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CLIMATE CHANGE AND THE TOURISM SECTOR: THE CLEAN DEVELOPMENT MECHANISM, A MARKET INSTRUMENT UNDER THE KYOTO PROTOCOL TO ACHIEVE MULTIPLE OBJECTIVES

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INTRODUCTION

The main objective of this research is to demonstrate that the Clean Development Mechanism (CDM), an instrument created under a global international treaty, can achieve multiple objectives beyond those for which it has been established. As such, while being already a powerful tool to contribute to the global fight against climate change, the CDM can also be successful if applied to different sectors not contemplated before. In particular, this research aimed at demonstrating that a wider utilization of the CDM in the tourism sector can represent an innovative way to foster sustainable tourism and generate additional benefits.

The CDM was created by Article 12 of the Kyoto Protocol of the United Nations Framework Convention on Climate Change (UNFCCC) and represents an innovative tool to reduce greenhouse gases emissions through the implementation of mitigation activities in developing countries which generate certified emission reductions (CERs), each of them equivalent to one ton of CO_2 not emitted in the atmosphere. These credits can be used for compliance reasons by industrialized countries in achieving their reduction targets.

The logic path of this research begins with an analysis of the scientific evidences of climate change and its impacts on different economic sectors including tourism and it continues with a focus on the linkages between climate and the tourism sector. Then, it analyses the international responses to the issue of climate change and the peculiar activities in the international arena addressing climate change and the tourism sector. The concluding part of the work presents the objectives and achievements of the CDM and its links to the tourism sector by considering case studies of existing projects which demonstrate that the underlying question can be positively answered. New opportunities for the tourism sector are available.

CHAPTER I

THE SCIENCE OF CLIMATE CHANGE AND

THE IMPACTS OF CLIMATE CHANGE ON DIFFERENT SECTORS

1.1 Weather and climate system

The key for understanding climate change is to understand what climate is and which are the causes that generate variability and changes of climate. Climate is usually described in terms of mean and variability of the main meteorological variables, over a larger area and a longer period of time, the classical period being 30 years as defined by World Meteorological Organization (WMO). Climate controls the weather, which corresponds to all the events happening each day in our atmosphere and connected to variability of temperature, rainfall, humidity, winds etc. Therefore, climate could also be defined as the "*average weather pattern*" in a place over many years.

The climate system is extremely complex, it does not only include the processes from the atmosphere, but is a composite system consisting of five major components: *atmosphere*, *hydrosphere* with the oceans, *cryosphere*, *lithosphere* and *biosphere*. These components act as a cascading system linked by complex physical processes involving fluxes of energy, momentum and matter across the boundaries and generating numerous feedback mechanisms (Figure1).

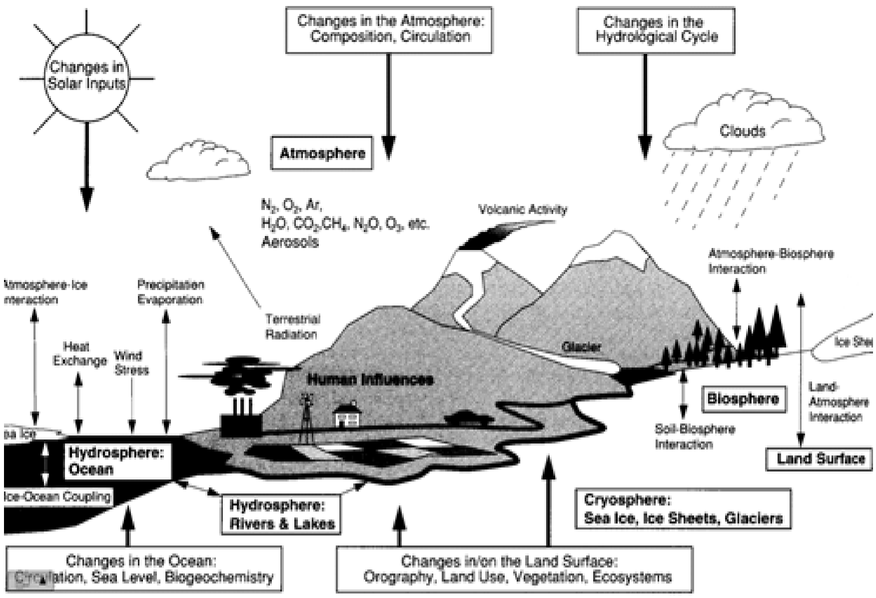


Figure 1: The components of climate system (source IPCC 2001)

A short description of the climate system component and their influence on the climate is included below.

The *atmosphere*, a mixture of gases that consists mostly of nitrogen (78%) and oxygen (21%), and other inert gases, plays the most important role in the regulation of Earth's climate. The atmosphere can be divided into four layers, namely, and starting from the surface: troposphere, stratosphere, mesosphere and thermosphere, separated by portion called pauses. The composition and concentration of the gases present in the atmosphere has a great influence on the climate and varies from one layer to another. For example, carbon dioxide is present and well mixed below the mesopause, water vapour is present in the lower troposphere, ozone is present in the middle stratosphere. Apart from these components, liquid and solid water, dust particles, sulphate aerosols and volcanic particles are also present in the atmosphere and even if in small quantities, they have an important influence on the climate. The atmosphere and in particular its first layer, the troposphere, plays an important role on the climate system through the large scale general circulation with eddy motions in middle latitude, turbulent motions mainly on the planetary boundary layer and near the jet streams. However, the atmosphere does not operate as an isolated system.

Flows of energy take place between the atmosphere and the other parts of the climate system for example with h*ydrosphere* -and in particular with the world's oceans. The atmosphere and the oceans are strongly coupled, as such oceans could be considered the second important component of the climate system. Oceans covers approximately two-thirds of the earth’s surface, such as most of the solar radiation that reach the globe falls on the oceans and is absorbed by them. The currents developed in the oceans move heat from warm equatorial latitudes to colder polar latitudes. Heat is also transferred via moisture. Water evaporating from the surface of the oceans stores heat which is subsequently released when the vapour condenses to form clouds and rain. Even if heat circulation in the ocean is slower than in the atmosphere and the turbulence is much less pronounced than in atmosphere, the significance of the oceans is given by the fact that they store a much greater quantity of heat than the atmosphere. The top 200 metres of the world's oceans store 30 times as much heat as the atmosphere. Others important components of the hydrosphere are the lakes, rivers and subterranean waters that through their salinity can influence the climate on regional or local scale.

The world's ice sheets, glaciers and sea ice, that formed the *cryosphere*, have a significant impact on the Earth's climate, through their albedo and lower conductivity. The cryosphere includes Antarctica, the Arctic Ocean, Greenland, Northern Canada, Northern Siberia and most of the high mountain ranges throughout the world, where sub-zero temperatures persist throughout the year. It plays an important role especially through its capacity to reflect a lot of sunlight (albedo) instead of absorbing it, through its lower thermal conductivity and therefore represents the largest reservoir of fresh water. The two continental ice sheets of Antarctica and Greenland influence the global climate over longer time scales, but could have also more rapid effects, for example in the case of significant warming as this could influence the sea level. Also, the permafrost influences soil water content and vegetation over vast regions and it is one of the cryosphere components which is most sensitive to atmospheric warming trends. As permafrost warms, organic material stored in permafrost may release greenhouse gases into the atmosphere and increase the rate of global warming. Glaciers and ice caps, as well as river and lake ice, with their smaller areas and volumes, react relatively quickly to climate effects, influencing ecosystems and human activities on a local scale and can be seen as good indicators of climate change. Without the cryosphere, more energy would be absorbed by the Earth's surface and consequently the temperature of the atmosphere would be much higher.

The *lithosphere*, composed by the continents with their topography, affects air motions. A strong interaction is noted between atmosphere and lithosphere with transfer of sensible heat, angular momentum and mass, in form of water vapour, rain, snow, dust, and particles from the volcanoes. Also, the soil moisture of the surface layer of the continental lithosphere has influence on the local energy balance affecting the rate of evaporation of the albedo and the thermal conductivity of the soil. The lithosphere is considered as the component with the longest response of all components of the climatic system.

The *biosphere,* the last component of the climate system, is formed by terrestrial and aquatic fauna and flora from the oceans. Each component has its importance and could influence the albedo, the evaporation, and the carbon dioxide concentration in the atmosphere and oceans.

The time scales of the above components of the climatic system vary from one sub-system to another. Due to the complexity of the internal climatic systems and on the basis of the different response times a hierarchy of internal systems could be defined taking into account firstly the components with the shortest response times, so that all the other component are considered to be part of the external system. For example, for time scale up to weeks, the atmosphere can be regarded as the only internal component of the climate, while the ocean, ice, land surfaces and biosphere represent the external forcings or boundary conditions of the system. If we are interested to study phenomenon for time scales of months to century, the climatic system must include in this case the atmosphere, oceans, snow cover, sea ice and biosphere.

1.2 Climate variability and climate change: causes of climate change

The whole climate system must be seen as continuously evolving, due to different causes/influences leading to two type of variability of the climate. One of these is *free* variability and is caused by the interactions between parts of the system (called *internal* instabilities) for example interaction atmosphere-ocean, and due to feedbacks mechanisms. The other type of variability is called *forced*, and is caused by the changes in *external* factors that affect climate (called "external forcings"). The distinction between the two classes of causes is not always very clear, and it is not very easy to separate them.

External forcings, those that are not determined by the climatic variables themselves, include in generally astronomical and terrestrial forcings.

The astronomical forcings include changes in:

- the intensity of solar irradiance;
- the orbital parameter of the earth such as eccentricity of the orbit, axial precession;
- the rate of rotation of the earth.

The terrestrial forcings include:

- variations in atmospheric composition due to natural or human activity (variations in the concentration of carbon dioxide, ozone, aerosol, etc);
- variation of land surface due to land use (for example deforestation, desertification);
- changes in tectonic factors such as continental drift;
- changes in volcanic activity and geothermal flux.

All these factors influence the climate and could determine "*climate variability*" or "*climate change*". These two concepts, even if they are close, are substantially different. *Climate variability* could be defined as the way in which the climatic variables (such as temperature, precipitation) depart from some average state, either above or below the average value while the "*climate change*" refers to a significant change in the state of the climate that can be identified by changes in the mean and/or the variability of its properties, and persists for an extended period, typically decades or longer (IPCC, 2007-AR4, WG1). Different definitions have been done for *climate change*, for example the UNFCCC defines *climate change* as 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" (glossary of IPCC, 2007). Both definitions, from the Intergovernmental Panel on Climate Change (IPCC) and the UNFCCC, underlay in fact that the climate change implies a significant change in the state of the climate, independently from the causes (natural or human) that generate these changes.

Long time series and large spatial scale are needed in order to study the climate variability and climate change and also in order to separate the responses of the system to different forcings. Supposing that the climate variable has a normal distribution, for example seasonal minimum /maximum/mean air temperature, a shift of the distribution to the "right" or to the "left" as well as change in the shape of the distribution (more flat or more "skewed") could be a schematic representation of the changes in the variable (figure 2). These change in the mean (1) or in the variance (2) are generally evaluated with respect to the present climate (1961-1990), and is considered a real change only if significant from the statistical point of view.

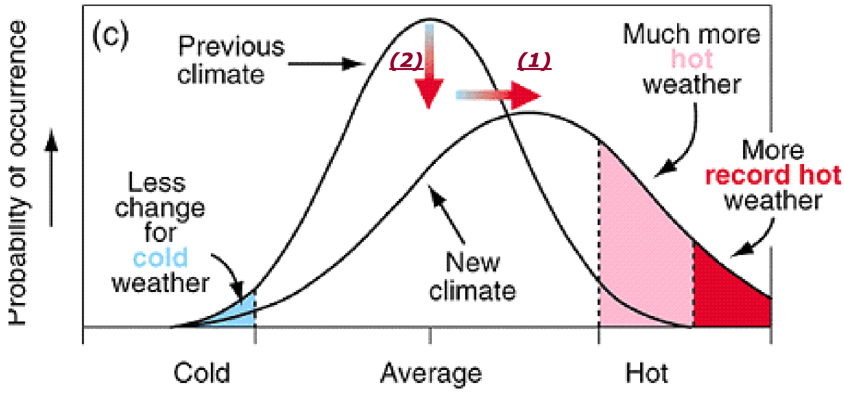


Figure 2: Schematic representation of climate (source: IPCC, 2007)

As underlined above, climate change occurs as a result of internal processes and external forcings. Some of the external influences, such as changes in solar radiation, in the orbital parameter or changes in the concentrations of aerosols arising from volcanic eruptions, occur *naturally* and contribute to the total "*natural*" variability of the climate system. For example, regular variation in the Earth's orbital parameters has been identified as the pacemaker of climate change on the glacial to interglacial time scale (Berger, 1988). These orbital variations, which can be calculated from astronomical laws, force climate variations by changing the seasonal and latitudinal distribution of solar radiation. Natural external forcing results from the volcanic eruption that scatter aerosols into the stratosphere. The volcanic sulphur dioxide (SO_2) ejected into the stratosphere forms sulphate aerosols and leads to a forcing that causes troposphere cooling and a stratospheric warming.

Natural climate variations can also occur in the absence of a change in external forcing, as a results of the instabilities of the components of the system, or due to complex interactions between internal components of the climate system, such as the coupling between the atmosphere and ocean that represents in fact the most important interactions between the components of climate system. One example of interaction air-sea is El Niño-Southern Oscillation (ENSO). This phenomenon born in the Pacific, involves large exchanges of heat between the ocean and atmosphere and affects temperatures and precipitation at global level.

The ENSO is defined in the atmosphere by the signal of the pressure difference between Tahiti and Darwin (Australia) and in the ocean by the warming or cooling of surface waters of the tropical central and eastern Pacific Ocean. El Niño, is the ocean "part" of the pattern and involves changes in ocean circulation, while the counterpart of the atmosphere is the Southern Oscillation (SO) that involves changes in trade winds, tropical circulation and precipitation. El Niño events occur every 3 to 7 years and alternate with the opposite phases of below-average temperatures in the eastern tropical Pacific (La Niña). Effects on weather vary with each ENSO event, that appear in generally around Christmas and is associated with floods/droughts and other weather disturbances in many regions of the world.

Apart from ENSO, there are other weather systems or patterns that determine the main seasonal and longer-term climate anomalies in the main climate variables (temperature, precipitation, moisture). These patterns arise from the differential effects on the atmosphere of land, ocean, mountains, and anomalous heating. Some of these patterns are very important to understand the regional climate anomalies. Some of the most important patterns influencing climate at global level and particularly the European climate are described below.

One of the most important atmospheric pattern prominent throughout the year in the Northern Hemisphere, affecting especially the climate in the North Atlantic, is the *North Atlantic Oscillation* (NAO) (Barnston and Livezey, 1987). This pattern represents in fact north-south oscillation in atmospheric mass with centres of action near Iceland and Portugal and could be observed analysing fields such as: mean sea level pressure, geopotential height at 500hPa. The NAO significantly affects weather and climate, ecosystems and human activities of the North Atlantic sector with an important influence on the European climate, even more pronounced during winter season (Hurrell et al.,1995). The effect of NAO can be noted especially on the temperature across much of the Northern Hemisphere, on storminess and precipitation over Europe and North Africa. During positive phase of NAO, an enhancement on westerly flow across the North Atlantic is noted, moving warm moist maritime air over large parts of Europe and far downstream, with dry conditions over southern Europe and northern Africa and wet conditions in northern Europe.

Another important pattern affecting European climate is the *atmospheric blocking.* It consists of a stationary synoptic feature which persists at least several days (5 to 10 days), around which the westerly air stream is deflected (Tibaldi et al.,1994). Blocking events, associated with persistent high-latitude ridging and a displacement of mid-latitude westerly winds are an important component of total circulation variability on intra-seasonal time scales. The preferred locations for the blocking are over the North Atlantic and North Pacific (Tibaldi et al., 1994), with a maximum in spring and a minimum in summer in the Atlantic-European region (Andrea et al., 1998; Trigo et al., 2004). The effect of the phenomenon could be quickly identified in the variability of temperature and precipitation, for example during blocking phase of the Central European pattern this connects to very low precipitation in Central Europe and higher-than-usual totals in the north.

Another important pattern affecting climate is the *cyclone activity*. A number of recent studies suggest that cyclone activity over both hemispheres has changed over the second half of the 20th century. General features include a poleward shift in storm track location and increased storm intensity. The *Scandinavian pattern* is another pattern that affects the Mediterranean climate. It has a more regional spatial extent and is usually associated with the occurrence of blocking patterns (with typical durations of 5-20 days) which influence the passage of cyclones and moisture to western Europe, often shifting systems towards the Mediterranean basin, or promoting the occurrence of extreme cold (winter) and warm (summer) extremes over the basin.

The patterns described above are only a selection of the most important pattern that affect the Northern Hemisphere/European climate with particular attention on Mediterranean/Italian climate. The relationships between these circulation patterns and the main climatological variables such as precipitation and temperature from the Euro-Atlantic sector were studied by different authors[1].

