricultural and food products, with the final aim of improving and increasing food and fibre production in the world, and at the same time reducing the quantity of emissions of greenhouse gases into the atmosphere.

5. ENVIRONMENTAL SUSTAINABILITY OF THE FOOD SECTOR

5.1 *Climate Foodprint*: the environmental impact of the food system

The *Climate Foodprint* measures the environmental impact generated by the production and consumption of food.

The concept of the *Climate Foodprint* falls within the scope of both the *Carbon Footprint* and in a broader sense, the *Ecological Footprint* (topics already dealt with in Chapter 2 of this report). In fact the production and consumption of food generates an environmental impact in terms of CO_2 emissions (*Carbon Footprint*) and in terms of demands on the Earth's ecosystems (*Ecological Footprint*).

Hence, the type, the composition, and the quantity of food which is produced and consumed has a significant affect on both the total quantity of CO_2 emissions, and consequently on the *Carbon Footprint*, and on the human demands placed on nature in terms of the ratio between the consumption of resources and the Earth's capacity to (re)generate them.

A number of studies conducted to investigate this matter, show growing concern for the ecological consequences connected to the food production and consumption system adopted in developed countries[125]. These concerns have led to the development in international institutional seats, of specific *action plans* aimed at encouraging the populations of various countries to adopt more sustainable models of food production and consumption[126].

121 Source: www.rggi.org. The ten participating states are: Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island and Vermont
122 Source: www.climatechange.govt.nz; www.maf.govt.nz/climatechange/slm/
123 Source: wbcarbonfinance.org
124 Source: www.globalecolabelling.net; http://ec.europa.eu/environment/gpp/projects_en
125 Loh J., Randers J., MacGillivray A., Kapos V., Jenkins M., Groombridge B., and Cox N. 1998. "Living Planet Report 1998: Over consumption is driving the rapid decline of the world's natural environments", WWF International, Gland, Switzerland, New Economics Foundation, London and World Conservation Monitoring Centre, Cambridge, UK; Parikh, J.K. and Painuly J.P. 1994. "Population, Consumption Patterns and Climate Change: A socio-economic perspective from the South". Ambio, Vol. XXII, No. 7, pp. 434-437
126 United Nations, 1993. Agenda 21: United Nations Conference on Environment and Development, Rio de Janeiro, Brazil. United Nations Department of Public Information, New York

Food is a primary necessity for mankind; so, being as suppressing production and consumption of food is not a conceivable option, it is necessary to find production methods which are more sustainable by favouring the consumption of foods which have the least environmental impact.

The consumption of food has an impact on the environment in different ways relative to the life cycle of the food itself. In particular, environmental impact occurs on the following different levels[127]:

- agricultural production;
- processing;
- storage;
- transport;
- preparation;
- waste.

A study carried out in Sweden in 1997[128], estimated that 20% of its national energy consumption was in some way connected to the food production and consumption chain.

To put it briefly, food has a relevant impact on the level of CO_2 emissions responsible for climate change and on the consumption of natural resources which makes the Earth's capacity to (re)generate them an even more critical factor.

In this light, two types of diet which prevail in the western world today, the **North American diet** and the **Mediterranean diet**, were analysed and their impact in terms of CO_2 emissions and ecological footprint demands were estimated.

The **North American diet**, which strongly identifies the eating habits of the USA, is **characterized by a significantly high consumption of meat and a growing consumption in sweet foods and foods containing a high concentration of sugars and fats**, and consequently with an elevated calorie count.

This trend is in continuous growth and, on average, over the last thirty years the daily calorie intake of an American has increased by 25%. Data held by the US Department of Agriculture indicates that the average consumer not only eats an ever-growing quantity of food, but also shows a net preference for high-calorie foods. According to *National Centre Health Statistics*, approximately 62% of Americans are today overweight compared to 46% percent registered as such in the 1980's.

The following table shows a summary of the ecological impact and the *Carbon Footprint* which characterize the North American diet.

Figure 75. The North American Diet

Food	Grams per day	Ecological footprint m2	Carbon footprint (fossil) g CO2	Carbon footprint (bio) g CO2
Pasta	220,1	3,1	378,6	- 323,5
Rice	24,7	0,1	11,5	- 37,1
Meat	242,3	15,0	5.016,2	-
Poultry	80,8	0,2	146,2	-
Fish	18,6	0,0	12,9	-
Vegetables	531,9	3,7	257,4	-
Fruit	346,7	0,3	52,0	- 346,7
Eggs	41,1	0,3	61,6	- 139,7
Sweet	188,9	4,0	377,8	- 283,3
Water	900,0	-	94,2	-
Milk, yogurt and cheese	68,3	0,1	88,9	- 0,4
Wine	5,0	0,1	11,2	-
Total	2.668,5	26,8	6.508,5	- 1.130,8

Source: The European House-Ambrosetti elaboration based on US Department of Agriculture and Studio LCE data

The *Carbon Footprint* aspect is divided into two parts: the so-called "Fossil carbon footprint", concerning the emissions of CO_2 into the atmosphere, and the so-called "Bio carbon footprint", which refers to the fact that during the production process of a specific food, CO_2 is actually absorbed from the atmosphere. In other words, it must be taken into consideration for example, that if on the one hand a certain quantity of CO_2 emissions are associated with the final consumption of fruit, on the other the plant which provided that fruit has also absorbed CO_2 from the atmosphere through the process of photosynthesis. Wherever possible, this effect has been estimated and highlighted in the table above.

To summarize, an **average person who feeds him/herself in accordance with a North American diet, leaves a 26.8 m^2 ecological footprint and releases approximately 5.4kg of CO_2 into the atmosphere each day**.

The **Mediterranean diet**, however, which strongly reflects the eating habits of the population in Italy and other Mediterranean countries, is **characterized mainly by the consumption of carbohydrates, fruit and vegetables**.

The Mediterranean diet is considered by many nutritionists and food scientists as one of the best diets for increasing physical wellbeing and for preventing chronic diseases, especially cardiovascular ones.

Figure 76. The Mediterranean Diet

Food	Grams per day	Ecological footprint m2	Carbon footprint (fossil) g CO2	Carbon footprint (bio) g CO2
Pasta	200,0	2,8	343,9	- 293,9
Rice	51,6	0,2	24,0	- 77,4
Meat	77,7	4,8	1.608,4	-
Poultry	33,3	0,1	60,3	-
Fish	45,0	0,1	31,1	-
Vegetables	262,0	1,8	126,8	-
Fruit	208,0	0,2	31,2	- 208,0
Eggs	21,0	0,2	31,5	- 71,4
Sweet	33,0	0,7	66,0	- 49,5
Water	836,0	-	87,5	-
Milk, yogurt and cheese	198,0	0,2	257,4	- 1,2
Wine	91,0	1,3	203,8	-
Total	2.056,6	12,3	2.872,0	- 701,4

Source: The European House-Ambrosetti elaboration based on Istituto Nazionale di Ricerca per gli Alimenti e la Nutrizione – INRAN (National Food and Nutrition Research Institute) and Studio LCE data

127 *Andersson K. 1998. "Life-Cycle Assessment (LCA) of Bread Produced on Different Scales: Case study". AFR report 214, Swedish Waste Research Council, Swedish Environmental Protection Agency, Stockholm, Sweden*
128 *Uhlin H-E. 1997. Energiflöden i livsmedelskedjan. Rapport 4732, Swedish Environmental Protection Agency, Stockholm, Sweden*

In short, an **average person who feeds him/herself in accordance with a Mediterranean diet, leaves a 12.3 m^2 ecological footprint and releases approximately 2.2 kg of CO_2 into the atmosphere each day**[129].