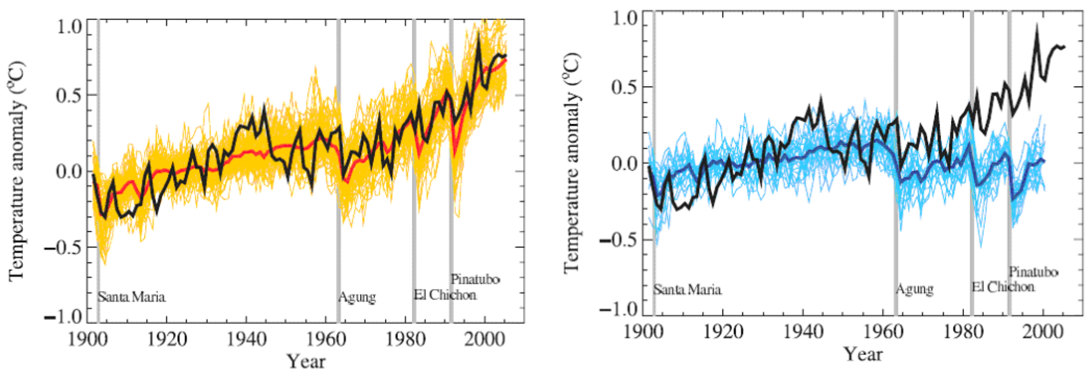
As emphasized at the beginning of this chapter, other external changes, such as the change in composition of the atmosphere could be due, not only to the natural contributions, but could also be a results of *human activity* and connect to the *anthropogenic variability/change* in the climate system. A great attention was paid to the study of human influence on the recent evolution of the climate before 1990, such as the first results of the human influence on climate which was described in the first IPCC Assessment Report (IPCC, 1990). Six years later, the IPCC Working Group I SAR concluded that there had been a 'discernible' human influence on the climate of the 20th century (IPCC, 1996). The analyses of widespread temperature and changes in other climate variables put in evidence the effect of external forcings on the climate and changes of these especially due to anthropogenic effects.

It is now widely accepted that the emission into the atmosphere of large amounts of greenhouse gases of anthropogenic origin is partially responsible for recent climate trends at the global scale (IPCC, 2007). However, the capacity to separate the roles of natural and human influences on climate change has only recently been elucidated at the global (or hemispheric) scales for surface air temperature, precipitation or sea level pressure as shown on the recent report of the IPCC. Climate change at a regional level can be more difficult to understand than changes occurring at the global or hemispheric scales.

There are many tools used to study, detect and attribute climate change. One of this is the global circulation models (GCMs), with the first generation represented by a simpler model in 1956. Later, many GCMs were developed incorporating many features or using different type of parameterization, increasing the temporal and spatial resolution. A great attention was paid in the last period to the interaction ocean atmosphere, connecting to a new

[1] Wibig, 1999; Marshal et al., 2001

generation of models, namely, ocean-atmosphere models (AOGCMs). These models are able to produce climate simulations for different periods starting from past to present and to future using a variety, typing and magnitude of forcings. Many studies refer to anthropogenic influences to climate change, especially the influence of aerosols and greenhouse gases such as: carbon dioxide, water vapor, methane, nitrous oxide and ozone. However, some forcings such as changes in carbonaceous aerosols and land-use are still omitted by many models and uncertainties remain in the treatment of those forcings. Now, more attention is paid to these forcings that could affect the regional climate and represent one of the main objective of "the modellers community". Recent studies emphasised that the simulations produced by different AOGCMs, using only natural forcings do not simulate the warming observed over the last three decades. Figure 3 shows the comparison between global mean surface temperature anomalies (°C) computed with respect to the 1901-1950 period from observations (black) and a number of simulations produced by different models forced with (a) both anthropogenic and natural forcings (red curve) and (b) natural forcings only (blue curve).The vertical line indicate the major volcanic eruptions, in both figures.



a) **b)**

Figure 3: Comparison between global mean surface temperature anomalies forced with (a) both anthropogenic and natural forcings and (b) natural forcings only (source IPCC, AR4,WG1,2007)

By analysing figure 3, it could be noted that there is much greater similarity between the general evolution of the warming in observations and that simulated by models when anthropogenic and natural forcings are included (3a) than when only natural forcing is included (3b). General Circulation Models (GCMs) represents also a powerful tool to explore the behaviour of the synoptic and large-scale phenomena, such as ENSO, NAO, blocking activity described before, in the past and how will change in the future under natural and anthropogenic influences, where no detailed observations exist.

However, the last IPCC report (2007) concluded that "it is extremely unlikely (<5%) that the global pattern of warming during the past half century can be explained without external forcing, and very unlikely that it is due to known natural external causes alone. The warming occurred in both the ocean and the atmosphere and took place at a time when natural external forcing factors would likely have produced cooling. Greenhouse gas forcing has very likely caused most of the observed global warming over the last 50 years".

Before analysing how climate will change in the next century as indicated by models simulations, in the next section the spatial variability and trend in temperature and precipitation derived from the observed data is presented.

1.3 Changes in observed surface climate: mean values and extreme values – from global to local scale

Climate has changed on all time scales. Some aspects of the current climate change are not unusual, but others are. Current global temperatures are warmer than they have ever been during at least the past five centuries, probably even for more than a millennium. If warming continues unabated, the resulting climate change within this century would be extremely unusual in geological terms. Another unusual aspect of recent climate change is its cause: past climate changes were natural in origin whereas most of the warming of the past 50 years is attributable to human activities (IPCC,2007 AR4-WG1). In order to monitor the climate, variability or changes in the climate, the scientific community defines indices that describe the climate variability. The global means of temperature and precipitation are the most common indices and most readily linked to global mean radiative forcing, and are important because they clearly indicate if unusual change is occurring. Apart from these indices, extreme indices describing extreme phenomenon have been defined starting from daily temperature and precipitation data. The spatial and temporal evolutions of these indices provide a "picture" of the climate variability/change.

Extreme events are those events whose characteristics fall in the tail of the statistical distribution of all possible weather events. They are by definition rare, and can be identified in different ways, as those events exceeding in magnitude some threshold, or as the maxima/minima of a variable over a certain period. Changes in the magnitude, frequency of the extreme events have high impact on the environment and the human activities. This is one of the main reasons to pay more attention to changes in the frequency, intensity or magnitude of such events in the past and to estimate whether they will occur more frequently in the future. Considering the casualties and the very high economic damages that have been experienced during the recent years in Europe due to various extreme weather events (floods or severe heat waves), there is a clear need for more reliable and high-resolution scenarios of extreme events in the future perturbed climate due to the increase of greenhouse gases. Different European projects deal with this issue, such as: STARDEX[2], PRUDENCE[3], and ENSEMBLES[4] analyzing the recent trends in mean and extremes and construction of scenarios of extreme events for selected European regions or study the impact of climate change on the environment such as MICE[5].

[2] http://www.cru.uea.ac.uk/projects/stardex),
[3] http://www.cru.uea.ac.uk/projects/prudence)
[4] http://www.cru.uea.ac.uk/projects/ensembles),
[5] http://www.cru.uea.ac.uk/projects/mice

Extreme events include phenomena such as droughts, floods, storms, cyclones and tornadoes, heat and cold waves. In order to describe these phenomenons the scientific community define indices, such as:

- frost days (Fd): measuring air frosts and is generally defined as the number of days with the minimum temperature below 0°C;
- diurnal temperature range (DTR): defined as temperature difference between the minimum at night (low) and the maximum during the day (high);
- heat wave duration index (HWDI): generally defined as the maximum number of consecutive days with maximum temperature higher than a certain thresholds (in generally the threshold is 90^{th} percentile of maximum percentile);
- the 10^{th}/90^{th}, percentile of minimum/maximum temperature: helps in general to understand changes in the distribution of the parameter;
- the maximum number of consecutive dry days (CDD) could potentially become a valuable indicator for the dry part of the year;
- maximum 5-days precipitation (R5d) or the simple daily intensity index (SDII) would similarly summarise the wet part of the year or more extreme precipitation;
- the fraction of the precipitation greater than or equal to the daily 95^{th} percentile (R95) would represent some of the more extreme precipitation.

These represents only a selection of the most important extreme indices that could describe extreme events. Long and homogenised time series, with a good quality of data is needed in order to analyse and to detect trends of the above indices.

1.4 Trends in observed mean and extreme values of minimum and maximum temperature

Global mean surface temperatures have risen by 0.74°C ± 0.18°C over the last 100 years (1906–2005). Figure 4 shows trends in annual global mean temperature for different periods of time. It is very important to underline that the trend analyses depends on the region and also on the length of the time series and period.

As shown in figure 4 the increasing is different in magnitude for different period of time, the warming has occurred in two phases: from 1910 to 1940 (0.35°C/decade) and more strongly from 1970 to the present (0.55°C/decade). In fact, from figure 4, emerges how the most intense trends is those corresponding to the last 25 years (1981-2005). At global level the warmest years in the annual instrumental records of global surface temperatures are 1998 and 2005. Then follows the 2002 to 2004 are the 3rd, 4th and 5th warmest years in the series since 1850. Numerous studies underline that eleven of the last 12 years (1995 to 2006) – the exception being 1996 – rank among the 12 warmest years on record since 1850. Also from the graph emerges that after 1990 only positive anomalies of the surface temperature was registered.

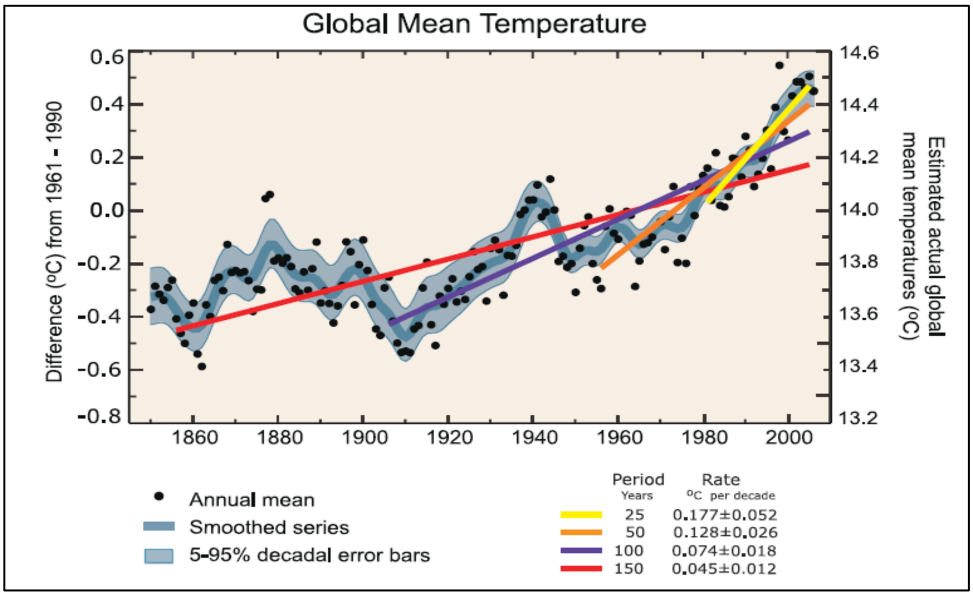
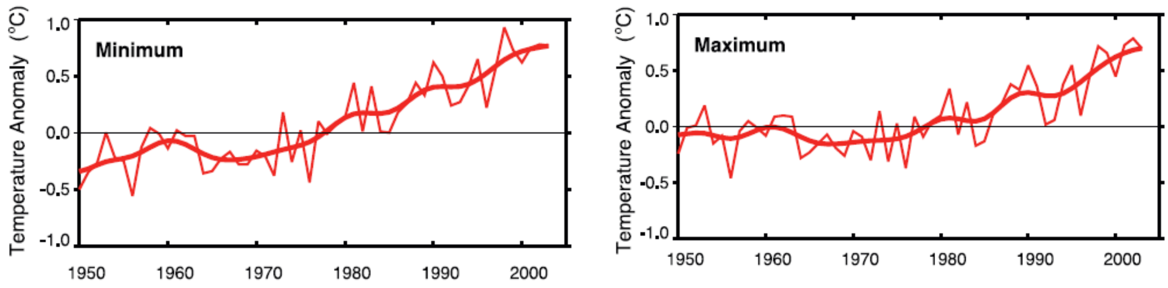


Figure 4: Trends in observed annual global mean temperature for different periods of time (source IPCC ,2007)

This warming is different from land to ocean, the surface air temperatures over land have risen at about double the ocean rate after 1979 (more than 0.27°C per decade vs. 0.13°C per decade), with the greatest warming during winter (December to February) and spring (March to May) in the Northern Hemisphere. At global level from 1950 to 2004, the annual trends in minimum air temperature are positive and slightly greater than those in maximum temperature (figure 5), 0.20°C /decade in minimum respect to 0.14°C /decade (Vose et al., 2005).



a) b)

Figure 5: Annual anomalies of minimum (a) and maximum (b) temperature (°C) of land areas (where data are available) for the period 1950-2004. (source: IPCC –AR4, WG1,2007)

Local climate changes are often much larger than global ones, since local factors (e.g., changes in oceanic or atmospheric circulation) can change the delivery of heat or moisture from one place to another and local feedbacks operate, such as the classification of the warmest year at local scale could be slightly different from those at global level.

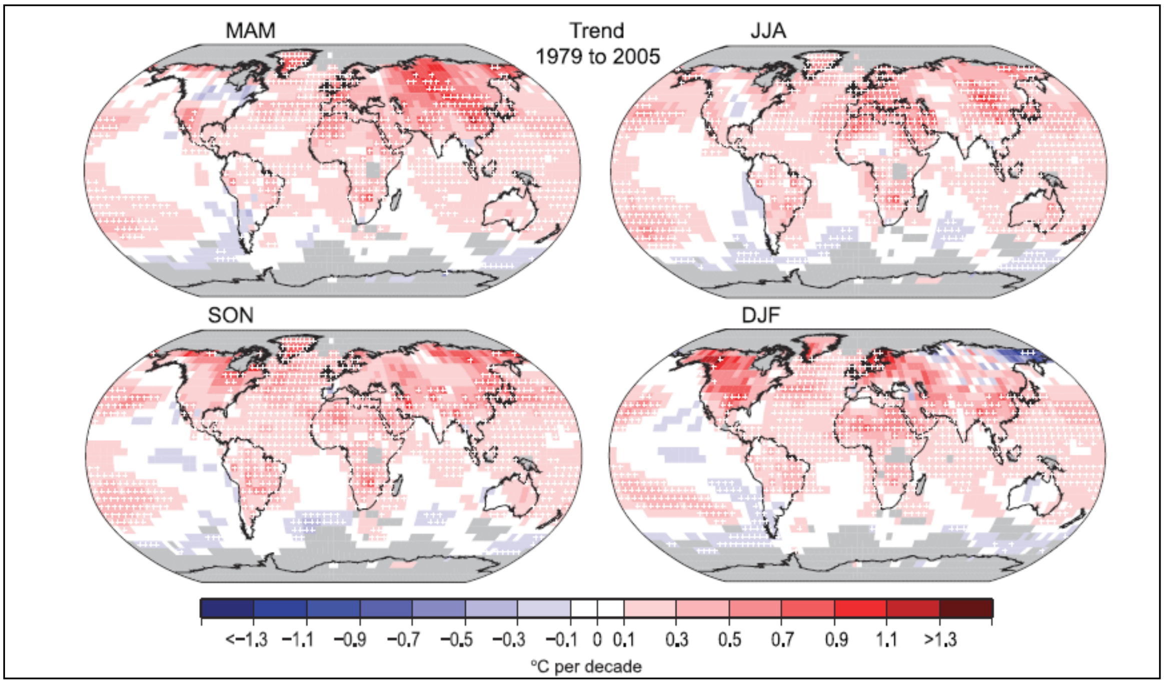


Figure 6: Spatial pattern of trends of seasonal mean air temperature for t he period 1979-2005(°C/decade). Areas in grey have insufficient data to produce reliable trends. The dataset used was produced by NCDC. Trends significant at the 5% level are indicated by white + marks (source IPCC 2007, AR4).

In figure 6, the red colour reveals positive trends, blue colour reveals negative trends, the white cross emphasis that the trends is significant at 5%. As it could be noted especially for land areas positive trends in mean air temperature dominates all the seasons, more pronounced (up to 0.9°C/decade):

- during winter: over western North America, Northern Europe and China;
- during spring: over Europe and northern and eastern Asia;
- during summer: over Europe and North Africa;
- during autumn: northern North America, Greenland and eastern Asia.

Insignificant negative trends could be observed over eastern Canada in spring, possibly in relation to the strengthening of NAO pattern.

Numerous studies have been done at regional and local scale in order to better quantify the signal of trends. For example, analysing the trends of temperature in central Europe, (Brazdil et al., 1996) identify an increase in both its maximum and minimum values during the period 1951-1990, more pronounced in the minima than in the maxima. A similar analysis has been done by Weber et al.,(1997) using records from 29 Central Europe stations at both low altitude and at high elevation. Marked warm periods around 1950 and 1960 were identify in maximum and minimum temperatures, and also a strong increase has been noted after 1980. As concern the stations at high elevation (mountains area) significant changes has been noted during winter and spring for the period 1951-1990, with an increase in both maximum and minimum temperature.

The STARDEX project in its final report concluded that in Europe over the last 40 years, more exactly for the period 1958-2000, significant trends in maximum and minimum temperature was founded in all season, more intense especially during <u>winter</u> and <u>summer</u> season.

During <u>winter</u>:

- an increasing in the extreme maximum temperature over most of the region, except the south-east part was registered;
- extreme minimum temperature increased over the entire region, apart from small decreases in parts of Greece, the Iberian Peninsula and Scandinavia;
- extreme minimum temperature increased more than extreme maximum temperature.

During <u>summer</u>:

- extreme maximum temperature increased in most area, except in northern Scandinavia, Eastern Europe and Russia
- extreme minimum temperature increase in almost part of the Europe.

An increase in mean air temperature has been found at smaller scale, for example over Italy for the period 1869-1996, more pronounced in the southern part of Italy than in the North, 0.4°C/100year in North (yearly temperature) respect to 0.7°C/100year in the south of Italy. Also, the increase is significant in all seasons, but with a higher magnitude in winter, followed by summer, autumn and spring (Brunetti et al,2004, Cacciamani et al., 1994). Trends of minimum and maximum temperature over the Italian territory was also investigated, using long and homogenised time series from the period 1865-2003. The trend is generally higher for minimum temperature than for maximum temperature for all the seasons and the year, the only exception being the Po valley region, whose trend is always higher for maximum temperature (Brunetti et al, 2006). As for mean temperature, also maximum and minimum temperatures show a lower trend in autumn, the only exception being the maximum temperature series of Alps that has a minimum trend value in summer.