The differences revealed in the *Ecological Footprint* and the *Carbon Footprint* between the North American diet and the Mediterranean diet can be traced back mainly to the following factors:

- the **quantity of food eaten**, which is higher in the North American diet;
- the **type of food eaten**, which is mainly meat and sweet foods in the North American diet as opposed to the carbohydrates, fruit and vegetables which characterize the Mediterranean diet;
- the **composition of the food eaten**, which on the whole has a far greater calorie count in the North American diet compared to the Mediterranean diet, on equival terms of type food.

With the aim of providing an undistorted estimate of the environmental impact of the two types of diet, standardization of the values was sought by removing the aspects concerning quantities of food and food composition while keeping the component relative to the type of food eaten intact.

In other words, being as it is not possible to compare two diets which are significantly different like the Mediterranean and North American diets, an attempt was made to "purify" the effect on the *Ecological Footprint* and the *Carbon Footprint* produced by the different quantities of food and the different calorie content of the same, to highlight how **the differences in terms of environmental impact depends on the mix of food consumed**.

Figure 77. Comparison of the Mediterranean and North American diets

	Ecological footprint m2	Carbon Footprint (fossile-bio) gCO2
Mediterrane diet (100 calories)	0,76	132,97
Nordamerican diet (100 calories)	1,20	240,14
Delta	57,9%	80,6%

Source: The European House-Ambrosetti elaboration based on Istituto Nazionale di Ricerca per gli Alimenti e la Nutrizione - INRAN (National Food and Nutrition Research Institute), United States Department of Agriculture and Studio LCE data

The results show that on an equal level of quantity and composition of food, the North American diet has a significantly higher environmental impact compared to the Mediterranean diet.

To be more specific, an intake of **100 calories of a North American diet has an ecological impact which is approximately 58% higher than that produced by an intake of 100 calories of a Mediterranean diet**. In terms of *Carbon Footprint*, on the other hand, a **100-calorie intake of food following a North American diet generates CO_2 emissions which are 80% higher than the emissions produced by a similar intake following a Mediterranean diet**.

5.2 The "food pyramid" and the environmental impact of foodstuffs

The current western lifestyle is characterized by a vast availability of food and an ever-increasing sedentariness, which leads to people apparently living in conditions of psycho-physical wellbeing but which often does not correspond to actual good health.

Eating habits have progressively moved towards foods with a higher content of protein, saturated fats and sugars, to a point where the daily intake of nutrients significantly exceeds biological requirements. During the day opportunities to consume food increase, while the physical activity is dedicated on average, only a marginal amount of time.

The result throughout the western world is an ever-increasing imbalance of calorie intake and calorie consumption, which is manifest in the general weight increase of the population. With the aim of orientating the population to healthier eating habits, the Italian Ministry of Health has commissioned a study to elaborate a dietary reference model which is coherent with current lifestyles and with traditional Italian eating habits[130].

The results of this study have lead to the creation of the **weekly lifestyle pyramid, which is based on the definition of the Healthy Quantity (HQ)**, referring both to food and physical exercise. The **Healthy Quantity indicates the number of portions**, the quantity of which is shown in the following table, **which should be consumed over one week** or during one day, whenever possible.

129 The approach used to calculate the indicators relative to the ecological and carbon footprint is based on life cycle analysis which involves a complete study of the production systems from an environmental point of view, following step by step the path taken by the raw materials from their extraction, through all the transformation processes and transport until they return to the earth as waste. This "broad" approach avoids making a single industrial operation more efficient or "cleaner" at the expense of others by simply transferring the pollution aspects into space or time, neglecting the fact that benefits obtained locally may be offset by consequences arising elsewhere (or in the future), with the final result of not obtaining real improvements or even of actually making the overall balance worse. Application of the LCA method, and in more general terms the "life cycle thinking" approach, became diffused in the '90's mainly in the industrial sector whereas its application is relatively recent in the agro-food industry. Further information on the LCA method are available in the work published by G.L. Baldo, M. Marino, S. Rossi, "Analisi del ciclo di vita LCA, Materiali, prodotti, processi" - Edizioni Ambiente, Milano 2008. The data used in this paper are from two types of source: direct data processing for products manufactured by Barilla; public and commercial data banks for other food products. With regards to the data banks, given the recent application of the LCA method to the food sector, the information is not characterized by a homogeneous level of reliability and above all they do not always provide the possibility to reconstruct the data provided

130 "Italian Food Pyramid: weekly guide to healthy living", Faculty of Food Science, Department of Medical Physiopathology, Rome University "La Sapienza", 2003

Figure 78. Food categories, portions and weekly and daily Healthy Quantities

		Grams per serving	Weekly quantity wellness	Daily quantity wellness
Vegetables and fruit	Vegetables	250	7	1,0
	Fresch salad	50	7	1,0
	Fruit	150	21	3,0
Cereals and tubers	Breac	50	16	2,3
	Pasta end rice	200	8	1,1
	Sweet	20	7	1,0
	Potatoes	200	2	0,3
Meat, fish, eggs and legumes	Meat	100	5	0,7
	Cold cut	50	3	0,4
	Fish	150	2	0,3
	Egg	60	2	0,3
	Legumes	100	2	0,3
Milk and dairy products	Milk	125	7	1,0
	Yogurt	125	7	1,0
	Fresch cheese	100	2	0,3
	Seasoned cheese	50	2	0,3
Dressing and sugar	Butter	10	5	0,7
	Sugar	5	21	3,0
Beverages	Wine	100	3	0,4
	Bear	330	4	0,6
	Water	1200	7	1,0

Source: The European House-Ambrosetti re-elaboration based on Department of Medical Physiopathology, Rome University "La Sapienza" data

Figure 79. The food pyramid

Source: The European House-Ambrosetti re-elaboration based on Department of Medical Physiopathology, Rome University "La Sapienza" data

Excessive consumption of only one food, or a diet based on a low number of different foods, nearly always leads to nutritional imbalance. As well as energy-providing foods it is important to consume enough water each day to suitably compensate water loss through skin and mucosa transpiration. On the whole, to meet bodily requirements, the daily intake of water should amount to 1 ml/kcal of consumed energy, hence, the recommended daily allowance of water is approximately 2 litres to be consumed under the form of food and drinks. If a part of this daily requirement is provided by food (600-800 ml) the remaining part (approximately 1,200 ml) must be consumed as drinks.

As the following figure shows, the food pyramid is divided into 6 sections. Each section contains in decreasing quantities the various food groups indicated in different colours to highlight that each group is characterized by a different nutritional content and therefore a different number of portions must/can be consumed.

The base of the pyramid is made up of vegetables and fruit, characteristic elements of the Mediterranean diet, due to their high nutrient and low calorie content (vitamins, minerals, water) and their healthy compounds (fibre and bioactive compounds of vegetable origin). Moving up the pyramid you find foods with an increasingly higher calorie content, foods which dominate the North American diet, which should be consumed in lower quantities to avoid weight problems.

To look into the base of the pyramid in greater detail, the fruit and vegetables found there have a low calorie content and provide the body with water, protein, carbohydrates, vitamins, minerals and fibre. The protein content is very low, as is the quantity of fats contained in these foods. The carbohydrate content of fruit and vegetables is provided mainly by simple sugars, which provide a readily available source of energy for the body, and very little starch. Vegetables are a main source of fibre which, as well as helping to maintain healthy intestinal functions, also contributes to the sensation of satiety and therefore makes it easier to limit the consumption of more fattening foods.

The second level of the food pyramid contains pasta, rice, potatoes, bread and biscuits. Pasta is rich in complex carbohydrates with a moderate quantity of protein and a minimal quota of lipids. Rice, like all cereals has a very high starch content, a low protein content and an even lower quantity of fats. Furthermore it contains small quantities of B vitamins and minerals. Potatoes have a very moderate content of fats and proteins while it is rich in starch and carbohydrates. It is also one of the most important sources of potassium, phosphorus and calcium. Biscuits are made up of a number of ingredients and therefore their nutritional and calorie contents are extremely variable. On a general level the content of starch and simple sugars is significant, while the fat content is very variable. Bread is a primary food source in that it provides the body with the necessary quota of carbohydrates to ensure the best fuel for the human body.

The third level of the food pyramid holds condiments. Extra virgin olive oil is made up of triglycerides, essential fatty acids, vitamin E and also includes substances such as polyphenols and phytosterols which carry out protective actions for the human body. The fat content is made up of short and medium chain fatty acids.

The fourth level of the food pyramid contains milk, yoghurt and cheese. Milk is almost 90% water containing traces of high quality protein, short chain saturated fats which are easily digestible and sugars (mainly lactose, a compound of galactose and glucose). The vitamins found in milk, in quite a considerable amount, are A, B1, B2, B12 and pantothenic acid. Milk is a main source of calcium in the human diet. Yoghurt, like milk, is a highly nutritional element, but can also be considered more digestible for those who are intolerable to lactose thanks to the presence of bacterial lactase. Cheeses contain proteins and fats and have an almost inexistent carbohydrate content. Of particular interest is the calcium content as it is present in a highly assimilable form, which makes it a valuable contribution to satisfying human needs. The sodium content is also very high. B vitamins are to be found in small quantities while there is quite a high vitamin A content.

The fifth level of the food pyramid contains meat, fish, eggs, pulses and cured meats. Meat is a fundamental element in the human diet as it provides high quality protein needed for the growth of muscle tissue. Approximately half of the proteins found in meat are made of essential amino acids which are essential for the health of the human body. The fat content is highly variable and can range from almost zero to 30% depending on the type of meat. The fats found in meat are mainly saturated, monounsaturated with some polyunsaturated. Meat also contains B vitamins and in particular B12, selenium, copper and zinc. Fish contains high quality protein and varying amounts of fat which can reach up to 10% of the overall weight. Fish oils contain polyunsaturated fatty acids which belong to the essential fatty acids category. The omega-3 family of fatty acids is considered very beneficial in the prevention of cardiocirculatory diseases. Eggs contain such high quality proteins that for years the protein composition of eggs was used as a reference value for evaluating the quality of proteins in other foods. Legumes are the vegetables with the highest protein content and also provide a considerable fibre content. Legumes are a source of B vitamins (B1 and B2), niacin and folates. They provide minerals and also contain a moderate amount of iron, zinc and calcium. Cured meats are a source of excellent proteins, rich in essential amino acids and easily digestible. They are a good source of B vitamins, especially B1, niacin and B12, and minerals such as iron and zinc which means they represent an alternative source of nutrition to meat.

The sixth and last level of the food pyramid contains sweeteners such as sugar and honey. Sugar, or saccharose, is a disaccharide made up of one glucose molecule and one fructose molecule and represents the best possible fuel for muscle cells and the brain. Honey is made up of glucose and fructose in a quantity which varies between 30% - 40%. It also contains 20% of water and a small quantity of another two sugars, maltose and saccharose.

After having analyzed the food pyramid and its composition, the following table represents the *ecological footprint* and the *carbon footprint*, in its fossil and bio components, produced by the foods contained in the pyramid.

Figure 80. Ecological footprint and CO_2 emissions of food categories which make up the food pyramid

	Grams per serving	Weekly quantity wellness	Daily quantity wellness	Ecological footprint m2	Carbon footprint (fossil) g CO2	Carbon footprint (bio) g CO2
Vegetables	250	7	1,0	1,77	171,0	-
Fresch salad	50	7	1,0	0,34	24,7	-
Fruit	150	21	3,0	0,15	77,5	150,0
Bread	50	16	2,3	0,20	86,0	73,5
Pasta and rice	200	8	1,1	1,84	218,6	297,0
Sweet	30	7	1,0	0,42	40,0	30,0
Potatoes	200	2	0,3	2,80	344,0	294,0
Meat	100	5	0,7	3,20	1.175,5	-
Cold cut	50	3	0,4	3,10	1.085,0	-
Fish	150	2	0,3	0,32	103,8	-
Egg	60	2	0,3	0,43	90,0	204,0
Legumes	100	2	0,3	0,69	48,4	-
Milk	125	7	1,0	0,13	154,0	0,7
Yogurt	125	7	1,0	0,13	154,0	0,7
Fresch cheese	100	2	0,3	0,11	130,0	0,6
Seasoned cheese	50	2	0,3	0,06	65,0	0,3
Butter	10	5	0,7	-	-	-
Sugar	5	21	3,0	-	5,0	2,0
Wine	100	3	0,4	1,39	224,0	-
Beer	330	4	0,6	-	-	-
Water	1.400	7	1,0	-	125,6	-