At smaller scale, for example over the Emilia-Romagna region in northern Italy, significant increase has been found over the period 1958-2002 in all seasons but more intense in maximum temperature than in minimum temperature, similar behaviour founded by Brunetti et al.(2006) for the Po valley. The annual trend over Emilia-Romagna for maximum temperature being 0.46°C/decade while those corresponding to annual minimum temperature being 0.27°C/ decade. As concern the seasonal analysis, summer is the season with more intense values, 0.6°C/decade for maximum temperature and 0.4°C/decade for minimum temperature (Tomozeiu et al., 2006). As indicated, not only the period is important in trend analysis but also the spatial scale.

Changes are observed not only in mean values, but also in the frequency of occurrence of extreme events and in their intensity. Numerous studies underlie an increases in warm night time temperatures across much part of the globe. These connect also to changes in diurnal temperature range (DTR), that decrease by 0.07°C/decade averaged over 1950-2004 (IPCC 2007). This is caused by temperatures increasing faster at night than during the day.

Karl et al.(1993) noted that : "*Since 1950 all of the increase of temperature across the U.S.A. is due to an increase in the minimum temperature (about 0.75 degrees C/ Century or 1.5 degrees F/Century) with no change in the daily maximum temperature. This caused a decrease in the diurnal temperature range.*" Subsequently, this type of behaviour has been observed at other locations and is stronger as one goes towards the polar regions. It now appears that most of the observed global surface warming of recent decades is occurring mostly at night. Figure 7 shows a synthesis of trends in DTR at global level for a shorter period, 1979-2004, the grey colour indicate incomplete or missing data, red indicate positive trends, while blue indicate negative trends. The pattern is complex, the cause of the DTR trend is still poorly understood, as is its relation to anthropogenic forcing. Karl et al., (1993), argue that increasing cloud cover and increasing soil moisture may be the cause of the observed DTR variations. Also, changes in land surface and the growth of urban heat islands can also cause decreases in DTR.

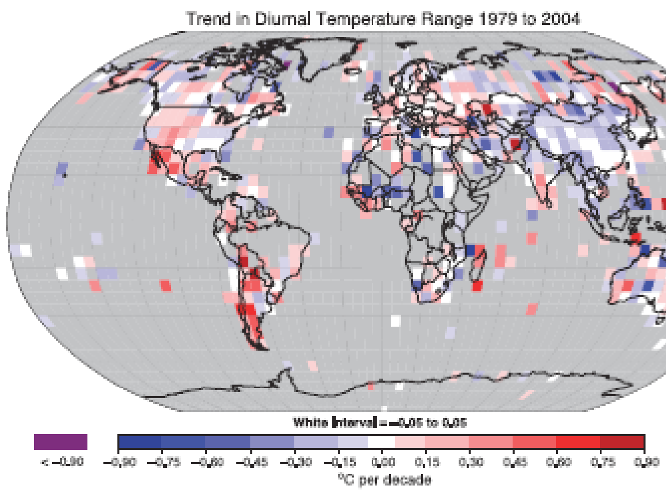


Figure 7: Linear trends in annual mean DTR for 1979-2004 (°C/decade), after Vose et al, 2005

From figure 7 could be noted that the Mediterranean area is characterised by a negative trends in DTR, many studies highlight a general tendency towards a negative trend in DTR. Similar results has been founded also looking in more detail over the Italian territory by

Brunetti et al.(2006) considering the whole series 1865–2003. They found a significant negative trend in the DTR in the year (−0.2 K per century), and in winter (−0.2 K per century), summer (−0.3 K per century) and autumn (−0.2 K per century).

This decreasing in DTR due to the increasing of the minimum temperature (during night) affects other extreme, such as the frost days (Fd) or the 10th percentile of minimum temperature. At global level, it was noted a widespread reduction in the number of frost days in mid-latitude regions, while the cold (lowest 10%, based on 1961–1990) nights have become rarer over the 1951 to 2003 period. (IPCC,2007). The results obtained by the STARDEX project focus on observed extreme events over Europe for the period 1958-2000, indicate a general shift to warmer conditions with more hot and fewer cold extremes, e.g., a reduction of the number of frost days (Figure 8a) and longer heat wave duration (Figure 8b).

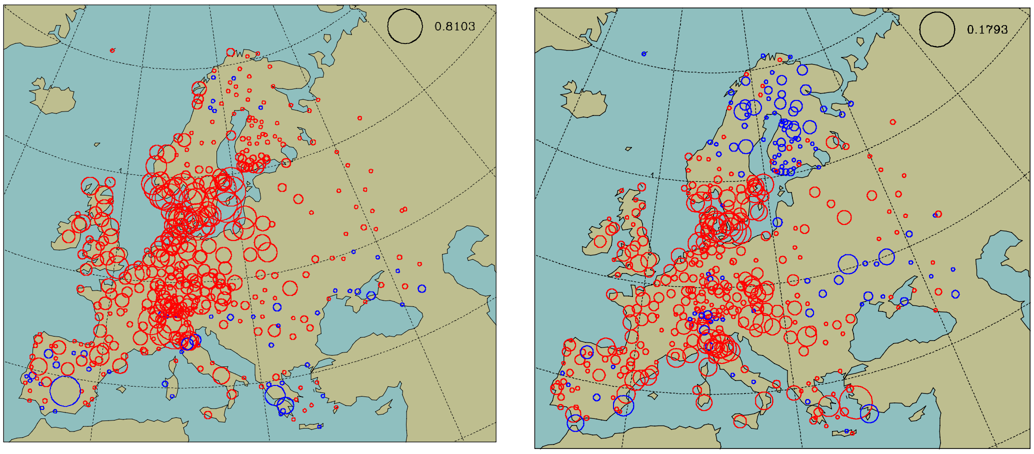


Figure 8: (a) Winter frost days (b) Summer heat wave duration

Source (STARDEX –final report)

In figure 8 (a) red colour represents negative trends, while in figure 8b red indicates positive trends. A significant and uniform pattern of decreasing in winter frost days is noted in whole the region, while as concern the heat wave duration index an increasing is noted except in generally the high latitude. Similar results were also identified for the above indices by Kostopoulou et al (2005) over the Mediterranean region for the period 1958-2000. They underlay that the greater trends for heat wave duration index are founded in the central Balkan countries and northern Italy. Although not all trends are statistically significant, they suggest an increase of 2–3 days per decade. The hottest summer in Europe, especially over western and central Europe still remain 2003 (Schair et al., 2004; IPCC 2007). Absolute maximum temperatures exceeded the record highest temperatures observed in the 1940s and early 1950s in many locations in France, Germany, Switzerland, Spain, Italy and the UK, according to the information supplied by national weather agencies (WMO, 2004). Based on early documentary records, Luterbacher et al. (2004) estimated that 2003 is very likely to have been the hottest summer since at least 1500.

One of the questions that appear after the 2003 event is: could a human influence such as increased concentrations of greenhouse gases in the atmosphere have ‘caused’ this events?

The studies performed for 2003 heat wave revealed that the event was associated with a very robust and persistent blocking high-pressure system, that was associated with very clear skies and dry soil, which left more solar energy available to heat the land because less energy was consumed to evaporate moisture from the soil. Other extreme events such as the formation of hurricane for example those from North Atlantic of 2004 and 2005 or the extreme rainfall events in Mumbai, India in July 2005 requires warm sea surface temperatures and specific atmospheric circulation conditions. Because some factors may be strongly affected by human activities, such as sea surface temperatures, but others may not, it is not simple to detect a human influence on a single, specific extreme event. Climate models are one tools used to determine whether human influences have changed the likelihood of certain types of extreme. For example, in the case of the 2003 European heat wave, a climate model was run including only historical changes in natural factors that affect the climate, such as volcanic activity and changes in solar output. Then, the model was run again including both human and natural factors. In this case the simulation reveals for the European climate a situation closer to that which had actually occurred. This underlies some evidence of the anthropogenic forcing on extreme temperatures (IPCC, 2007).

1.5 Trends in observed mean and extreme precipitation

Many studies indicate that the rainfall trends are more spatially and seasonally variable than temperature trends. Many causes generates this variability in the precipitation filed, one of this is also the difficulties in the measurement of precipitation, in situ measurements are especially affected by wind effects, on the gauge catch, particularly for snow but also for light rain. Many data set of precipitation that cover different period have been created in order to construct a time series of global annual land precipitation, that could be used then in trend analysis. Such kind of analysis is a little difficult to interpret taking into account that the precipitation fields is more noise than temperature, different region of the globe could have large anomalies of opposite sign. The studies of regional precipitation could allow a more complete analysis of trends in precipitation. Figure 9 presents the variability for the period 1900-2005 of the anomalies of annual global land precipitation, using different data sets.

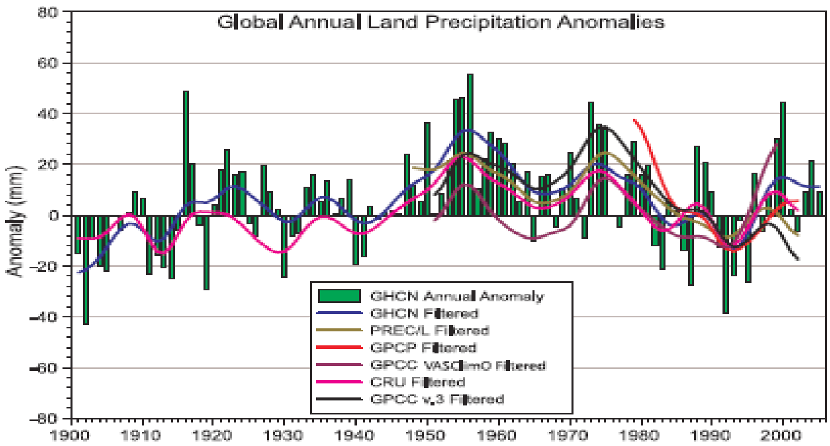
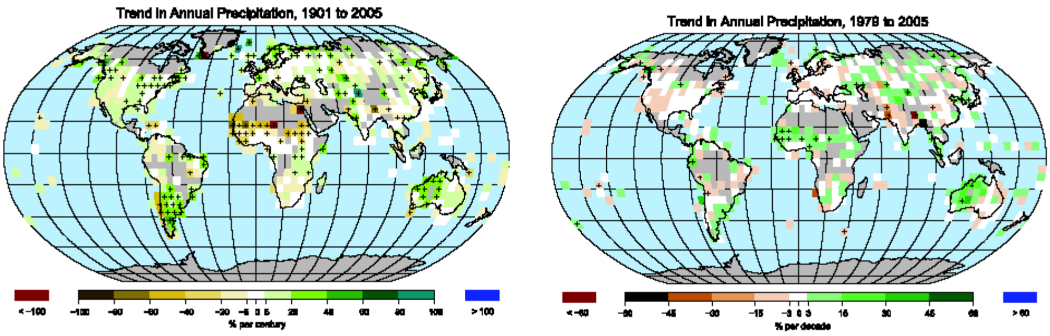


Figure 9: Temporal variability of global anomalies of annual precipitation for different data-sets (IPCC –AR4-WG1-2007).

In figure 9, the temporal variability of annual precipitation given by different data sets is similar. The global mean land changes are not at all linear, positive anomalies were registered especially during 1940-1970, a decrease until the early 1990s and then a recovery of the anomalies.

A spatial pattern of trend analysis of annual precipitation using GHCN data set and for two periods, 1901 to 2005 and 1979 to 2005, is presented in figure 10a and 10b. As could be observed for long time period, positive trends in annual precipitation has been registered in different part of the world, for some region trend is statistically significant (marked by black +), for example: over North America, and especially over high-latitude regions in Canada, Amazon Basin and south-eastern South America, including Patagonia, northern part of Europe, Australia were registered. The largest negative trends in annual precipitation were observed over western Africa, the Sahel and some Mediterranean parts (see figure 10a).

Analysing in more details trends in annual precipitation for the shorter period (figure 10b) could be noted how many regions became "poorly" in precipitation, for example the Mediterranean area or the Eastern Europe where negative trends could be observed. Also changes in annual precipitation over the North-western part of Australia that shows area with moderate increases in annual precipitation (figure 10b) in comparison with longer period (figure 10a) where, significant increases were observed.



a) **b)**

Figure 10: Trend of annual land precipitation amounts for 1901 to 2005 (a) and 1979 to 2005 (b) expressed in % per decade. The percentage is based on the means for the 1961 to 1990 period. Areas in grey have insufficient data to produce reliable trends. Trends significant at the 5% level are indicated by black + marks (source IPCC, AR4 –WG1 2007).

The distribution of annual precipitation over the seasons is different from one region to other. Different studies have been done at seasonal level and for vary region of the world. For example Moberg et al., (2006) analysing precipitation from Europe, west of 60°E for the period 1901-2000, found that winter precipitation totals, averaged over 121 European stations north of 40°N, have increased significantly by approximately 12% per 100 years, while no overall long-term trend occurred in summer precipitation totals.

With regard to the Mediterranean region, Kostopoulou and Jones (2005) show that especially in the eastern part (Balkan Peninsula, Cyprus and western Turkey) almost all stations show decreased precipitation, which is especially large and significant during winter in the Greek, Cypriot and Turkish stations. A decreasing precipitation has been founded also over Italy during the period 1833-1996 by Buffoni et al., (1999) analysing the trends in annual quantities of precipitation. More recent studies based on data on Italian stations confirm the negative trends in winter precipitation, while no significant trends was founded in summer precipitation (Brunetti et al., 2000, Tomozeiu et al 2002, Pavan et al, 2005).

A prominent indication of a change in extremes is the observed evidence of increases in heavy precipitation events over the mid-latitudes in the last 50 years (IPCC-WG1 AR4, 2007). The increase in heavy precipitation could connect to floods. This was the situation from example of the catastrophic flood occurred along several central European rivers in August 2002 when high precipitation registered and together with soils conditions that were completely saturated and the river water levels that were already high because of previous rain generate floods.

In Europe, there is a clear majority of stations with increasing trends in the number of moderately and very wet days (defined as wet days (≥1 mm of rain) that exceed the 75th and 95th percentiles, respectively, during the second half of the 20th century[6]. Similar conclusions were founded for the USA by Kunkel et al. (2003) and Groisman et al. (2004) that confirmed earlier results and found statistically significant increases in heavy (upper 5%) and very heavy (upper 1%) precipitation of 14 and 20%, respectively. Much of this increase occurred during the last three decades of the 20th century and is most apparent over the eastern parts of the country. In addition, there is new evidence from Europe and the USA that the relative increase in precipitation extremes is larger than the increase in mean precipitation, and this is manifested as an increasing contribution of heavy events to total precipitation[7]. Similar studies have been done over the Mediterranean basin by Kostopoulou and Jones (2005) for precipitation using observed data from the period 1958-2000.

They “divided” the basin in two areas that have contrasting precipitation trends, with the western (including Italy) part showing positive trends towards increased precipitation, larger precipitation total amounts and increases in intense rainfall events. Studies done on smaller scale, over Italy reveal a substantial increases in heavy precipitation events (R95 index) and in precipitation intensity over the period 1951-1996 (Brunetti et al, 2004). An

[6] Klein Tank and co-authors, 2002; Haylock and Goodess, 2004
[7] Klein Tank and co-authors, 2002; Groisman et al., 2005

increasing trends was founded also in the maximum 5-day precipitation totals (R5d index-see figure 11).

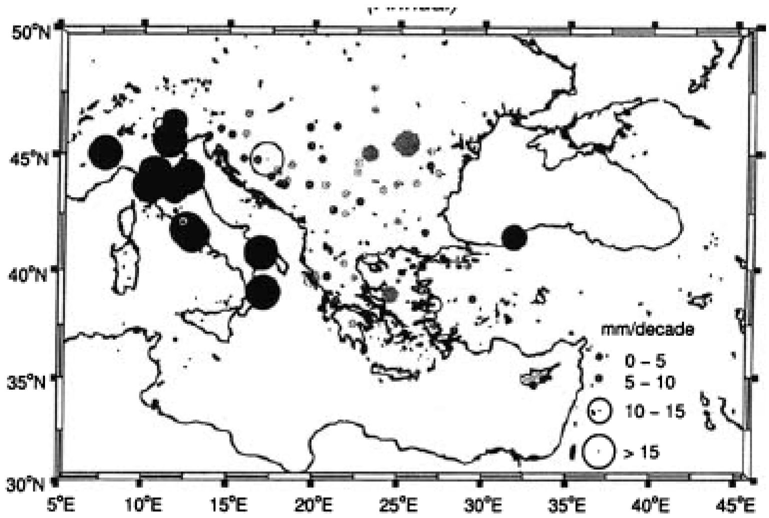


Figure 11: Decadal trends in the annual number of days with maximum 5-day precipitation total. Filled circles reflect trends statistically significant at the 95% level (source Kostopoulou and Jones, 2005).

In contrast, the eastern side of the basin reveals generally negative trends indicating tendencies towards a drying climate over time. This was seen especially at the southern coastal and island stations, which present large positive and significant trends also in the maximum number of consecutive dry days (CDD index). The opposite phenomenon of floods is droughts that have become more common, especially in the tropics and subtropics, since the 1970s. Observed marked increases in drought in the past three decades arise from more intense and longer droughts over wider areas. The regions where droughts have occurred seem to be determined largely by changes in SSTs, especially in the tropics, through associated changes in the atmospheric circulation and precipitation. In the western USA, diminishing snow pack and subsequent reductions in soil moisture also appear to be factors. In Australia and Europe, direct links to global warming have been inferred through the extreme nature of high temperatures and heat waves accompanying recent droughts.