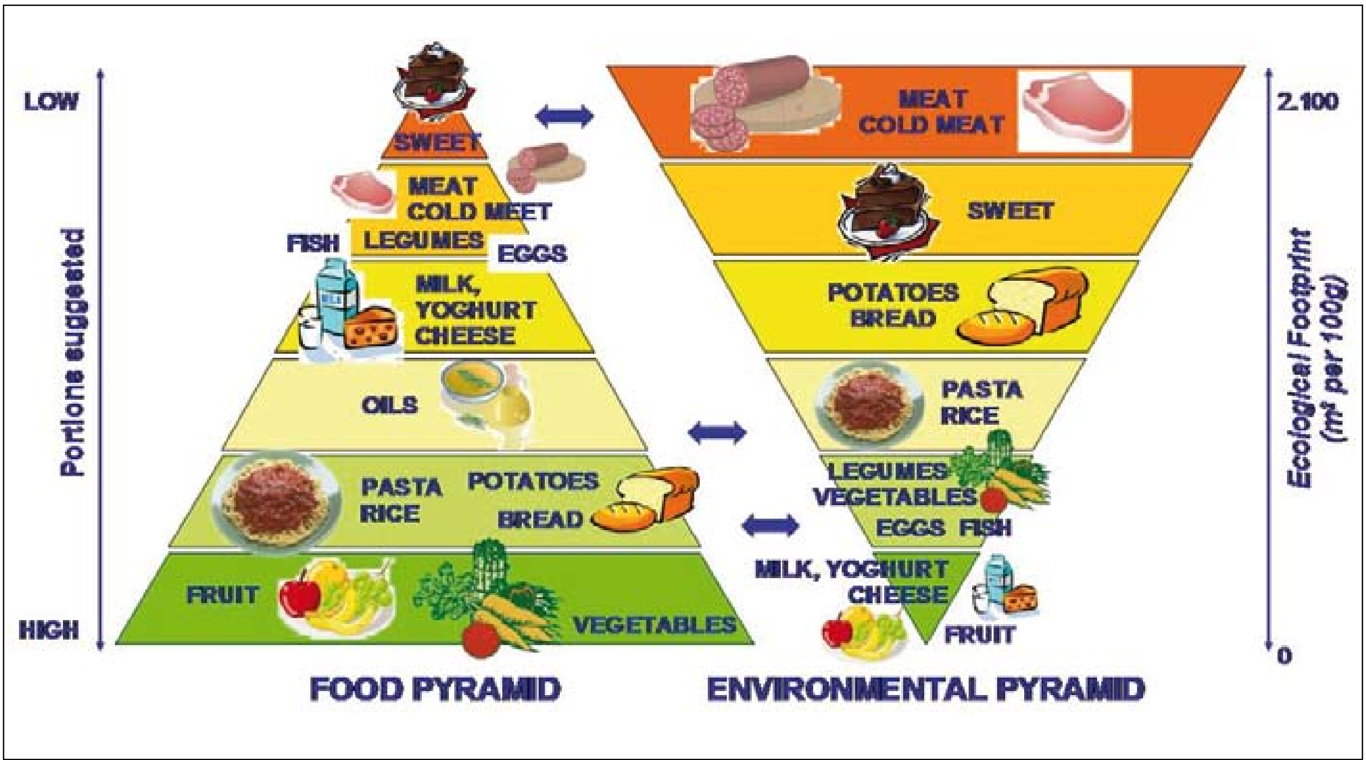
Source: The European House-Ambrosetti re-elaboration based on Department of Medical Physiopathology, Rome University "La Sapienza" and Studio LCE data

The table highlights yet again how the food items in the top levels of the pyramid, such as meat and cured meats, are responsible for leaving the greatest environmental impact in terms of ecological footprint and greenhouse gas emissions.

In particular, appears to be very interesting matching the food pyramid to an "environmental pyramid" built considering the environmental burden (measured through the Ecological Footprint) of each food. In this way, it is possible to obtain a "reversed pyramid" (Figure 81), where at the apex, which is on the bottom, we find foods with a low environmental impact (first of all fruits, but also milk yoghurt and cheese, fish, eggs and vegetables and at the next level pasta[131] and rice), and at the base – which is positioned at the top – we find food which productions implies an higher consume of environmental resources (especially meet, cold meet and sweets). Looking at the picture, it is possible to note that for some products there is high correspondence between higher suggested consumption and lower environment impact (fruits, vegetables, pasta and rice). It is possible to observe the same relationship for products like meet, cold meet and sweets, characterized by low suggested consumption and high environmental impact.

131 *Please not that the Ecological Footprint value used for pasta includes the whole life cycle of wheat, till the delivery of the final product, because it has be calculated ad hoc for the purposes of this analysis. On the contrary, for other foods, the Ecological Footprint considers the production phase only. Thus, pasta's Ecological Footprint values appear to be overestimated*

Figure 81. The food pyramid and the environmental pyramid



Source: The European House-Ambrosetti re-elaboration of different sources

Part C: recommendations

6. THE AREAS OF INTERVENTION

The topic of climate change has, over the years, been widely debated in regard to both the more general elements of the phenomenon – elements which cross the various sectors of activity (e.g. energy policy) – and the more specific aspects inherent to individual *industries*.

Even the questions related to the food sector (area which is strictly related to, and dependent on, environmental dynamics, with the implications we have sought to bring to the fore throughout this document) are the object of growing concern by international bodies and *policy makers*. As has been mentioned, for the first time, the Copenhagen protocol will include specific objectives for reducing environmental impact by the agrifood sector.

At the same time, however, it must be recalled that there does not yet appear to be any widespread **adequate awareness** of the importance of the challenge on the part of international sector operators or the consumers of agrifood products.

Before making the recommendations[132] we feel timely, it must first be pointed out that there are three methodological aspects of crucial importance for the final goals. These are the assumptions used as the basis for interpretation of the recommendations themselves and the pertinent operations developed.

More specifically:

- **A SHARED RESPONSIBILITY**. Through their deeds all players in the field bear must realize that they are responsible for introducing factors of climate change. This holds true for all parties: the **Citizens/Consumers**, the **Policy Makers**, the **Companies/Economic Operators, Research Canters, Universities and NGOs** each with different nuances and weights. For this reason, the response - through specific, clearly defined, clearly communicated strategies - must also touch on all parties that can affect the overall result. It is only through synergistic, coordinated action of Citizens/Consumers, the businesses (in the fields of production and distribution) Research Centers, NGOs and the public authorities that effective solutions will be achieved for this complex problem that requires a systematic, integrated reading of the phenomena and joint, shared responses (see Figure 82);
- **THE ECONOMIC CRISIS AS A DRIVER FOR LOW CARBON ECONOMY**. The current **economic crisis** must not be seen as an adequate reason for postponing discussion and resolution of such serious problems as those linked to climate change. Not only would a strategy of postponement worsen the already worrisome picture; the ability to create a *low carbon emission* economy could even provide an extraordinary opportunity from both the economic and technological points of view. In reality, in some cases, this is already under way. There are signs that, with realism and respect for the economic and social balance, Governments and companies are seeking to speed up the process in this direction. Long been at the forefront in areas of environmental protection - through the introduction of innovative elements - Europe in particular must continue to push forward in the process of transnational management of the climate emergency;
- **FOCUS ON THE AGRIFOOD SECTOR**. According to the nature and mission of the Barilla Center for Food & Nutrition, the recommendations given below regard the **agrifood sector and, more specifically, the food sector**. For this reason, we have refrained from formulating recommendations on crucial aspects with broader range that cross all activity sectors. In particular, this refers to the energy and transport aspects. In fact, techniques for the production of *non oil* energy and the optimized/reduced consumption of fuels are compulsory steps in fighting the climate change induced by human activities and its negative effects. Here they are not studied in depth but this does not mean we have underestimated their importance; rather this has been an intentional field choice.

This being stated, we feel that there are six priority areas for intervention. In brief, these are listed below:

1. PROMOTE AND SPREAD THE USE OF OBJECTIVE ENVIRONMENTAL IMPACT INDICATORS THAT ARE SIMPLE AND CAN BE COMMUNICATED AT ALL LEVELS

Referring to all individual, social and economic activities that raise awareness of the impact on the ecosystem and help virtuous behaviours emerge. For example, the *Lifecycle*

132 *As its scientifically valid and recognised knowledge base, the recommendations were developed using the data and publications of major international institutes and research organisations, including the IPCC (Intergovernmental Panel on Climate Change), UNEP (United Nations Environment Programme), FAO (Food and Agriculture Organisation), IEA (International Energy Agency) and EEA (European Environment Agency), as well as a number of leading universities worldwide*

Assessment logic for the products moves precisely in this direction. This Assessment follows a systemic, integrated logic to consider everything that occurs in each and every stage of processing, logistics and consumption. In particular, we feel that it is essential to emphasize the use of the *Ecological Footprint* in addition to the *Carbon Footprint*, as a comprehensive instrument for measuring the environmental impact of individuals, companies (production and distribution within each and every sector), and countries. It evaluates the best strategies for intervention and measures their progress. The *Ecological Footprint* appears to be a comprehensive, intuitive and easily communicable indicator.

2. ENCOURAGE ECONOMIC POLICIES AND A SYSTEM OF FAIR, EFFECTIVE INCENTIVES/DISINCENTIVES

It must be pointed out that, as is usually the case, while there is broad agreement on the principle at the theoretical level, the search for shared, accepted solutions appears more difficult. Today the debate records different positions on such topics as the effectiveness of the carbon dioxide cap and trade certificates, use of fiscal pressures, introduction of incentives for the purchase of more environmentally sustainable goods and services. Today policies that are based on economic policy instruments that apply such mechanism of internalization of emissions costs are increasingly being adopted, and this is an essential condition for passage to a more sustainable economic arrangement.

3. RE-LOCALIZE CROPS, REDUCE INCIDENCE OF ZOOTECHNICAL ACTIVITIES, PROTECT FORESTS

We must recognize the effects climate change is likely to have both in terms of its impact on agricultural productivity (impoverishing some geographical areas) and prevention strategies now deemed indispensable (e.g. reducing environmental impact of zootechnical activities). We must recognize these so we can actively manage the ongoing processes and reduce their inevitable economic and social impact. The current deforestation process occurring in many regions in the world for the vegetal extracts production (for example palm oil in Indonesia) leads to huge emissions of GHGs and a relevant reduction of the Earth's biocapacity.

4. ENCOURAGE TECHNOLOGICAL INNOVATION AND PROMOTE SUSTAINABLE AGRICULTURAL POLICIES (BEST PRACTICE)

Likewise the Intergovernmental Panel on Climate Change (IPCC) has worked in depth on this topic, producing guidelines that express great scientific consensus and can be effectively implementated. What appears evident at this stage is that we cannot rise to a challenge such as *climate change* with policies rooted on the past. Rather we need to step on the accelerator of technological innovation and transfer knowledge from research to concrete applications.

The introduction of more ecofriendly fertilizers and best practices are key issues.

5. PROMOTE TRANSPARENT COMMUNICATION POLICIES (UP TO *GREEN LABELLING*)

It involves promoting information that is more clear-cut regarding the environmental impact of individual products throughout their life cycle.

Correct information for consumers and players throughout the supply chain is the prerequisite for adopting more responsible consumption styles in terms of use of natural resources by the individuals.

6. PROMOTE ECO SUSTAINABLE LIFE STYLES AND DIETS

In this light, several topics are worth mentioning: the excess consumption of meat worldwide (as related to the *Ecological Footprint* of zootechnical activities); the need to revamp the agricultural product transport systems to favour close proximity consumption, where possible; more closely following the seasonal cycles.

The execution of the six actions implies a co-responsibility among all the different players involved as well as the active role of a *process owner* responsible to start and manage the whole process (Figure 82).

We shall deal in greater detail with each of these aspects.

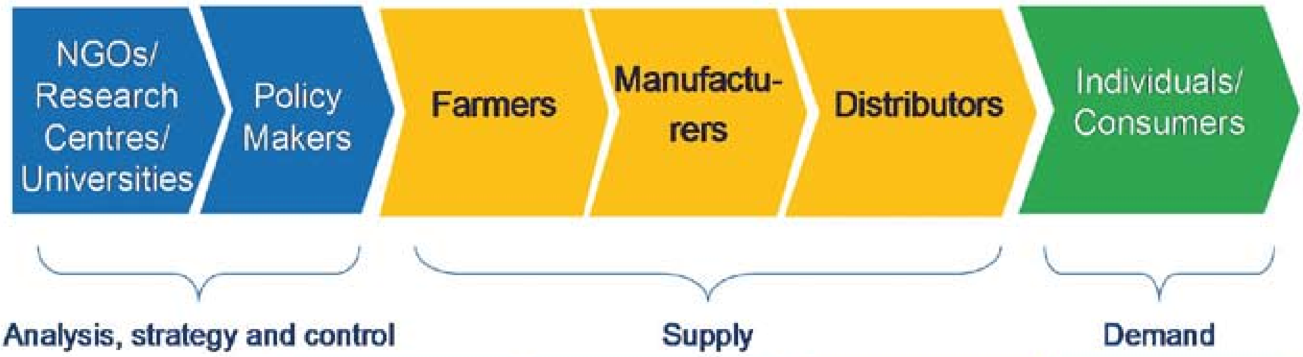
1. PROMOTE AND SPREAD THE USE OF OBJECTIVE ENVIRONMENTAL IMPACT INDICATORS THAT ARE SIMPLE AND CAN BE COMMUNICATED AT ALL LEVELS

In particular, we feel that it is essential to emphasize the use of the *Ecological Footprint* as a comprehensive instrument for measuring the environmental impact of individuals, companies (production and distribution within each and every sector), and countries. It evaluates the best strategies for intervention and measures their progress. This indicator sets human consumption of natural resources in relation with our planet's ability to regenerate those resources and measures the biologically productive area needed to produce the resources consumed by man and to absorb the wastes generated. Since it considers all the main categories of land involved in human activities (see paragraph 2.2 of the present document) and reduces them to a common denominator (global hectare equivalent), assigning each a weight proportional to its average world productivity, this appears to be a complete, intuitive indicator that is easy to communicate[133].

It is our feeling that this environmental impact measurement is useful both at the Government and Institutional level and for individual companies and final consumers.

133 *A number of scholars have recently raised questions regarding the methodology used in calculating the index. However, the index is constantly updated and revised not only by the Ecological Footprint Network, but also by numerous countries (such as Switzerland, Germany, Belgium and the United Arab Emirates) which use it to measure the environmental sustainability of their initiatives. For this reason, it is felt that the Ecological Footprint is already a sufficiently reliable indicator, which does not obviate the fact that the relevance and precision of its results could be improved*

Figure 82: The chain of responsibility for Climate Change and the proposed recommendations