Results derived from STARDEX project with regard to extreme precipitation over Europe, for two seasons with high signal, could be summarised as follows:

Winter longest dry period:

- Increased in the southern part of the Europe;
- Decreased in the north part of Europe;
- The increase is generally greater than the decrease;
- Summer longest dry period;
- Less coherent signal;
- Most stations in the central part, the UK, and southern Scandinavia showed an increase in dry period.

Winter heavy rainfall extremes:

- Increased in central Europe, the UK and Scandinavia;
- Decreased in Eastern Europe, Greece and western Iberian Peninsula;
- Summer heavy rainfall extremes;
- Increased across northern Scandinavia and Russia;
- Decreased across the UK and NE Europe;
- Increased across SW Europe;
- Decreased across the northern Iberian Peninsula;

The changes reported above are for the most important climatic variables, namely temperature and precipitation but significant changes were registered in other fields, for example (as reported in IPCC, 2007):

- sea level that rise around1.7 ± 0.5 mm yr–1 during the 20th century, but the rate increased to 3.1 ± 0.7 mm yr–1 from 1993 through 2003;
- increases in ocean heat content and associated ocean expansion are estimated to have contributed 0.4 ± 0.1 mm yr–1 from 1961 to 2003 more in the last period,

1993 to 2003, when the increase value is of 1.6 ± 0.5 mm yr–1 for 1993 to 2003. In the same period, glacier and land ice melt has increased ocean mass by approximately 1.2 ± 0.4 mm yr–1;

- changes in land water storage are uncertain but may have reduced water in the ocean;
- sea ice extents have decreased in the Arctic, particularly in spring and summer, and patterns of the changes are consistent with regions showing a temperature increase, although changes in winds are also a major factor. Sea ice extents were at record low values in 2005, which was also the warmest year since records began in 1850 for the Arctic north of 65°N.
- snow cover has decreased in many NH regions, particularly in spring, consistent changes in permafrost: temperatures of the permafrost in the Arctic and sub arctic have increased by up to 3°C since the 1980s with permafrost warming also observed on the Tibetan Plateau and in the European mountain permafrost regions.

1.6 How climate will change in the next future?

In order to assess climate change and to evaluate the risk of climate change caused by human activity, an international panel by the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP), called IPCC, was created in 1988. There are already four reports produced by the IPCC, the first one was produced on 1990, followed by a supplementary report in 1992, then the others were released in 1995, 2001, and 2007.

The IPCC reports are based on the results obtained and published by the scientific community. One of the topics covered by the IPCC reports is the problem of climate change as result from the application of different tools developed by the scientific community in order to construct climate change scenarios. *Global climate models* in which the atmosphere and ocean components are involved, known as Atmosphere-Ocean General Circulation Models (AOGCMs) is one tool that are most widely used to generate scenarios of climate change. The AOGCMs evolve in the last time such as many processes from the climate system are well described by the new model generation, but their relatively coarse spatial resolution (typically 300 km to 100 km) –means that downscaling is required to the finer spatial scales relevant for studying the impacts of climate change. This might be much finer resolution grids (e.g., 50 km or 25 km) or individual points (for consistency with instrumental station locations). Two major approaches to downscaling, dynamical and statistical, began to be developed and tested 5-10 years ago by different research groups and were shown to offer good potential for the construction of high-resolution climate change scenarios. Initially, work on both approaches was focused on their use in the construction of scenarios of change in mean climate. *Dynamical downscaling* involves the nesting of a finer-scale regional climate model (RCM) within the coarser global climate model (AOGCM). *Statistical downscaling* involves the application of relationships identified in the observed climate, between the large-scale and smaller-scale, to climate model output. Each dynamical or statistical approach has its own disadvantages and advantages. In order to create climate change scenarios, in the above models different forcings are applied.

Four different narrative storylines, ***A1, A2, B1 and B2***, were developed to describe consistently the relationships between the forces driving emissions and their evolution and to add context for the scenario quantification. The ***A1*** storyline and scenario family describes a future world of very rapid economic growth, global population that peaks in mid-century and declines thereafter, and the rapid introduction of new and more efficient technologies. The A1 family include three groups: ***A1F1, A1T, and A1B*** (based on a balanced between different factors). The ***A2*** family describes a very heterogeneous world, the ***B1*** family describes a convergent world with the same global population, that peaks in mid-century and declines thereafter, and with rapid change in economic, while the ***B2*** family describes a world in which the emphasis is on local solutions to economic, social and environmental sustainability. These scenarios (family) encompass a wide range of emissions greenhouses gases and anthropogenic sulphur dioxide emissions. Figure 12 presents on example of the distribution of atmospheric concentration of carbon dioxide for the six scenarios.

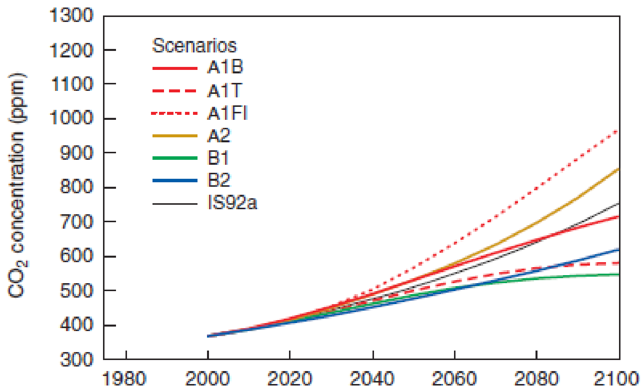


Figure 12: Atmospheric concentration of carbon dioxide for six SRES scenarios (source: IPCC 2007)

In the following section a description of the future changes in the mainly climatic variables, mean values and extremes, as result from different tools is presented. The projections are focused on the “medium” scenario- A1B.

1.7 Projections of future changes in temperature- mean and extreme values

A range of projections of future climate change has been conducted using a high number of coupled AOGCMs and different periods. Table 1 describes a synthesis of global changes in annual mean surface air temperature derived from the multi-model ensemble mean, different scenarios (A2,A1B,B1) and for four periods of time: 2011-2030, 2046-2065, 2080-2100 relative to 1980-1999 period (the temperature mean for the reference period is 13.6°C) (IPCC; 2007). As shown an increase in mean air temperature at global level is expected for each scenario, more intense to the end of century, when the mean changes in annual temperature could be around 3°C (Table 1 scenario A2).

	Global mean warming (°C)				Measures of agreement (M × 100, *mae* × 100)			
	2011–2030	2046–2065	2080–2099	2180–2199	2011–2030	2046–2065	2080–2099	2180–2199
A2	0.64	1.65	3.13		83, *8*	91, *4*	93, *3*	
A1B	0.69	1.75	2.65	3.36	88, *5*	94, *4*	100, *0*	90, *5*
B1	0.66	1.29	1.79	2.10	86, *6*	89, *4*	92, *3*	86, *6*

Table 1: Changes in annual mean surface air temperature from the multi-model ensemble mean for four time periods relative to 1980 to 1999 (source IPCC, AR4, 2007)

A spatial representation of changes in annual mean temperature give the pattern of warming over land and over ocean. As an example, figure 13 shows the changes in annual mean temperature from the multi-model ensemble mean, A1B scenario, and for different periods. As underlined, the annual temperature is projected to increase more at the end of the century (right panel), spatial distribution indicating values that reach 6°C of anomalies respect to 1980-1999 observed period.

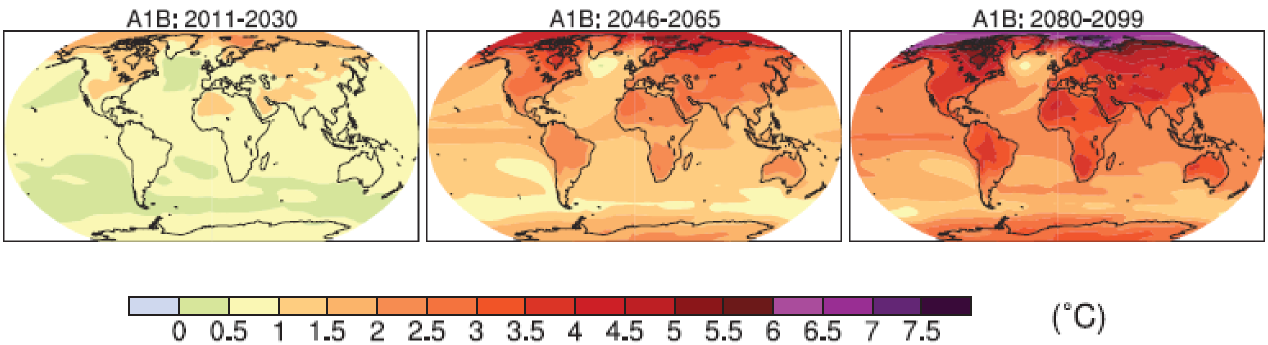


Figure 13.Changes in annual mean temperature for different periods respect to 1980-1999, multi-model ensemble mean, A1B scenario (source IPCC, WGI, 2007)

As shown in figure 13, the interiors of continents are projected to warm more than the coastal areas. The major assessment of air mean temperature change, was that it is *very likely* that all land areas will warm more than the global average (with the exception of Southeast Asia and South America in June, July and August; JJA), the amount of projected warming generally increases from the tropics to the poles in the Northern Hemisphere. It is very interesting to see how this warming is distributed at seasonal level. This issue were studied by AOGCMs, RCMs, statistical downscaling community. The projections done by AOGCMs at seasonal level, reveal that winter and summer are the seasons with more intense signal. The results obtained by regional climate models and statistical downscaling models from the recent projects like: STARDEX, PRUDENCE and ENSEMBLES sustain these behaviours of seasonal changes, but with some differences in the magnitude of changes. One major problem for all kind of models involved in the above projects was to try to quantify and reduce uncertainty in modelling climate. In the ENSEMBLES project seven European climate modelling centres ran AOGCMs, using a common forcing from the A1B scenario such as do not introduce uncertainty due to emission scenario, then fifteen institutions ran their RCM at 25km spatial resolution with boundary conditions from five different GCMs, and many statistical downscaling schemes were developed in order to try to asses the uncertainties.

The RCM projections was focused in generally on the European region and over Africa and provide plausible scenarios of detailed seasonal and annual changes consistent with the other tools. Figure 14 presents seasonal changes in mean air temperature under A1B scenario for the period 2021–2050 relative to 1961–1990 for the European region.

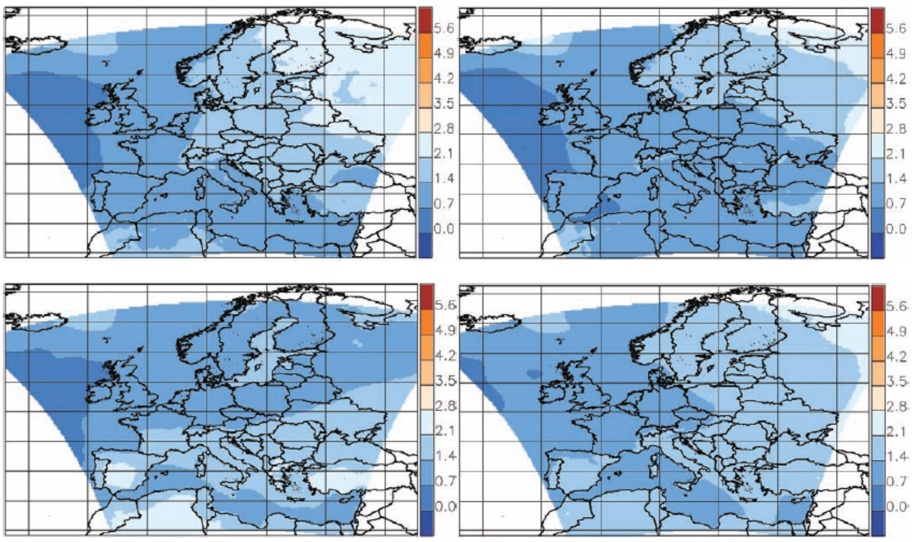


Figure 14: Projected changes in seasonal mean surface air temperature (K) under the A1B scenario, multi-model ensemble mean of RCM simulations for the period 2021–2050 relative to 1961–1990 seasonal means. Top left panel is DJF, top right is MAM, bottom left is JJA, bottom right is SON (source Ensembles final report).

As can be noted, a warming between 1 and 2°C is projected in each season, for the period 2021-2050. The pattern is slightly different in magnitude from season to season, summer being the season with more pronounced increase. Also, the summer warming is slightly higher in Mediterranean area, Eastern Europe than in the rest of the studied area.

Similar pattern has been founded for the period 2071-2099, A1B scenarios, when the increasing in summer mean air temperature could reach values around 5°C. As in the case of the 2021-2050 period, the pattern of warming is different; during winter, spring and autumn the increasing is more pronounced in the North-east part of the European domain, while during summer the increasing is more pronounced in the Mediterranean area and Eastern Europe.

With regard to Africa, the second region were RCM focused, the warming for the end of century is around 3°C in equatorial and coastal areas and larger, around 4°C, in the western Sahara. The largest temperature responses in North Africa are projected to occur in summer (June, July august) while the largest responses in southern Africa occur in September, October and November.

Future changes will result not only as changes in the mean climate state, but also in the variability of the climate. Addressing the interannual variability in monthly mean surface air temperature and precipitation of 19 AOGCMs in CMIP2, Räisänen (2002) finds a decrease in temperature variability during cold season in the extra tropical Northern Hemisphere and a slight increase in temperature variability in low latitudes and in warm season northern mid-latitudes.

As it was discussed in this chapter, the extreme events are those events that fall in the tail of the statistical distribution and could be defined based on the percentile of time series. An increase in the 10^{th}, 50^{th} and 90^{th} percentile of mean air temperature has been projected for the end of this century (2080-2099), more intense in 90^{th} percentile. Figure 15 presents an example of changes of summer 90th percentile of mean air temperature for the period 2080-2099 respect to 1980-1999, A1B scenarios, as result from runs of RCM model.

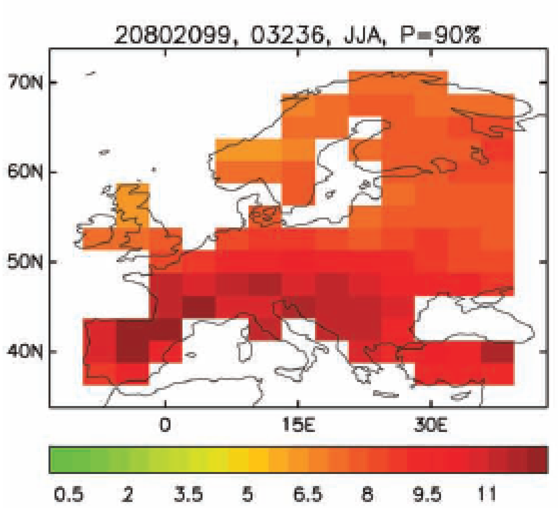


Figure 15: The ENSEMBLES projection of 90th percentile of summer mean air temperature for Europe under the A1B emission for the period 2080–2099 relative to the 1961–1990 baseline period.(source ENSEMBLES)

It can be noted that the increase is intense in all region, around 6°C, but higher values of increasing is projected for e Mediterranean and East European zone.

Minimum winter temperatures are projected to increase more than the average in northern Europe, while maximum summer minimum temperatures are projected to increase more than the average in southern and central Europe (patterns not shown).

Similar pattern of changes were founded for the percentile of minimum and maximum temperature, this affecting the distribution of other extreme events (frost days or heat wave duration). As concern the diurnal temperature range, the last IPCC report (2007) synthesized that in the framework of A1B scenario and for the end of this century a decrease is projected over most continental regions, due in generally to the night temperatures that will increase faster than the day temperatures. Also, a decrease in number of frost days is projected everywhere (Tibaldi et al.,2006) while frequent heat waves in summer over almost all continents is projected to increase in frequency, intensity and duration (Barnett et al., 2006;

Clark et al., 2006; Tibaldi et 2006). Figure 16 present the distribution of projected changes in annual frost days and heat wave duration as results from the multi model simulation of 9 GCMs for the end of century, more precise for the period 2080-2099 respect to 1980-1999, scenario A1B.