	NGOs/Research Centres/Universities	Policy Makers	Companies/ Economic operators	Individuals/ Consumers
Use of objective, simple and communicable environmental impact indicators	Develop research into potential environmental impact indicators	**Identify the Ecological Footprint (EF) as the tool for evaluating environmental impact**	Utilize the EF as a tool for corporate social responsibility	Utilize the EF in making daily consumer choices
Economic policies and incentive/disincentive systems that are equitable and effective	Contribute through research into identifying the best economic-financial solutions that can be implemented	**Define and adopt economic incentives to orient agricultural/industry choices**	Evaluate economic opportunities of eco-sustainable choices	
Relocate crops, reduce impact of livestock raising, preserve woodlands	Evaluate impact of agro-alimentary activity on cultivated/woodland areas	"Managed" relocation policies for crops / combat deforestation	**Evaluate the impact of agro-alimentary activity on cultivated/woodland areas**	
Technological innovation and sustainable farming techniques	**Research into agricultural techniques that limit impact on the environment and into eco-sustainable practices**	Create incentives for research/ application of green technologies Define guidelines for eco-sustainable agriculture	Utilize agricultural techniques that limit environmental impact	
Clear communications policies	Research and spread of information on environmental impact of human/natural phenomena and on eco-sustainable products and practices	Communications initiatives to make the public and economic operators aware of the environmental impact of consumer/industry choices	**Introduction green labelling practices to promote awareness when purchasing**	Preference for public/private operators who adopt clear information policies
Eco-sustainable alimentary and life styles	Scientific identification of eco-compatible alimentary behaviour (optimal composition of diets, etc.)	Public guidelines (health, school, etc.) for an eco-compatible alimentary sector	Offer products with lower ecological impact	**Choose products with lower ecological impact**

☐ = OWNER

In fact, for governments, the *Ecological Footprint* instrument is used to monitor and regulate the real environmental impact of the activities developed within its territory, evaluating and measuring the results of the sustainability policies implemented to develop systems of rewards and sanctions. In this regard, the European Union has recently deemed the *Ecological Footprint* a highly effective indicator for evaluating and communicating the progress achieved in its *Sustainable Use of Natural Resources Strategy*. This strategy was launched in 2005 and, for Europe, recognizes that increasingly efficient use of natural resources is an indispensible element for future economic development and environmental preservation.

For companies, this instrument can determine the environmental sustainability of its own production processes – in order to identify areas for improvement and thus improve its competitive edge. In addition, it is also an indicator that can even be applied to communication and marketing logics: if used to measure the environmental impact of individual products and services, the consumer can view it as an indirect expression of corporate focus on environmental sustainability and social responsibility.

Finally, the *Ecological Footprint* can be a simple instrument used by final consumers to increase their own awareness of the environmental impact their habits (including diet) have on the planet. It enables them to evaluate and focus their choices from the environmental sustainability point of view.

2. ENCOURAGE ECONOMIC POLICIES AND A SYSTEM OF FAIR, EFFECTIVE INCENTIVES/DISINCENTIVES

Above and beyond the specific solutions adopted (taxes, cap and trade certificates, etc.), there are two essential characteristics for any good economic policy aimed at overcoming the criticality of *climate change*:

- effectiveness of the overall results, in the absence of any elements that strongly distort conduct. The criticism many economists have with some market solutions – for example those forcing the mechanisms of *clean development* – hinge on this topic (i.e. incentives for *unfair behaviour*) more than on overall inefficiency (which on the contrary is quite high) (see paragraph 3.1.1). In reality, the model has functioned relatively well to date, even if it needs to be revised and improved in view of the assessment that will be made in 2012;
- substantial equity of the solutions identified. From this point of view, it must be pointed out that taxes and the system of incentives/disincentives plays a key role in moulding collective conduct. For this reason, above and beyond the specific solutions identified, the costs associated with incorrect conduct must, to the extent to which they are known, be shared evenly over the entire procurement-production-distribution-consumption supply chain.

3. RE-LOCALIZE CROPS, REDUCE INCIDENCE OF ZOOTECHNICAL ACTIVITIES, PROTECT FORESTS

The evidence produced during the work in question have shown how, in the scenario deemed most likely, there will be a future decrease in agricultural productivity, without any radical intervention and sown surface being equal (see chapter 4). Moreover, climate change could have a negative effect on some geographic areas and their ability to guarantee adequate levels of production vs. the current volumes; this is particularly due to increases in temperature and more severe water access conditions (the most significant impact will be seen at the equator, the Mediterranean and Australia, etc.). In brief we could see the best latitudes for agriculture shift northward for an extremely significant percentage of the crops.

We must counteract this phenomenon, as far as possible, but this also requires mid-to-long term plans aimed at managing the effects which could be potentially devastating for entire areas of the planet. We need to set a clear view of the possible future development of the scenario and make economic policy choices with a transnational view.

Moreover, we are seeing the growing of zootechnic and use of the territory for the related activities. While it is true that zootechnical management processes to reduce the environmental impact can be optimized, it is likewise true that these trends cannot be sustained in the mid-to-long term. Even before the production model, the dietary model must be reviewed as it is excessively tilted toward the consumption of meat and zootechnological derivatives.

Last but not least, we must protect the Planet's forestry resources much more efficiently than we have up till now, allocating agricultural activities on the basis of their environmental impact. Forests, in fact, play a fundamental role in the biological equilibrium of the Earth. The indiscriminate use of land, through deforestation – a practice that is taking place in Indonesia in order to make way for new plantations of palm oil – generates extremely serious damage inasmuch as it reduces the Earth's biocapacity.

4. ENCOURAGE TECHNOLOGICAL INNOVATION AND PROMOTE SUSTAINABLE AGRICULTURAL POLICIES (*BEST PRACTICE*)

From this point of view, there are several often controversial aspects to be dealt with. These include:

- contrary to common opinion, agriculture is becoming an increasingly more complex series of activities, whose high knowledge and technological content is underestimated. The level of scientific knowledge contained in eco sustainable practices and techniques is, in fact, significant. This *know how* needs, however, to become a widespread and shared resource, and this particularly applies to aspects related to the protection of land. See paragraph 4.4.2. for a detailed analysis of the strategies and cultivation techniques recommended;
- the environmental impact of fertilizers and their correct use. Inorganic fertilizers have played a major role in guaranteeing production earnings which were inconceivable before their use on an industrial scale. Unfortunately, however, the negative consequences of their use are also known: environmental pollution, greenhouse gas emissions, leeching of the soil. Today, with even the most attentive fertilizer manufacturers realizing the importance of this situation, we are seeing the promotion of best practices for use – to limit the more damaging effects – while seeking products with increasingly reduced environmental impact.

In general, without necessarily having to push scientific research and technological innovation to the edge, the intrinsic nature of agrifood activities, a sector with a strong *knowledge* base is quite evident. Therefore a ma jor priority is to promote significant investments in training and in the transfer of knowledge from science to concrete agricultural and zootechnical production applications, particularly in some areas of the world (developing countries). Simply adopting best practices and avant-garde management techniques vs. the best *standards* (Best Tecniques) would per se be a meaningful step forward toward environmental sustainability.

Mention must also be made of the debate around the role of GMOs (Genetically Modified Organisms) which, both for economic reasons and the implications of their development on biodiversity, still give rise to concern and significant doubt. Nonetheless, research into scientific solutions capable of surmounting current contradictions and creating the conditions for agricultural output that is high in productivity (but less tied to the use of chemical substances) is being proposed on the other side of the Atlantic as a potential line of action for meeting environmental sustainability in the future.

5. PROMOTE TRANSPARENT COMMUNICATION POLICIES (INCLUDING *GREEN LABELLING*)

Towards this goal, adoption of green labelling policies are suggested, policies that have already been successfully tested, for example, in the area of energy efficiency (e.g., the positive results from labelling appliances with their energy ratings).