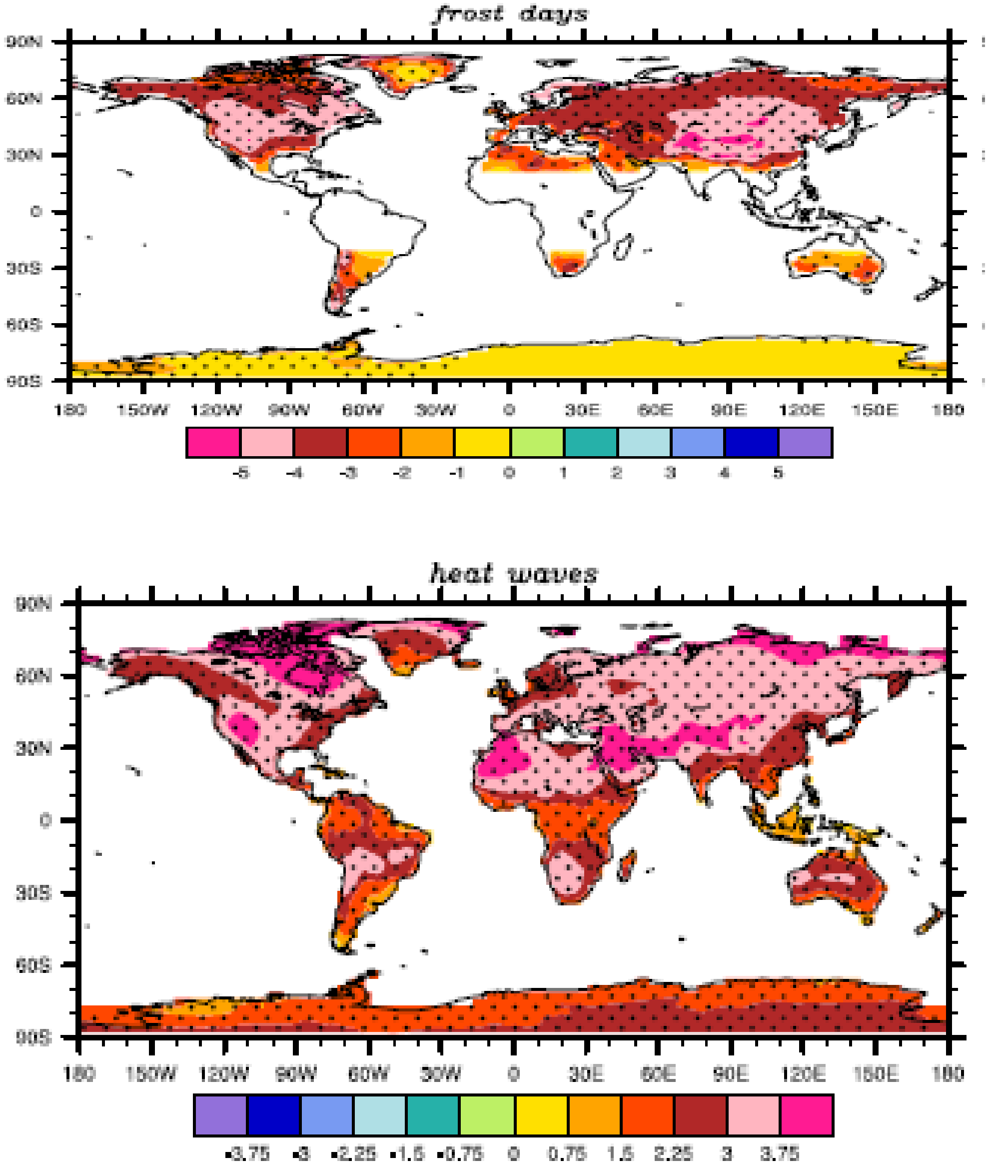


Figure 16: Projected changes in annual frost days (above) and heat wave duration (below) as results from the multi model simulation of 9 GCMs for the period 2080-2099 respect to 1980-1999, scenario A1B. (Source Tibaldi et al 2006).

As shown in figure 16 (above) the annual number of frost days decrease over the lands and is more intense over the high latitudes of North America, propagating southward along the western edge of the continent. For Europe and Asia the decrease is weaker along the Atlantic and Mediterranean coasts. The largest decreases are in the Scandinavian regions, and in most models following the topography of the higher elevations of Central Asia and Tibet. The North-Eastern part of Asia shows a less substantial decrease. The southern tips of South America and Africa see the largest decreases compared to other areas of those continents, consistent with the patterns of change in global mean temperatures which are greater at higher latitudes. As concern the heat wave pattern, figure 16 (below), a general significant increase over the land masses, with large positive values especially (around 4 days) over the southwest U.S., over North and central Australia and the high latitudes of the Asian continent, Mediterranean area, Northern African continent.

Seasonally and at smaller scale, the output derived from dynamical and statistical downscaling model shows that in generally, the largest signal is for winter as concern the frost days and summer as concern the heat wave duration.

1.8 Projections of future changes in precipitation - mean and extreme values

For the precipitation fields, the current generation of models projected increases for the period 2080-2099 respect to 1980-1999 (A1B scenario), in annual precipitation of over 20% at most high latitudes, as well as in eastern Africa, central Asia and the equatorial Pacific Ocean. The change over the ocean between 10°S and 10°N accounts for about half the increase in the global mean (Figure 17, above). Analysing in more details the pattern of changes from figure 17 could be noted that a substantial decreasing, reaching 20%, will occur in the Mediterranean region and the subtropical western coasts of each continent. Changes are projected also in annual average evaporation (Figure 17, below) that could increase over much part of the Oceans.

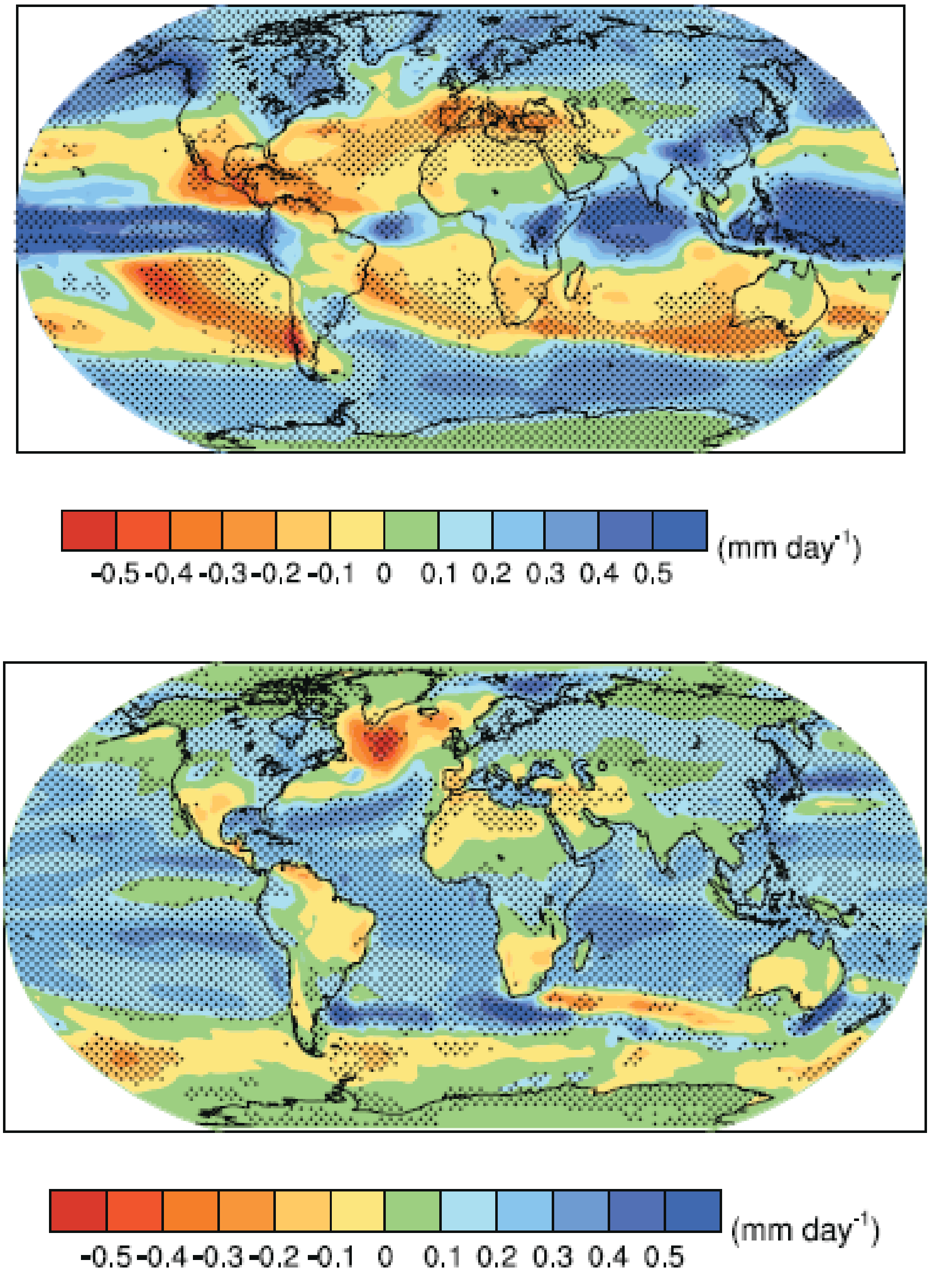


Figure 17: Multi-model mean changes in
(a) precipitation (mm day–1), (above) and evaporation (mm day–1) (below).
Changes are annual means for the SRES A1B scenario for the period 2080 to 2099 relative to 1980 to 1999.
(source IPCC, WGI, 2007)

Going onto details provided by regional and statistical downscaling models and for the European area, a south-north contrast in annual precipitation changes across Europe is indicated, with an increase in the north and decreases in the south (figure 18 left). The largest increases in northern and central Europe are simulated in winter (figure 18 middle) due to a possible increases of westerly winds while in summer, as could be noted from figure 18 right, the precipitation south of the 55°N will decrease significantly, probably due to more easterly and anticyclone flow. However, differences in the simulated circulation changes among the individual models were accompanied by large differences in precipitation change, particularly in summer.

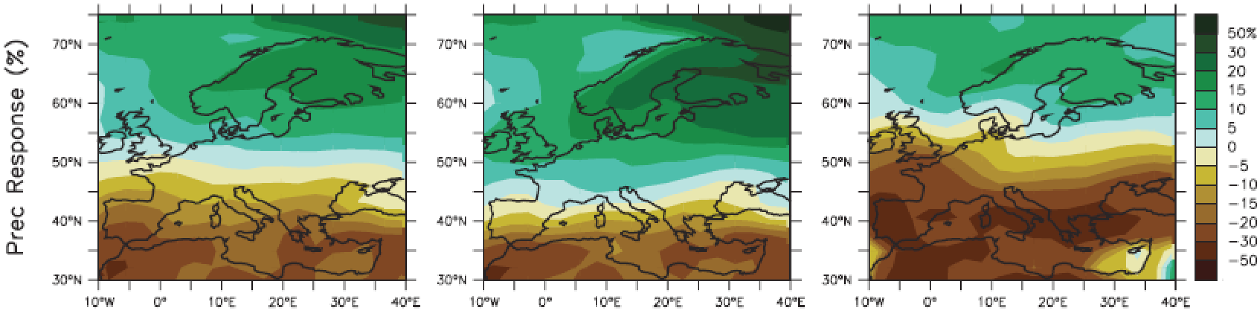


Figure 18. Precipitation changes over Europe between 2080 to 2099 and 1980 to 1999, averaged over 21 models - A1B simulations (left: Annual mean, middle –winter season and left –summer season; source: Supplementary Material for Chapter 11of the Working Group I contribution to the IPCC Fourth Assessment Report)

For the high extremes of precipitation the outputs from several GCMs shows that in northern Europe and in central Europe in winter, where the mean precipitation is simulated to increase, high extremes of precipitation are projected to increase in magnitude and frequency. In the Mediterranean area and in central Europe in summer, where reduced mean precipitation is projected, extreme short-term precipitation may either increase, due to the increased water vapour content of a warmer atmosphere, or decrease due to a decreased number of precipitation days (Frei et al., 2006; Beniston et al., 2007).

The risk of drought is likely to increase in many region more pronounced for example in the Mediterranean, southern and central Europe (see figure19). Increased risk of drought was noted also in southern areas of Australia and Central America. Tibaldi et al.(2006) analysing annual projections for extreme precipitation from the end of the century (2080-2099 respect to 1980-1999) revels that it rains less frequently, but when it does rain, there is more precipitation for a given event.

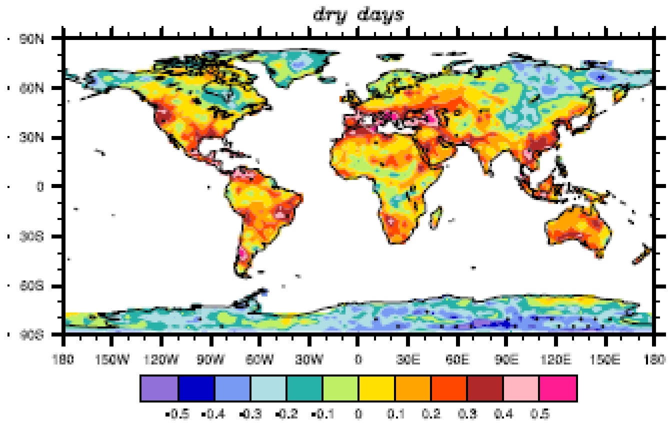


Figure19: Multi-model averages of spatial patterns of change at the end of the 20th century for dry days index (source Tibaldi et al, 2006)

Changes were projected not only for temperature and precipitation but also for other fields, for example for wind patterns or for the duration of the snow season that is very likely to be shorten in all of Europe. Also, snow depth is likely to decrease in at least most of Europe region. With regard to the sea level, this is projected to rise between the present (1980– 1999) and the end of this century (2090–2099) by 0.35 m (0.23 to 0.47 m) for the A1B scenario, but due to ocean density and circulation changes, the distribution will not be uniform. Also as the last IPCC report underlines there is high confidence that by mid-century, annual river runoff and water availability are projected to increase at high latitudes (and in some tropical wet areas) and decrease in some dry regions in the mid-latitudes and tropics. There is also high confidence that many semi-arid areas (e.g. Mediterranean Basin, western United States, southern Africa and north-eastern Brazil) will suffer a decrease in water resources due to climate change.

1.9 *Impacts of climate changes on different sectors –from present to future*

The last IPCC report concluded from the analysis of the observed climatic variables 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 (IPCC, AR4-WG1 2007)”. As for the precipitation from 1900 to 2005 “the precipitation increased significantly in eastern parts of North and South America, northern Europe and northern and central Asia but declined in the Sahel, Eastern, and Mediterranean region”.

The increases in observed temperature, and not only, produce changes in physical and biological systems. Figure 20 summarise changes in physical systems (including snow, ice and frozen ground; hydrology; and coastal processes) and biological systems (including terrestrial, marine, and freshwater), together with surface air temperature changes over the period 1970-2004. For this study, a subset of about 29,000 data series was selected from about 80,000 data series from 577 studies (source IPCC, WG3, 2007).

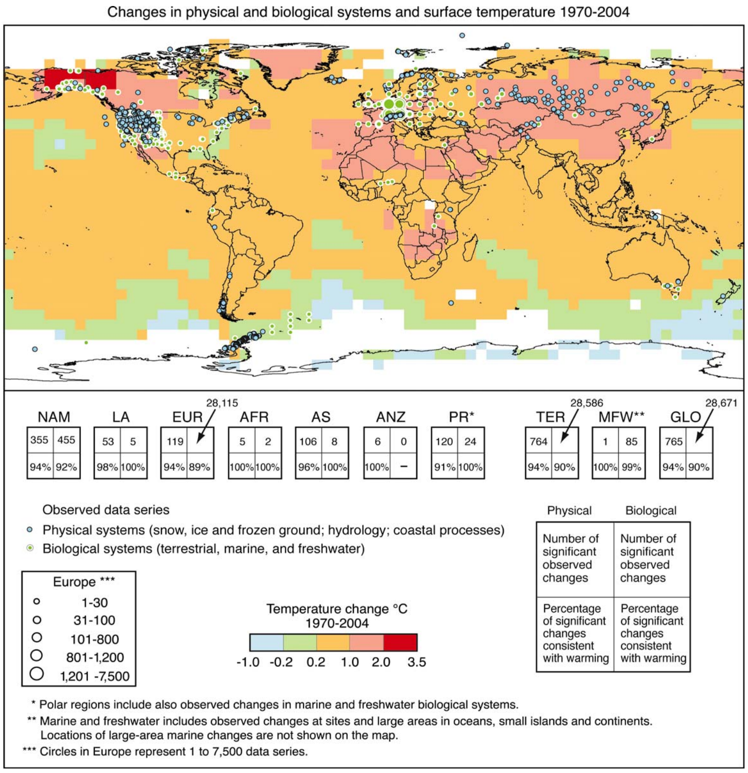


Figure 20. Changes in physical, biological systems and surface temperature for the period 1970-2004 (IPCC)

As it could be noted, the increase in observed air temperature for the period 1970-2004 has already impacted on both, physical and biological systems from different region of the world. Attribution of observed regional changes in natural and managed systems to anthropogenic climate change is complicated by the effects of natural climate variability and non-climate drivers (e.g., land-use change). Numerous studies have linked responses in some physical and biological systems directly to anthropogenic climate change using climate process and statistical models. Furthermore, the consistency of observed significant changes in physical and biological systems and observed significant warming across the globe cannot be explained entirely and only by natural variability or other confounding non-climate factors. This section focuses not on the attribution but on the impact of present and future climate change on life and different sectors of activity.

Some of the most damaging and costly impacts of climate change are expected to be those generated by the extreme weather events. Recently, many research projects have focused their objectives on the impacts of climate change/extreme events on different sectors and for different region of the world, such as MICE, ENSEMBLES,CIRCE. How the impacts of extreme event and climate change on life or how they damage the natural ecosystems, forests, agriculture, infrastructure, human health, tourism, are shortly presented as a result of the analysis of observed data.

Heavy rainfall from August 2002, caused the deaths of 100 people from flooding registered in Germany, Austria, Russia, and Czech Republic. The event was expanded rapidly over Europe causing severe damage to housing, and public infrastructure, forcing people to leave their home. In addition, the rising water levels contribute to the spread of disease and pollution, damage the water supply and food.

S*ummer heat wave of 2003* from Europe, when temperature exceeded 40°C in early August, lead to sharp increase in the number of death in Europe, especially in France. Also, during summer 2003 many forest fires were registered, with more than half a million hectares of woodland destroyed across Mediterranean Europe. Fires cause considerable damages in terms of loss of life, environmental terms through the destruction of flora and fauna. Also, during summer 2003 when anomalies of temperatures was up to 6°C above long-term means, and precipitation deficits up to 300 mm, a record drop in crop yield of 36% occurred in Italy for maize grown in the Po valley, where extremely high temperatures prevailed (Ciais et al., 2005). In France, compared to 2002, the maize grain crop was reduced by 30% and fruit harvests declined by 25%. Forage production was reduced on average by 30% in France while wine production in Europe was the lowest in 10 years (IPCC 2007, WGII). The impacts of such extreme events were highly registered also on energy sector. In generally energy demand presents a peak on July and December, is lower during spring and autumn, but the seasonal cycle of demand could change in response to changes in maximum temperature and increasing of the heat wave duration.