However, there must be clear-cut guidelines for how to calculate environmental indicators (i.e., grams of CO_2), and what and how to communicate in order to guarantee correct, clear and, above all, verifiable information.

6. PROMOTE ECO SUSTAINABLE LIFE STYLES AND DIETS

The global population increase seen over the last few decades have led to life styles that have an increasing effect on the ecological balance of the planet. Above all, in the food sector, the models we have seen arise are contradictory to the goals of environmental protection:

- increased consumption of meat reflects the rise in the economic condition of entire populations and the spread of some western dietary models;
- deseasonalization of consumption of fruits and vegetables by "forcing" of natural processes;
- globalization of trade in agricultural goods to the detriment of local consumption, resulting in increased release of greenhouse gases due to transportation.

Even when not intrinsically negative (after all the consumption of meat certainly is not), these phenomena become problematic if they are brought to their extreme consequences. These consequences, as such, must be carefully managed.

REFERENCES

ABARE: "Climate Change: Impacts on Australian agriculture", 2007

Andersson K., "Life-Cycle Assessment (LCA) of Bread Produced on Different Scales: Case study". AFR report 214, Swedish Waste Research Council, Swedish Environmental Protection Agency, Stockholm, Svezia, 1998

B. Mertz, O. Davidson "Climate Change 2007: Mitigation of Climate Change", Contribution of Working Group III to the Fourth Assessment Report of the Intergovernamental Panel on Climate Change", Cambridge University Press, 2007

Barilla Center for Food & Nutrion, Position Paper "Water Management", 2009

Baldo G.L., Marino M., Rossi S., "Analisi del ciclo di vita LCA, Materiali, prodotti, processi - Edizioni Ambiente", Milano 2008

Barbier E. B., "A Global Green New Deal", United Nations Environment Programme - Economics and Trade Branch, February 2009

Bullard, C.W., Penner, P.S. and Pilati, D.A., "Net energy analysis: Handbook for combining process and input-output analysis". Resources and Energy, 1978

Calgeri A., "No-tillage System in Parana State, South Brazil", 2001

Carbon Trust, "Carbon footprints in the supply chain: the next step for business". Report Number CTC616, novembre 2006

Carbon Trust, "Renewable energy sources", 2006

Carbon Trust, "Carbon Footprint Measurement Methodology, Version 1.1". 27, febbraio 2007

Carbon Trust, "EU ETS Impacts on profitability and trade", 2008

Carraro C., et al., "Gli Impatti dei Cambiamenti Climatici in Italia", Ed. Ambiente, 2009

Cline W., "Global Warming and Agriculture", Centre for Global Development, 2007

Centro Euro-Mediterraneo per i Cambiamenti Climatici, documenti vari

Council of the European Union, "Council adopts climate-energy legislative package", 2009

Department for Environment, Food and Rural Affairs, "The Environment in Your Pocket", 2006

Department for Environment, Food and Rural Affairs, "Step forward on reducing climate change impacts from products." DEFRA press release, 30 maggio 2007

ENEA, "Dossier per lo studio dei cambiamenti climatici e dei loro effetti", 2007

ENEA, "Progetto Speciale Clima Globale", 2006

ENEA, "Rapporto Energia e Ambiente: analisi e scenari", 2007

EM-DAT - Emergency Events Database, http://www.emdat.be

Energetics, "The Reality of Carbon Neutrality", 2007

European Commission, "White Paper: Adapting to climate change: towards a European framework of action", 2009

European Commission, Green Paper From the Commission to the Council, the European Parliament, the European and Social Committee, and the Committee of the Regions, "Adapting to climate change in Europe - options for EU action", 2007

European Commission Agriculture Directorate-General, European Climate Change Program, Working Group 7 - Agriculture, Final Report: "Mitigation potential of greenhouse gases in the Agricultural Sector", 2003

European Commission, "Attitudes of European citizens towards the environment", marzo-settembre 2008

European Commission, "European's attitudes towards climate change", 2008

European Environmental Agency, "A Life Cycle Assessment", 1998

European Environmental Agency, "Greenhouse Gas emission trends and projections in Europe 2008", 2008

European Environmental Agency, "Climate change: the cost of inaction and the cost of adaptation, 2007

European Environmental Agency, "Impacts of Europe's changing climate", 2008

European Commission, DG Environment, "Potential of the Ecological Footprint for monitoring environmental impacts from natural resource use. Analysis of the potential of the Ecological Footprint and related assessment tools for use in the EU's Thematic Strategy on the Sustainable Use of Natural Resources", maggio 2008

European Commission, DG Energy and Transport, Market Observatory for Energy, Report 2008, "Europe's energy position: present & future", 2008

Facts and Trends - Water, World Business Council for Sustainable Development (WBCSD), 2006

FAO, "Climate Change: Implications for Food Safety", 2008

FAO, "Community based Fire Management: Case Studies from China, The Gambia, Honduras, India, the Lao People's Democratic Republic and Turkey", 2003

Fondazione ENI Enrico Mattei, "Climate Policy and Markets", No 6, 2008

Foran, B., Lenzen, M. and Dey, C., "Balancing Act: A triple bottom line analysis of the 135 sectors of the Australian economy". CSIRO Resource Futures and The University of Sydney, Canberra, 2005

GAP, SEI and Eco-Logica, "UK Schools Carbon Footprint Scoping Study". Report by Global Action Plan, Stockholm Environment Institute and Eco- Logica Ltd for the Sustainable Development Commission, London, marzo 2006

Galeotti M., "The Cost of Climate Change: Sharing the Burden", Fondazione Enrico Mattei, 2007

GFN, "Ecological Footprint Glossary". Global Footprint Network, Oakland, CA, USA, 2007

Global Environmental Change and Food Systems (GECAFS), Environmental Change Institute University of Oxford, "Climate Change, Food and Agriculture - Globally", 2007

Global Footprint Network, Research and Standards Department, "Calculation methodology for the national Footprint accounts", 2008

Global Footprint Network, Research And Standards Department, "The Ecological Footprint Atlas", 2008

Global Footprint Network, "Calculation methodology for the National Footprint Accounts", 2008 Edition

Global Footprint Network, Research and Standards Department, "Guidebook to the national footprint accounts", 2008

Grubb and Ellis, "Meeting the Carbon Challenge: The Role of Commercial Real Estate Owners, Users & Managers", Chicago, 2007

Hammerschlag, R. and Barbour, W., "Life-Cycle Assessment and Indirect Emission Reductions: Issues Associated with Ownership and Trading",Institute for Lifecycle Environmental Assessment (ILEA), Seattle, Washington, USA, maggio 2003

Hammond, G., "Time to give due weight to the 'carbon footprint' issue". Nature 445(7125): 256, 2007

Heijungs, R. and Suh, S., "The computational structure of life cycle assessment". Kluwer Academic Publishers, Dordrecht, 2002

Heijungs, R., de Koning, A., Suh, S. and Huppes, G, "Toward an Information Tool for Integrated Product Policy: Requirements for Data and Computation". Journal of Industrial Ecology 10(3):147-158, 2006

Institute for Agriculture and Trade Policy, "Identifying our climate "Foodprint": Assessing and Reducing the Global Warming Impacts of Food and Agriculture in the U.S.", 2009

International Food Policy Research Institute, "Agriculture and Climate Change: an Agenda for negotiation in Copenhagen", Focus 16, marzo 2009

Intergovernmental Panel on Climate Change, "Third Assessment Report: Climate Change 2001", 2001

Intergovernmental Panel on Climate Change, "Fourth Assessment Report: Climate Change 2007", 2007

Intergovernmental Panel on Climate Change, "Climate Change 2007: Synthesis Report. Summary for Policymakers", 2008

Intergovernmental Panel on Climate Change, "Mitigation of climate change", 2007

International Energy Agency, "Issues behind competitiveness and Carbon Leakage", 2008

International Energy Agency, "Ensuring Green Growth in a Time of Economic Crisis: The Role of Energy Technology", 2009

International Energy Agency, Gadgets and Gigawatts: Policies for Energy Efficient Electronics, 2009

International Energy Agency, "World Energy Outlook", 2008

International Fertilizer Industry Association, "Fertilizer Best Management Practices", 2007

International Food Policy Research Institute, "Climate Change: Minimizing the Risks and Maximizing the Benefits for the Poor", 2007

Kyoto Protocol, United Nations, 1998

International Fertilizer Industry Association, "Fertilizer Best Management Practices", 2007

Lerda L., et al., "L'Evoluzione del negoziato sul cambiamento climatico con particolare riguardo alle problematiche per l'attuazione del Protocollo di Kyoto del 1997", 2003

Lehmann J., "Bio-Char Sequestration in Terrestrial Ecosystem - A review", 2006

Lenzen, M., "Errors in Conventional and Input- Output-based Life-Cycle Inventories". Journal of Industrial Ecology 4(4): 127-148, 2001

Lenzen, M., "Uncertainty in Impact and Externality Assessments - Implications for Decision- Making (13 pp)". The International Journal of Life Cycle Assessment 11(3): 189-199, 2006

Lenzen, M., "Double-counting in Life-Cycle Assessment". Journal of Industrial Ecology: submitted, 2007

Lenzen, M., Murray, J., Sack, F. and Wiedmann, T., "Shared producer and consumer responsibility - Theory and practice". Ecological Economics 61(1): 27-42, 2007

Loh J., Randers J., MacGillivray A., Kapos V., Jenkins M., Groombridge B., and Cox N, "Living Planet Report 1998: Over consumption is driving the rapid decline of the world's natural environments", 1998

Macchiati A., "Le politiche contro il cambiamento climatico nell'Unione Europea e in Italia", 2008

Martini A., Capriolo A., Studio Peseta, "Europa, gli effetti dei cambiamenti climatici", 2007

MIT, X. Wang, "Impacts of Greenhouse Gas Mitigation Policies on Agricultural Land", febbraio 2008

Neely C.L. e Hatfield R., "Livestock System", 2007

NOAA, "Climate of 2008 Annual Report", 2009

OECD, "Assessing the impacts of climate change: a literature review", Economics Department Working Paper No. 691, 2009

OECD, "Environmental Outlook", 2008

OECD, "Economics Aspects of Adaptation to Climate Change: costs, benefits and policy instruments", 2008

Parikh, J.K. e Painuly J.P., "Population, Consumption Patterns and Climate Change: A socio-economic perspective from the South", Vol. XXII, No. 7, pp. 434-437, 1994

Pasini A. et al., "Kyoto e dintorni. I cambiamenti climatici come problema globale", Franco Angeli, 2006

Patel, J., "Green sky thinking". Environment Business (122):32, 2006

Pettenella D., et al., "Il settore primario e la riduzione delle emissioni di gas ad effetto serra", PAGRI, 2006

Rotz Al, "Grazing and the Enviorment", 2008

Scherr S. and Sthapit S., "State of the world 2009", 2009

Scottish Executive, "Changing Our Ways: Scotland's Climate Change Programme, Edinburgh", 2006

SEI, WWF and CURE, "Counting Consumption - CO_2 emissions, material flows and Ecological Footprint of the UK by region and devolved country". Published by WWF-UK, Godalming, Surrey, UK, 2006

Smith, P., D. Martino, Z. Cai, D. Gwary, H.H. Janzen, P. Kumar, B. McCarl, S. Ogle, F. O'Mara, C. Rice, .J. Scholes, O. Sirotenko, M. Howden,T. McAllister, G. Pan, V. Romanenkov, U. Schneider, S. Towprayoon, M. Wattenbach, and J.U. Smith "Greenhouse gas mitigation in agriculture", Philosophical Transactions of the Royal Society, 2007

Steinfeld H. et al, "Livestock's Long Shadow: Environmental Issues and Options", 2006

Stern N., "Stern Review: the Economics of Climate Change", HM Treasury, 2006

The World Bank, "State and Trends of the Carbon Market", Washington, 2008

Tukker, A. and Jansen, B., "Environmental impacts of products: A detailed review of studies". Journal of Industrial Ecology 10(3):159, 2006

Uhlin H-E. "Energiflöden i livsmedelskedjan", Rapport 4732, Swedish Environmental Protection Agency, Stockholm, Svezia, 1997

UNEP, "Global Outlook for Ice and Snow", 2007

United Nation, "United Nations Framework Convention on Climate Change", 1992

United Nations, "Agenda 21: United Nations Conference on Environment and Development, Rio de Janeiro, Brazil". United Nations Department of Public Information, New York, 1993

United Nations, "Remarks at the UN Development Programme (UNDP) event on the Human Development Report", 11 dicembre 2007

UNFCCC, "Investments and Financial Flows to address climate change: an update", novembre 2008

UNFCCC, "Report on the analysis of existing and potential investment and financial flows relevant to the development of an effective and appropriate international response to climate change", 2007

Uphoff et al., "Biological approaches to sustainable soil systems", 2006

Wackernagel M, Rees W.E., "Our Ecological Footprint – Reducing Human Impact on theEarth", New Society Publishers Gabriola Island, Canada, 1996

Wackernagel, M., Monfreda, C., Moran, D., Wermer, P., Goldfinger, S., Deumling, D. and Murray, M, "National Footprint and Biocapacity Accounts 2005: The underlying calculation method", 2005

WHO, "Alluvioni: Effetti sulla salute e misure di prevenzione", a cura di Epicentro, 2002

Wiedmann, T., Barrett, J. and Lenzen, M., "Companies on the Scale - Comparing and Benchmarking the Footprints of Businesses". International Ecological Footprint Conference, maggio 2007

Wiedmann, T., Minx, J., Barrett, J. and Wackernagel, M., "Allocating ecological footprints to final consumption categories with input-output analysis". Ecological Economics 56(1): 28-48, 2006

Wiedmann T. e Minx T., "A definition of Carbon Footprint", ISA UK Research Report, 2007

World Resources Institute, "Earth Trends Information Portal", 2008

WRI Policy Note, "Agriculture and Climate Change: Greenhouse Gas Mitigation Opportunities and the 2007 Farm Bill", marzo 2007

WRI Policy Note, "Agriculture and Climate Change: The Policy Context", ottobre 2006

WWF, "Living Planet Report 2008", 2008

WWF, "Per un piano di adattamento al cambiamento climatico in Italia", 2007

World Watch Institute, documenti vari

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