The observed warming registered in many region connect to significant advance in phenology, timing of many life-cycle events, such as blooming, migration and insect emergence, had shifted earlier in the spring and often later in the autumn. The lengthening of the growing season has contributed to an observed increase in forest productivity in many regions, while warmer and drier conditions are partly responsible for reduced forest productivity and increased forest fires and pests in North America and Mediterranean basin. Various changes on plant and animal were noted such as different species of plants and animals shifted pole ward and higher in elevation; population sizes have started to increase in some areas and declining in others. The observed increasing in temperature impacts on health, leading to changes in the distribution of some human disease, for example cholera and malaria occurring in different part of the world during certain seasons or erupting from unseasonable flood or drought conditions (Patz et al, 2002). Earlier onset and increases in the seasonal production of allergenic pollen have occurred in midland high latitudes in the Northern Hemisphere.

The impacts frequently reflect projected changes in temperature and precipitation, sea level or concentrations of atmospheric carbon dioxide. The magnitude and timing of impacts will vary with the amount and timing of climate change and, in some cases, the capacity to adapt. In the following are presented some of the most important future impact due to projected changes in climatic conditions on: *crop* and *food (1.5.1)*, *health (1.5.2)* and one of the most important sectors for the economy- *tourism (1.5.3)*.

1.10 Impacts on crop and food

Crop productivity is projected to increase slightly at mid-to high latitudes for local mean temperature increases of up to 1-3°C depending on the crop, and then decrease beyond that in some Regions (IPCC 2007, WGII). At lower latitudes, especially seasonally dry and tropical regions, crop productivity is projected to decrease for even small local temperature increases (1-2°C). Increases in the frequency of droughts and floods are projected to affect local crop production negatively, especially in subsistence sectors at low latitudes. Rosenzweig et al. (2002) show that, under scenarios of increased heavy precipitation production could losses due to excessive soil moisture. Monirul and Mirza (2002) computed an increased risk of crop losses in Bangladesh from increased flood frequency under climate change. In scenarios with higher rainfall intensity, Nearing et al. (2004) projected increased risks of soil erosion, while van Ittersum et al. (2003) simulated higher risk of salinisation in arid and semi-arid regions, due to more water loss below the crop root zone.

Studies done for different crops indicate that climate-related increases in crop yields are expected mainly in northern Europe, e.g., wheat: +2 to +9% by 2020, +8 to +25% by 2050, +10 to +30% by 2080 (Alexandrov et al., 2002;), and sugar beet +14 to +20% until the 2050s in England and Wales (Richter and Semenov, 2005). The largest reductions of all crops are expected in the Mediterranean, the south-west Balkans and in the south of European Russia (Olesen and Bindi, 2002). In southern Europe, general decreases in yield (e.g., legumes -30 to + 5%; sunflower -12 to +3%and tuber crops -14 to +7%by 2050) and increases in water demand (e.g., for maize +2 to +4% and potato +6 to +10% by 2050) are expected for spring sown crops (Audsley et al., 2006). Some crops that currently grow mostly in southern Europe (e.g., maize, sunflower and soybeans) will become viable further north or at higher-altitude areas in the south (Audsley et al., 2006).

Simulations done by the ENSEMBLES project underly that for durum wheat, a crop widely cultivated over the Mediterranean Basin, the projected climate changes in this region, in particular rising temperature and decreasing rainfall, may seriously compromise durum wheat yields, thus representing a serious threat for the cultivation of such a typical Mediterranean crop. Figure 21 presents the spatial changes in durum wheat risk of yield shortfall, for the periods 2010-2030 (a), (b) 2031-2050, (c) 2051- 2070 and (d) 2071-2090, respect to the baseline (1961-1990), under future climate projected for A1B scenario.

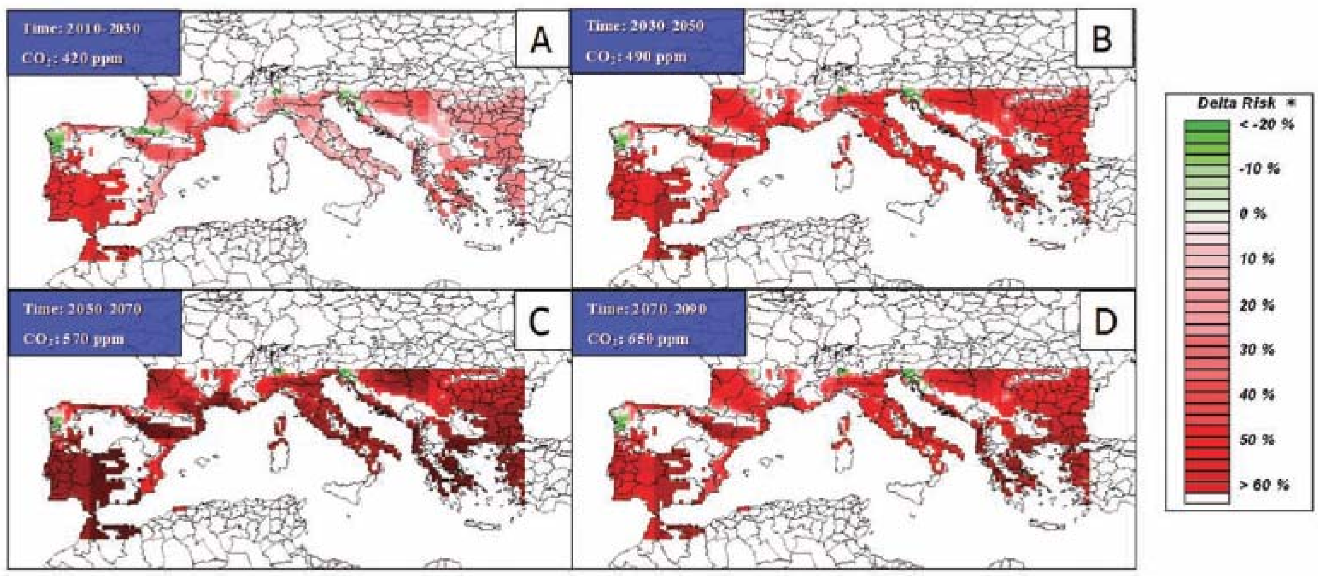


Figure 21: Spatial plots of changes in durum wheat risk of yield shortfall by: (a) 2010-2030, (b) 2031-2050, (c) 2051- 2070 and (d) 2071-2090. Shortfall is defined as yields below the 20th percentile yield calculated for the present-day period 1990-2010 (Ensembles)

In figure 21, green areas indicate a decreased risk of shortfall; pink and red areas show an increased risk. As could be noted in all analysed period there is increased risk of yield shortfall, with maximum by mid-century (figure 21c). The areas above 700m elevation, where durum wheat is rarely cultivated, were excluded from the analysis and are indicated as white areas on the maps.

Figure 22 represents a synthesis over the world of the major impacts of climate change on crop (cereal crop productivity) and livestock yields, and forestry production by 2050 based on literature (IPCC; 2007, WGII).

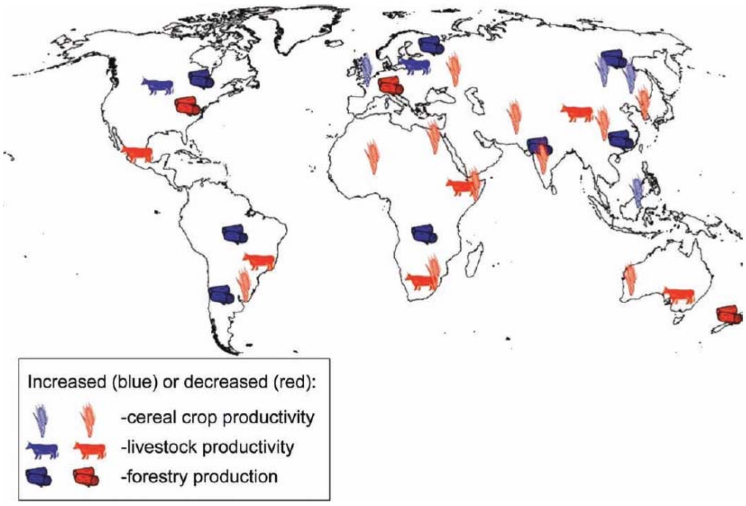


Figure 22: The major impacts of climate change on crop and livestock yields, and forestry production by 2050 based on literature (source IPCC; 2007, WGII).

With regard to the potential for food production, at global level this is projected to increase with increases in local average temperature over a range of 1-3°C, but above this it is projected to decrease (IPCC, 2007). Agricultural production represents access to food in different parts of the worlds, for example in many African countries and regions, and it is projected to be severely compromised by climate variability and change. The area suitable for agriculture, the length of growing seasons and yield potential, particularly along the margins of semi-arid and arid areas, are expected to decrease. This would further affect food security and exacerbate malnutrition in the continent. In some countries, yields from rain-fed agriculture could be reduced by up to 50% by 2020.

Small holder and subsistence farmers, pastoralists and fisher folk will suffer complex, localised impacts of climate change.

1.11 Health

Many studies put in evidence that climate change plays an important role in the seasonal pattern or temporal distribution of different diseases such as malaria, dengue, tick-borne diseases, cholera or cardiovascular disease. The projected increasing in temperature up to 2100 and the increasing of the heat wave duration could affect the health status of millions of people, particularly those with low adaptive capacity, through:

- increases in malnutrition and consequent disorders, with implications for child growth and development;
- increased deaths, disease and injury due to heat waves, floods, storms, fires and droughts;
- the increased burden of diarrhoeal disease;
- the increased frequency of cardio-respiratory diseases due to higher concentrations of ground-level ozone related to climate change; and, the altered spatial distribution of some infectious disease vectors.

Countries in Europe currently experience mortality due to heat wave period that are projected to increase in the next century, this will determine an increasing heat-related deaths, even after assuming acclimatisation. Cold mortality is likely to decline with milder winters, but the major determinants of winter mortality include respiratory infections and poor quality housing. Climate change affects water quality and quantity in Europe, and hence the risk of contamination of public and private water supplies (Miettinen et al., 2001). Higher temperatures have implications for food safety, as transmission of salmonellas is temperature sensitive, while extreme rainfall and droughts can increase the total microbial loads in freshwater and have implications for disease outbreaks and water quality monitoring.

Future climate change may cause significant air-quality degradation by changing the dispersion rate of pollutants, the chemical environment for ozone and aerosol generation, and the strength of emissions from the biosphere, fires and dust. Pollen phenology is changing in response to observed climate change, especially in central Europe, and at a wide range of elevations (Emberlin et al., 2002). Climate change may increase summer episodes of photochemical smog due to increased temperatures, and decreased episodes of poor air quality associated with winter stagnation.

1.12 Tourism

The impacts described above are in generally those due to changes in temperature and precipitation. Another important changes is those in sea level that contribute together with human development to losses of coastal wetlands and mangroves and increasing damage from coastal flooding in many areas Coasts are highly vulnerable to extreme events, such as storms, annually, about 120million people are exposed to tropical cyclone hazards. These killed 250,000 people from 1980 to 2000 (IPCC, WGII, 2007). Throughout the 20th century, the global rise of sea level contributed to increased coastal inundation, erosion and ecosystem losses, but the precise role of sea-level rise is difficult to determine due to considerable regional and local variation due to other factors. Late 20th century effects of rising temperature include loss of sea ice, thawing of permafrost and associated coastal retreat at high latitudes, and more frequent coral bleaching and mortality at low latitudes. The future projections reveals an accelerated rise in sea level of 0.2 to 0.6 by 2100; further rise in sea surface temperatures of 1 to 3°C; more intense tropical and extra-tropical cyclones; generally larger extreme wave and storm surges; altered precipitation/runoff; and ocean acidification. Changes in sea-level and increased sea-water temperature are likely to contribute to accelerated beach erosion, that will impacts on an important sector that has a great contribution for the economy- the *tourism*.

This is a sector very sensitive to climate variability and climate change, as tourists prefer spending time and travel to enjoy the sun or landscape. International tourism is the largest and most rapidly expanding economic activity in the world today. The natural environment and climate conditions are very important in determining the attractiveness of a region as a holiday destination. Different studies, underline that climate is a major factor for tourists when choosing a destination (Aguiló et al., 2005) and both tourists and tourism stakeholders are sensitive to fluctuations in the weather and climate. Statistical analyses and simulation study (Hamilton et al., 2005), have shown the relevance of climatic factors as determinants of tourist demand, followed by economic and political conditions, fashion, media attention, and environmental quality.

Globally, travel to sunny and warm coastal destinations is the major factor for tourists travelling from Northern Europe to the Mediterranean and from North America to the Caribbean.

The warming projected by different climate scenarios will change summer destination preferences, especially for Europe: summer heat waves in the Mediterranean may lead to a shift in tourism to spring and autumn (IPCC, 2007, WG II) with growth in summer tourism around the Baltic and North Seas.

Study done by Hamilton et al., (2005) indicate that an arbitrary climate change scenario of 1°C would lead to a gradual shift of tourist destinations further north and up mountains affecting the preferences of sun and beach lovers from western and northern Europe. Mountainous parts of France, Italy and Spain could become more popular because of their relative coolness (Ceron and Dubois, 2000). One study done by the Climate Research Unit (David., 1999) reveals that in the present more frequently visited short-haul destinations are Spain, Greece, France, Italy, Turkey, but also the accessibility of far-flung exotic holiday destinations or small islands, for example Maldives, is increasing in the last time. During the 1980s, tourism in the Maldives became one of the most important and highest growth sectors of the economy. The low elevation of the Maldives archipelago makes them particularly vulnerable to sea level rise. At best a rise in sea level would cause coastal erosion and at worst a sizeable proportion of the landmass could become submerged over the next 30 years (David et al., 1999). Future projections of sea level are critical. The higher the sea level the more frequently these small islands will be over washed by storms. The dangers of salt water intrusion of the island aquifers combined with sea level rise, may lead to many of the islands becoming uninhabitable in the future. The coral reefs provide protection and stability to the islands, represent a great biological diversity of marine ecosystems and have become a very important attraction for tourists. Tourism is the fastest growing economic sector associated with coral reefs and is set to double in the very near future. However, a temperature increase of only 1 or 2°C could not only cause coral 'bleaching', (death of the coral caused by increased sea temperatures) but also increase the threat of subsequent flooding. An international team of coral experts reported that the 1997/1998 sea surface temperatures were the warmest in the observed record. The coral bleaching associated with this event had impacted almost all species of corals and many other invertebrates and had a devastating effect on reefs in the Maldives[8].

Greece, *Turkey* and *Italy* are countries from the Mediterranean basin with attraction for tourism due a high number of islands (Greece) or due to an extensive coastline from Greece, Italy or Turkey that are bordering by the Black Sea, the Aegean Sea and the Mediterranean, and has land borders with Greece, Bulgaria, Syria, Iraq, Georgia and Armenia. The climate is Mediterranean with mild winters and long, hot summers with maximum temperatures often exceeding 40°C. Climate modelling suggests that mean summer temperature increase for this area will be in excess of 4°C by the middle of the next century (IPCC, WG1, 2007). As a result of climate change it is estimated that temperatures in the hot summer months may exceed several thresholds of human comfort as the frequency of extreme hot days increases. Increases in summer temperatures to above 40°C will reduce personal

[8] (NOAA, 1998, http://www.osdpd.noaa.gov/ml/ocean/cb/hotspots_1998anim.html).

comfort in these countries and can lead to increased incidence of heat stress and mortality. The increase in temperature and decreasing in comfort index may discourage tourists to visiting these places on August. Alternatively, holiday-makers may opt for an earlier or later time of the year (since climate models suggest that June in 2020 will be as warm as July, August and September at present) or they may switch to alternative locations in other countries. Even during the last two decades, Athens has endured uncomfortably high temperatures which have led to an excess number of heat-stress incidents.

Spain is another Mediterranean destination for tourist, the climate has warm summers with large amounts of sunshine and low amounts of rainfall, coupled with mild winters. With climate change, temperatures are likely to increase, for example, September in 2050 may be as warm as July is today. As a results the summer months tourism employs 9.5% of the workforce in Spain and is treated by the government as a key economic sector with good prospects. Recent studies changes in climate will result in this region becoming a more suitable habitat for certain species of mosquito. Malaria, which is the worlds largest killer, is spread by a number of species of mosquito which carry either the Plasmodium falciparum or Plasmodium vivax parasite. At present the mosquito and parasite are found in North Africa, but it is anticipated that by the 2020s suitable habitats for Malaria will have spread northwards into Spain. Also, in the last year there has been a tendency for the annual number of forest fires to increase in Spain, as a result, large areas of forest and parkland may be closed off to summer visitors.

The European Alps are one of the primary winter holiday destinations for skiing activities. The position, in a double border area between the temperate latitudes and the Mediterranean subtropics, and between oceanic and continental Europe, makes an ideal area especially for winter holidays. The evolution of climate reveals that winter tourism may be affected, as the Alps and other skiing destinations experience less snowfall and shorter skiing seasons.

Figure 23 shows future climate scenarios for snow amounts, constructed from climate change experiments performed at the Hadley Centre (Mitchell et al, 1995) with HadCM2 model. As it could be noted, it is expected that as temperatures rise there will be a considerable shortening of the snow season and a reduction in the amount of precipitation that falls as snow. In many areas this reduction in snow amount may be as much as 30% by the 2020s and over 50% by the 2050s for the European Alps.

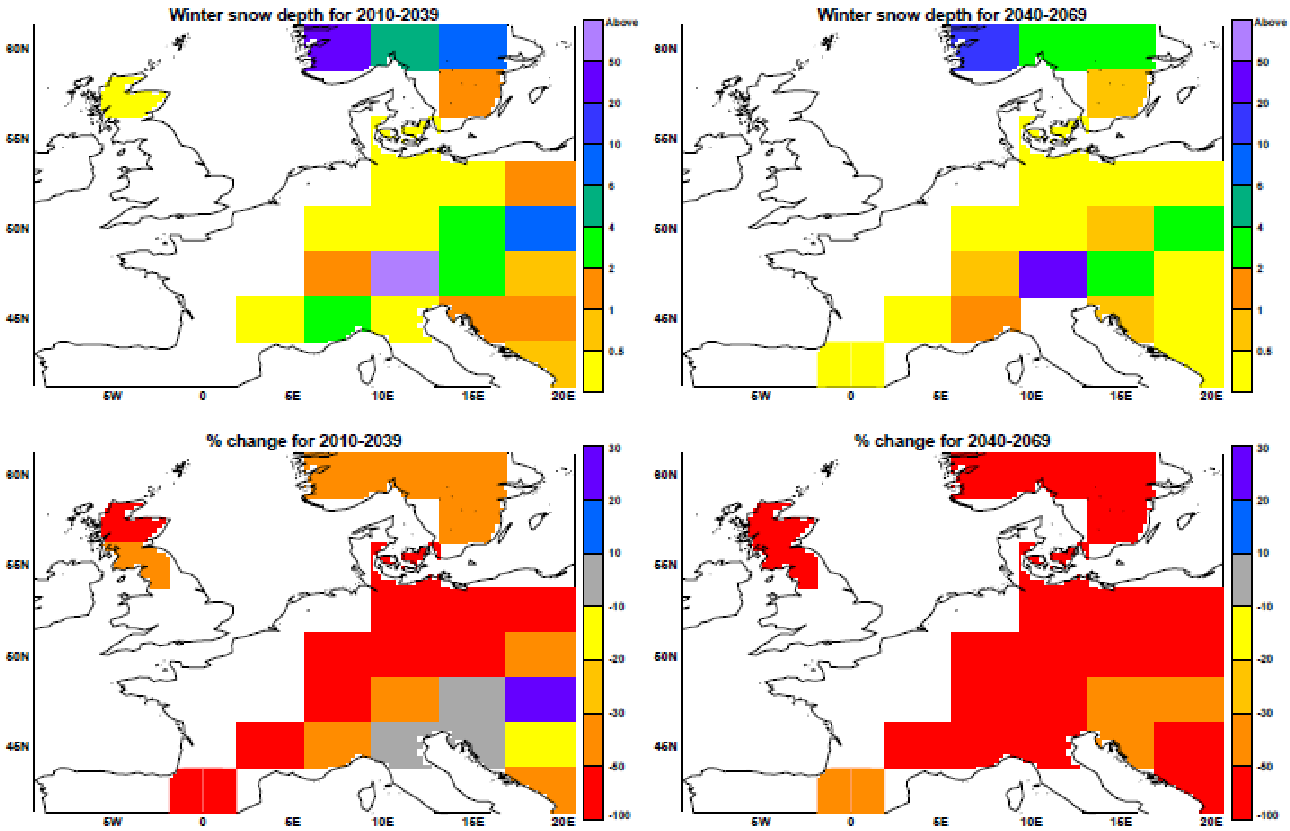


Figure 23: Evolution of snow cover for the European region as estimated by HadCM2 GCM with the IS92a emissions scenario (source Mitchell et al, 1995).

More recent simulations done by the ENSEMBLES project with regional climate model indicate that until 2100 snow cover is reduced all over Europe and will have almost completely disappeared in the southern and western Europe. In the Alps, the decrease is much smaller above 2000m.

As last IPCC report underlay, the ski industry in central Europe is likely to be disrupted by significant reductions in natural snow cover especially at the beginning and end of the ski season. Hantel et al. (2000) found at the most sensitive elevation in the Austrian Alps (600 m in winter and 1400 m in spring) and with no snowmaking adaptation considered, a 1°C rise leads to four fewer weeks of skiing days in winter and six fewer weeks in spring. Beniston et al. (2003) calculated that a 2°C warming with no precipitation change would reduce the seasonal snow cover at a Swiss Alpine site by 50 days/yr, and with a 50% increase in precipitation by 30 days.

Nature-based tourism is one of the booming industries in *Asia*, especially ski resorts, beach resorts and ecotourism. For this area only a few assessment studies were done. Fukushima et al. (2002) reported a drop of more than 30% in skiers in almost all ski areas in Japan except in the northern region (Hokkaido) and high altitude regions (centre of the Main Island) in the event of a 3°C increase in air temperature.

The SRES scenarios underlies that for southeast *Australia* by 2020, there will be 5 to 40 fewer days of snow cover per year, a rise in the snowline of 30 to 165 m, and a reduction in the total snow-covered area of 10 to 40% (Hennessy et al., 2003). By 2050, the duration of snow cover reduces by 15 to 100 days, the maximum snow depth reduces by 10 to 99%, the snowline rises 60 to 570 ma and the total area of snow cover shrinks by 20 to 85%.

Similarly, in New Zealand, changes in seasonal snow cover are likely to have a significant impact on the ski industry. Fitzharris (2004) shows that the snow line will rise by 120 to 270 m based on scenarios for the 2080. Tourist flows from Australia to New Zealand might grow as a result of the relatively poorer snow conditions in Australia.

Nature-based tourism will still be a major market in different parts of the world, for example visits to Canada's national parks system are projected to increase by 9 to 25%

(2050s) and 10 to 40% (2080s) as a result of a lengthened warm-weather tourism season (Jones and Scott, 2006).

As could be noted, climate change could have negative impact on some region but could also bring benefits to places that are currently not popular with tourists. Bigano et al. (2006) simulates the effects of development and climate change on tourism and projects shifts in international tourist flows towards higher altitudes and latitudes.

In this chapter the basic scientific evidences of climate change have been presented, from the analysis of its causes to the observed current data and from projected future trends to examples of impacts of climate change on different sectors at present and in the future.

It appears clearly that the tourism sector is one of the economic sector that can and will suffer the most from climate change and therefore it has to play a role both active to mitigate and passive to adapt to climate change. The next chapter will analyse more in details the links and interdependencies between climate and the tourism sector.

CHAPTER II

CLIMATE AND THE TOURISM SECTOR

2.1 Introduction

Weather can be defined as the state of the atmosphere in a given place at a given time, and can be described for one particular weather station or for a specific area of the earth's surface. By contrast, climate is the prevailing condition of the atmosphere deduced from long periods of observation. Thus, the knowledge of the latter is directly determined by the knowledge of the former; climate is a generalization while weather reflects a particular event. To talk about the climate is to talk in an abstract way since it is its elements that allow characterizing it. The elements of the climate are the components that define it and they are, at the same time, the variables through which it influences the other elements of the natural and human environments. Its elements that have the greatest influence on tourism are temperature, number of sun hours, precipitation, wind, humidity, and fog. In this chapter climate is used as a set of interrelated elements that influence the natural and human environments.

People are well aware of how weather and climate influence their lives, just as they also observe how much some of these activities affect the atmosphere. Clearly, economic activities are affected by and influence climate and weather and, of these, outdoor ones, like tourism, are a case in point. Tourism can be defined as movement in space undertaken by man in order to use other spaces as places of leisure. Tourists wish to enjoy the different geophysical resources or attractions offered by the place they have travelled to, observe the genealogical elements contained therein; that is, they want to admire the historical remains with a certain monumental, historical or cultural value that survive in the area (Sanchez 1985).

Tourism, therefore, requires and uses a geographical space. This space has a physical substrate, the natural environment, consisting of physical and biological elements (its climate, geology, topography, flora and fauna, etc.); and also has elements created by human activities.

This geographical space (and its constituent elements, including climate) can act simultaneously as a factor influencing the location of tourism, as a resource supporting a wide range of activities, and as an attraction in its own right.

2.2 Climate as a factor of location for tourism

Every economic activity requires a territorial base, and this applies to geographical space acting as a support for tourist activities. However, this does not mean that it plays a neutral role in the social and economic processes that are operative. The kind of terrain in the support area also influences where activities are carried out. Thus, tourist activities are not distributed homogeneously in space; rather, certain activities are concentrated in specific points or areas. Numerous factors account for this pattern, in keeping with the varied and complex nature of tourism itself.

Both economic and other factors influence where tourism is located, although the former dominates in most decisions concerning location.

Two classes of economic factors can be highlighted (Butler 1986): spatial and environmental. The former are associated with distance, accessibility, transport costs, the presence of markets, the concentration of economic activities, land prices, and competition with other activities, while the latter are associated with natural and cultural variations from one place to another. Natural environmental factors that are particularly prone to variation are climate, geology, hydrology, soil, topography, fauna, and natural vegetation. Cultural environmental factors include archaeological remains, historical monuments, museums, crafts, folklore, and traditional festive celebrations. Although space and environment should be considered as interacting factors, in some places the location of certain resorts can be largely explained in terms of environmental factors, while in other places location can be mainly attributed to space perse, related to market accessibility and other concentrations of economic activity[9].

Climate is one of the geophysical elements that make up for geographical space, contributing to the environmental conditions that facilitate or hinder human settlement. People seek to settle in those spaces that offer the greatest comfort and possibilities of survival in terms of climate.

Tourism, as a human activity, is also governed by these same imperatives. Therefore, climate is an important criterion for locating tourism centers, helping to determine how an area is to be used. However, there is a general tendency among geographers to assume that climate is only important for locating tourism centers when the territorial scale of the phenomenon or the analysis is small. Thus, climate is often said to delimit optimal zones for tourism at a global and regional scale, as illustrated by the warm temperate zone, considered optimum for sun and beach tourism[10]. By contrast, other factors are believed to be more important in accounting for tourism development in places at a more local level.

Factors that have an influence at a local scale are different from those that account for global tourism zoning. Yet it cannot be concluded that climate is of no importance in large-scale analyses: an understanding of local climatology is becoming increasingly important in the study of tourism prospects[11]. Clearly, local climatology and the succession of different weather types influence the location of resorts, the calendar of tourist activities, the use and efficiency of the infrastructure, and the return on investments. Indeed, many resorts have prospered thanks to the ability to turn the favourable local climatic conditions to their

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[9] Burkart and Medlik 1986; Butler 1986; Cazes, Lanquar and Raynouard 1980; Defert 1954; Pearce 1981; Vera, Lo´pez, Marchena and Anto´n 1997

[10] Burton 1991; Callizo 1991; Lozato Giotart 1990; Vera, Lo´pez, Marchena and Anto´n 1997

[11] Billet 1975; Cazes, Lanquar and Raynouard 1980; Dauphine and Edelga 1971; Escourrou 1981, 1984; Makita and Kikuchi 1977; Renaudin 2002

advantage[12]. Furthermore, at this scale, planning not only exploits the advantages of the climate, but also attempts to minimize or correct the possible excesses of certain climatic elements (wind, high temperature, sun hours) so as to create more benevolent microclimates that match tourists' expectations more closely[13].

Conversely, tourism developers have excluded some areas because of their seemingly ''inclement'' weather that could not be readily countered.

Elsewhere, because of the failure to consider the climate as a locational factor, certain resorts have not developed as hoped.

2.3 Climate as a Tourism Resource

When tourism makes use of a geographical space, it does so because there are certain constituent elements which, depending on how they are valued socially, can be exploited and subsequently incorporated into a tourism good or service. In this way, the elements of geographical space become resources and form the basis of any tourism development project. Without first analyzing them, any attempt at planning activities would be deficient. But the value of the space-resource varies with other essential circumstances, such as accessibility, the existence of initiatives to exploit the resource, legal and governmental regulations, the attraction of the landscape, etc. However, also and more significantly, the space will always be perceived in accordance with those societal values (tastes, fashions, etc.), diffused in advertising campaigns or in the mass media, that eventually impose on society how they represent the space (Valenzuela 1986).

[12] (Aguilar and Gonza´lez 1995; Barbier 1984; Becker 1998, 2000; Besancenot, Mounier and de Lavenne 1978; Dauphine and Edelga 1971; Escourrou 1980; Olcina and Vera 1998; Renaudin 2002; Vera 1985, 1987.

[13] Besancenot 1991; Palomares 1964.

This shows that fashion influences the type of resource used to form a product and, as a result, there may be a variation in the value afforded to it over time, reflecting social changes.

Climate is a natural tourism resource and it is an element that, thanks to human intervention, facilitates tourism and the satisfaction of demand. Climate exists outside of any tourism project, but it becomes a resource when it is incorporated within a good or service.

The good is promoted for consumption and advertised via communication or commercialization channels, though it should always satisfy a latent need. Indeed, it is this need that induces the demand for the tourist to travel to the area. In this way, climate, a natural resource, is part of the tourism product.

Virtually all forms of tourism use natural resources to some extent: they all place a social value on the whole natural environment that is, the climatic, geological, hydrological and landscape characteristics of a given space. Thus, ‘‘a large part of modern-day tourism is based on the use of certain physical-natural characteristics that come together in a given space’’ (Furio 1996). But developing an area does not normally rely on one single tourism resource; rather, it requires a wide range of resources and, in particular, natural ones. Climate can be either a basic or complementary resource. However, this natural resource forms part of the contingency inherent in all that affects man. So, to ensure the success of a tourism resort, good weather is not sufficient. The climate is merely a prior condition: undoubtedly an important asset, a necessary condition, but in no case, a sufficient argument on its own (Besancenot 1991).

Furthermore, with identical potential, the essential determinants of tourism lie not so much in the attraction of the climate and the landscape but in the dominant social models of demand, in the local willingness to welcome tourists and to plan the sector, in the complex interplay of the multiple factors of travel (Cazes 1987).

Climate is a basic resource for various activities, which depend on the climate/weather to use Smith's (1993) terminology—which include sun and beach tourism, winter sports, health tourism, and water sports, among others. Heliotropism is a fundamental argument that accounts, in its own right, for major movements of tourists: seeking and enjoying the sun is one of the main reasons why many tourists go away on holiday (WTO 2001). Similarly, winter sports depend directly on climatic resources: without snow or low temperatures for the artificial production of snow, the development of ski resorts would not have been possible.

These and other examples show that the climatic elements exploited as resources today are the high number of sun hours, high temperatures, and snow. Other parameters, such as wind, have been rejected historically, although even these can be re-evaluated, as in the growth of gliding and wind surfing. Thus, new types of tourism have emerged, thereby turning previously rejected elements into the main ''raw material'' (basic tourism resource) of many recreational activities. This, in turn, has helped to transform marginal areas with these elements into important resorts.

Climate (sun hours, temperature, snow, wind, etc.) is often the main resource upon which a whole series of activities designed to satisfy tourist demand depend. Elsewhere, however, climate merely complements other basic resources. In such cases, climate does not directly ''generate'' tourism but does facilitate its development, given that the climate and weather conditions allow or favour certain outdoor tourist or recreational activities (such as hiking, rafting, golf, hunting, fishing and climbing). To use Smith's (1993) terminology again, these are ''activities sensitive'' to the climate and weather.

2.4 Characteristics of Climate as Tourism Resources

Atmospheric elements, independently of whether they are basic or complementary tourism resources, are somewhat different in character from other natural resources and these differences need to be considered when exploiting them. Thus, several factors should be borne in mind. One, climate is a free resource: it is so abundant that it needs no mechanism for allocating it or sharing it. Given the nature of the resource, no conflicts arise from using it, unlike other scarce resources that are often the focus of tension. This is the case, for example, in Mediterranean areas, where agriculture and tourism fight over water and land.

Two, climate is a resource that cannot be transported or stored. The consumer must travel to a specific place to enjoy its climate. Thus, it is a natural element that has a ''fixed'' physical space and must be enjoyed in situ (Besancenot 1991). Hence, climate-dependent activities are linked to a particular geographical space that has certain atmospheric characteristics. For this reason, developers of tourism projects should undertake detailed studies of it and of the pattern of weather types in a place, in order to ensure that adaptation is optimum and that the resource is used appropriately.

As to the third factor, the distribution of the climate resource varies in space and time. Climate is not homogeneous over the earth's surface and is not a tourism resource (basic or complementary) in all places: there are climates that limit tourist activities and others, which favour them. But wherever this resource is to be found, ''it is subject to great temporal variations - from one day to the next, one season to the next and one year to the next'' (Besancenot 1991).

This variation from one day to the next means that it is virtually impossible to guarantee ''good'' weather, even though the choice of an enclave may be considered optimum in terms of its climate-tourism potential. It can cause major variations in use even on successive days: the number of visits for a given activity, particularly open-air ones, varies enormously from a rainy to a sunny day (Besancenot 1991). However, if the day-to-day variation is not too marked (that is, if the days of bad weather do not extend over too long a period), it has little effect on overall figures and the only apparent effect is the switch from outdoor to indoor activities[14]. Thus, resorts need to include activities that can be performed indoors, sheltered from the inclement weather, to guarantee customer loyalty even during bad weather. This would discourage the abandonment or sudden change of destination, or dissatisfaction, boredom, and the decision not to return.

As climatic conditions are decisive in drawing up the school and work calendars, seasonal variation in the climate has generated a strong concentration of the tourism offer and demand, although it is not the only factor affecting seasonality[15].

This has occurred most notably where tourism products are not highly diversified and are based largely on climate; seasonality is less notable in those places where the offer has been diversified, by adapting activities to the various weather types that appear during the year and by promoting open-air activities that rely on other basic resources.

Increasingly, fear of seasonality is forcing centers and firms to make greater efforts to diversify, in an attempt to escape the ‘‘single cropping’’ practices of the past[16].

Finally, ‘‘the variability in the weather from one year to another has repercussions on the number of visitors. Migratory flows vary geographically depending on the vagaries of the climate’’ (Besancenot 1991:19). In extreme cases, this inter-annual variation can bring about a shift in the orientation of tourist flows both in the short- and long-term: a particularly bad season can dissuade people from travelling to a region for two or three years[17].

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[14] Besancenot 1991; Bettinger 2002; Perry 1972
[15] Ramo´n and Abella´n 1995
[16] Crowe, McKay and Baker 1977
[17] Besancenot 1991; Monferrand 2002

Four, if such variations are examined, it can be seen that there are extreme weather events (such as cyclones, seasons of torrential rain or heavy snowfall, floods, heat waves, avalanches) that can endanger lives and threaten tourism infrastructure, resulting in major financial losses. For this reason, tourism potential studies also should be accompanied by studies of extreme weather events and associated response plans.

Further, five, when discussing climate, a set of parameters is referenced that make themselves manifest at the same time and which are interrelated and directly affect elements of the natural and human systems, including the economy. These parameters, in turn, impact tourists as individuals in physical (the case of rain and wind), physiological (the case of temperature and humidity), and psychological (the case of cloud cover, the intensity of the sun hours and fog) ways.

These influences, which are manifest in multiple combinations, are not evaluated identically by everyone and, hence a complex explanatory variable has to be introduced, namely perception. It follows that the study of tourism potential should include its consumers (through surveys, interviews, or observed behaviour) to complement the indices used in the earliest studies of tourism climatology[18].

Finally, six, climate has traditionally been considered as a special natural resource because it is renewable and non-degradable in the sense that the climate available next year cannot be affected by the amount of it used this year. This differs from other natural resources (such as water and flora) for which the quality and quantity available for the following year depend on the amount used in the preceding year. However, recent climate change studies have shown that certain human activities can modify the climate and weather, alter the resource, and alter today's tourism sites, affecting local and regional economies greatly[19].

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[18] Burnet 1963; Clausse and Gue´rout 1955; Davis 1968; Flocas 1975

[19] Breiling and Charamza 1999; Ko¨nig and Abegg 1997; Ko¨nig 1999; Maddison 2001; Scott and McBoyle 2001; Scott, McBoyle, Mills and Wall 2001; Wall 1992; Wall and Badke 1994

Thus, the most innovative studies on climate and tourism are those that examine how the industry should be adapted in the future and those that emphasize this as a key consideration in planning projects.

2.5 Climate as an attraction

Climate can also be an attraction in itself and plays a decisive role in the selection of destinations. When tourists are thinking about buying a product, they weigh up its different elements, such as resources, infrastructure, services, and price. The climate is also evaluated in this process, as it is a natural resource that usually forms a part of the product. This assessment influences the decision to purchase and is determined by a set of internal (perception, motivation, learning, personality, attitudes) and external (economic, social and cultural factors, social class, reference groups, family composition) variables, the purchasing behaviour of tourists responding to both personal circumstances and to the influence of society. All of this, in turn, depends upon a person's way of being, thinking, and behaving[20]. In this context, climate becomes a factor in attracting people when, as a result of these complex influences, it acquires greater importance than the other elements and is valued so positively that tourists decide to buy the product (recent studies show that the weather and climate, together with the level of safety and the socio-political situation in destinations, have most influence on tourists' choices[21].

Advertisers are well aware of the importance of climate/weather in the decision making process and introduce it quite explicitly in advertising, so that it forms part of the image of the tourism product or destination.

The firms and agencies seek to create favourable opinions by transmitting messages that establish a clear market image. Yet, at the same time, they also try to show the

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[20] Aaker and Myers 1991; Go´mez Martı´n 2000; Valls 1996
[21] Maddison 2001; Monferrand 2002

tangible and intangible benefits of their products. The combined effect of these messages is to create an image of the product, firm, or destination in the minds of potential consumers. The image should make them believe that ‘‘what they think of the reality is real and not an artificial representation of this reality’’ (Chaves 1988). Tourists aim to satisfy their needs and expectations based on the benefits, attributes, and functions manifest in these representations of reality (Miossec 1977).

Tourism products and destinations do not in themselves satisfy; it is their projection in the form of an image which generates the experience and, becomes the image that underpins the decision to purchase. It also influences satisfaction and is what induces tourists to return to the destination (Valls 1996).

On occasions, these idealized representations created in the minds of the potential consumers have certain shared characteristics penetrating the collective consciousness and forming a myth. This latter expresses those aspects of the destination and product that most surprise or have the potential to surprise the tourists. Often the myth is simplified and trivialized eventually becoming a stereotypical image. These myths and stereotypes taking shape in people’s minds (thanks to the various stimuli that they receive) have a considerable influence on their decision making.

Frequently, although this depends on the destination, one of the most exploited myths used to attract tourists is that of climate. According to Besancenot, ‘‘the iconographic analysis of tourist brochures and the careful reading of the accompanying text only confirm the obsessive presence of references, direct or indirect, to the climate’’ (1991). Cazes, in addition to highlighting the importance attached to the climate in advertising, also referred to the way in which this is done. He pointed out that the climate boasted of often has little in common with the actual conditions: The image given is not always false, [but] the stereotypical photograph though is clearly taken at the best possible time of day and from the most favourable angle so as to cover up anything that might be a source of disappointment. The advertiser, certainly, never creates a completely fictitious climate, but selects a number of elements which give the impression of paradise; they only offer us stereotypes (beaches, sun, blue skies, half-naked women) which recreate an image that trigger the stimuli for travel.

Thus, while it is true that tourists have a vast range of reasons for going on holiday, they all share certain aspirations, and it is to these that the key words and images that fill the tourist brochures need to refer[22].

Several researches[23] have analyzed the way in which climate is used in the advertising of tour operators. These studies concluded that a high percentage of brochures contain references to it.

Many of these extol the virtues of the climate, while others offer tables of quantitative data (largely monthly and annual means) referring to the air temperature and number of sun hours. Most resorts and regions manage to combine, with varying degrees of accuracy, idyllic descriptions and numerical values, in seeking to compose brochures that both attract tourists and provide a source of information. Indeed, studies[24] show that tourist demands for information have changed considerably in recent years. Customers increasingly call for improvements in the quantity and quality of the information: the generalizations and mean values which conveyed the impression that a region's climate is spatially and temporally uniform have given way to more detailed analyses that include more climatic parameters, such as comfort indices and ultraviolet indices, and that provide such information as probability tables for different weather types and specific recommendations regarding safety. In fact, a number of recent studies[25] have highlighted the fact that the number of guests at certain resorts

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[22] Cazes 1975 in Besancenot 1991:208
[23] Chadefaud (1988), Escourrou (1980), Go´mez Martı´n (1999, 2000), and Lanquar and Hollier (1986)
[24] Monferrand 2002; Renaudin 2002; Williams, Dossa and Hunt 1997
[25] Bettinger 2002; De Freitas 2001

is partly attributable to two interconnected variables: climatic/meteorological conditions and the information regarding these given to the tourists.

2.6 Weather, Climate and Tourism Planning

Although, climate may act as a support, resource, locational factor, and attraction, the nature of these relationships requires closer analysis and the reasons why it has an influence on tourist planning need to be elucidated. But first, a number of conceptual questions should be clarified.

Over the years, climate has determined whether a given zone is suitable for tourism: activities are organized within the context of the prevailing climate(s) of that place. In the short term, however, weather determines the best moments for a particular activity or for programming a series of activities. For these reasons, it is apparent that the climate is experienced by tourists as weather. Climate and weather have implications for tourism planning.

First, climate affects the environmental context in which tourism can be undertaken: it is a key to vegetation patterns, morphogenetic processes, the distribution of fauna, and certain diseases, river flow, and water supply. All of these are vital to the development of an attractive and functional setting for tourism. For instance, one may consider the seductive power of lush, verdant, landscapes (due, in part, to certain climatic conditions) over tourists, in particular those accustomed to living in dry environments; or how hunters choose different natural environments according to the species they wish to hunt; or the ways in which tourists from the north of Europe see the Mediterranean resorts as a land of paradise.

Existing settings, both attractive to tourists and functional, may in the near future be modified as a result of global climate changes. Indeed, some studies already show certain symptoms that are of concern to the tourism industry. In the Mediterranean, one of the leading destinations with over 120 million tourists each year, there has been a marked increase in the number of heat waves. These have caused deaths among tourists and local populations[26]. Similarly, marked declines in precipitation levels have had a severe impact on water reserves, giving rise to conflicts among different economic activities[27]. These increases in temperature and drops in precipitation have left forests more vulnerable to fire, with a considerable rise in the number of forest fires over the last few years[28]. Likewise, the increases in air and sea temperatures favour the proliferation of certain organisms (such as mosquitoes, algae, and medusas) that pose a health threat and, consequently, affect the normal provision of tourism activities. The industry has reacted rapidly to these changes by increasing the amount of research being undertaken and by adopting measures that allow resorts to adapt to these changes. Examples include campaigns to raise awareness among tourists, providing them with more information, and changing the activity schedules.

Second, climate has also a strong influence on the seasonality of tourism activities, while its degree for a tourist zone partly determines its profitability: long seasons mean the infrastructure and services are more extensively exploited and, consequently, allow a higher return on the capital invested. Favourable climatic conditions for a particular tourist activity usually occur in certain periods of the year. The seasonality problem can be exacerbated by activities poorly adapted to the climate or poorly diversified to suit the conditions recorded during the year. It is of greater importance when destinations are dependent on one activity and climate is promoted as one of the resources. It is even more significant when they depend on the climate rather than being merely sensitive to it. For example, cultural tourism has fewer problems of seasonality given that the weather and the climate have limited influence on this activity. Other types of tourism, however, are highly affected because they promote climate as the main attraction, since it acts as a basic input into the creation of the product: this is the case

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[26] Conte, Sorani and Piervitali 2000; Katsouyanni 1988; Perry 2001
[27] Perry 2001; Wheeler 1995
[28] Perry 2001; Pinol, Terradas and Lloret 1998

of sun and beach tourism, health tourism, winter sports, water sports, and tourism linked to certain adventure sports.

But the seasonality of activities is not only linked to the temporal concentration of the offering; it also depends, albeit to a lesser degree, on the time-concentration of the demand. During the year, the climate largely determines when people work and when they go on holiday. These periods are usually established on the basis of the climatic requirements of the former, as extreme conditions make working arduous and, above all, highly unproductive. As such, only a detailed knowledge of the climate and an optimum adaptation of activities to it can ensure that seasonality (one of the problems causing most concern to the industry) is minimized. Daily evaluations of tourism potential, of varying degrees of complexity, over a series of several ten-year periods, could play an important role within the detailed understanding of it. They should consider the combination of atmospheric elements and perceptions and disseminate the results in intelligible graphic and cartographic images; this should help in drawing up activity schedules that ensure well-informed decisions for both tourism offer and demand.

Third, weather influences tourists and what and when (especially outdoor) activities can be carried out. The tourist desiring an activity should consider the weather when deciding whether the activity can be completed with satisfactory safety, enjoyment and comfort. Thus, for example, those interested in hunting will need to consider the day's weather conditions because the performance of their tracking dogs, the effectiveness of the hunters themselves, and the presence or absence of the prey will depend on elements such as temperature, wind velocity, sun strength, and rainfall. The wrong combination of these conditions may more than suffice to cancel the scheduled program.

The same is true of other activities: a wet ground following heavy rain can cause accidents among those on a cycling holiday; a windy day might also make cycling, a round of golf, skiing, or swimming in the sea difficult; storms put a stop to almost all outdoor activities or, at the very least, make them very dangerous. On occasions, when faced by adverse weather conditions, tourists have to rethink their activities, abandoning outdoor in favour of indoor ones perhaps of a more cultural or social nature. So, knowledge of climate allows for general strategies, and knowledge of weather conditions allows for appropriate tactics to try to ensure that tourists have a good day. This is why weather information is so important: a resort's guests (and potential tourists) are usually attentive to forecasts and bulletins available in newspapers and on Internet, television and radio. The amount of media information has grown substantially in response to this growing need. Thus, weather data (especially the day's weather and the short-term forecasts for 24, 48, and 72 hours) are displayed in the tourism information centers of most resorts, as well as on the resort WebPages. Similarly, the general weather forecasts broadcast on all television channels seek to meet this need by offering (above all during holiday periods), information such as the temperature comfort index, the UV index, snow thickness, snow type, risk of avalanches, condition of the sea and water temperatures. Thus, it can be concluded that the quality of weather information helps to improve the quality of one's experience.

Fourth, a place's climate and weather are frequently presented as attractions in their own right. The climate can be a main appeal of an area, as shown by the popularity of many enclaves of the Mediterranean, Caribbean and Pacific, and the success of many ski resorts. However, the term ‘‘good climate’’ or ‘‘good weather’’ is entirely relative, as it depends on the activity tourists wish to engage in. Climate and weather considered optimum for skiing are quite different to those considered optimum for windsurfing or swimming in the sea. What might be considered a ‘‘good climate’’ by some is just the opposite for others.

While each activity requires its own particular climate and weather, there appears to be a particular predilection among tourists for sun and relatively high temperatures (environmental comfort): most seek to have a holiday in places characterized by gentle temperatures and plenty of sun. These same preferences can also be seen in other types of tourism: for example, skiers prefer sunny weather and pleasant temperatures to overcast with low temperatures.

The latter would, in fact, be better to maintain the surface layer of snow needed to ski. Most tour operators, aware of these such preferences, incorporate climate within the brand image of the product: brochures are full of pictures and supporting written information (body of the text, statistical tables, slogans and headings) regarding the weather (Gomez Martın 1999), so as to appeal to tourists, as they know that this might influence the customer when choosing where to go on holiday.

This search for the sun is a relatively recent phenomenon among tourists, which shows that the way tourism resources are valued, depends substantially on cultural factors and fashion: The stubborn pursuit of the sun, heat and a good sun tan that so inspires our contemporaries would have seemed quite incongruous in the last century. At that time the ladies were supposed to keep their skin as white as possible, if not diaphanous, and they sought shelter under a parasol whenever the sun came out. \No single climate in its own right has the ability to attract and hold on to the summer holidaymaker. If it did, in spite of everything, it could only be as a function of a certain idea that one might have of tourism and holidays, as regards a certain ideal climate and a given clientele. Such an ideal climate could only be the expression of a cultural system which mixes the sensibility, imagination, lifestyles, ways of thinking, and the values of a particular period or of a particular society. Relations, therefore, between tourism and climate are not immutable either in time or in space (Besancenot 1991).

Fifth, a high risk of climatic disaster (or natural catastrophes in general) is incompatible with any type of tourism activity. In analyzing any site, it is important to consider extreme events that might threaten the life and property of tourists, or services and infrastructure. Although absolute safety in activities can never exist, a sound tourism plan should take into account the risks of storms, winds, blizzards, and fog, to give just a few examples. However, failure to give due consideration to these elements often means that sites suffer greatly from climatic risks. The catastrophic nature of many events depends on the human uses of the geographical space. For example, tourists, lured by the location of services, often place themselves in areas that are at particular risk from the vagaries of nature. For example, many camp alongside rivers and run the risk of being the first victims of the slightest rise in the water level or the most modest of storms (Besancenot 1991).

Sixth, climate and weather have a major influence on tourism complexes and infrastructure. They largely determine whether or not a region will be frequented by tourists and determine the type of stay and the types of accommodation and constructions built. Climate both determines the ideal type of accommodation (for example, cool wet climates are not the most appropriate in which to camp; hotel accommodation is less sensitive to the meteorological conditions than other forms) and has an influence on the architecture of the tourism complex. The type of construction should ensure occupants will enjoy comfortable and safe indoor environments.

This can be achieved by carefully considering the weather of a place when designing the buildings and, when necessary, by installing artificial devices such as air conditioning. Suitable systems of ventilation and humidification, heating and cooling, and air conditioning are of little use if the floors, walls, and roofs do not have proper thermic and hydrometric insulation. But, what is more, the choice of appropriate materials for these purposes is not enough. The site, foundations, and the thickness, shape, colour and orientation of the roofs and facades, the existence and dimensions of eaves, terraces, openings and patios must be rationally planned. This must be done by taking into consideration the normal values and the variations in elements such as sun intensity, temperature, humidity, rainfall, fog, snowfall and prevailing winds (Palomares 1964).

Architectural projects for tourism developments also need to take into account how important trees, bushes, and vegetation in general are in moderating certain types of weather: ‘‘Since ancient times, lines of trees have been used, for example, as exceptionally effective windbreaks, while in hot dry climates, gardens have been used for both their ornamental value and their cleansing and refreshing effects in inhabitable places’’ (Palomares 1964:84-85). Similarly, the use of awnings, sunshades, and wooden outhouses should be considered in outdoor areas as they can contribute considerably to moderating certain atmospheric elements. In short, it is a matter of using both the knowledge and techniques that have been built up about the weather of a place to create comfortable, healthy climatic environments within the closed and open spaces that are frequented by the tourists.

Seventh, climate and weather have a major influence on whether transport and communication systems work smoothly and facilitate or confine tourists’ mobility. This factor is undeniably important given that the definition of tourism requires movement in space. In addition, tourists have become increasingly more dynamic and, as a result, demand efficient systems of transport and communication that allow them to fulfil their objectives.

Weather and climate are frequently considered when planning airports, coastal infrastructure, and river navigation projects; however, they have been somewhat neglected when planning overland transport routes, mainly roads and railway lines (Palomares 1964). Yet elements such as temperature, humidity, rainfall, fog, snowfall, and winds should also be considered when planning different overland routes, in order to determine the possible weaknesses or diseconomies caused by road surface erosion (due, for example, to frequent frosts) and road closures (resulting from frequency of fog or the drifting of snow, for instance) and to be able to take the most appropriate measures to rectify the problems (such as route changes, provision of snow ploughs).

Eighth, climate and weather influence the tourists' enjoyment. Certain conditions can stimulate positive psychological reactions (such as optimism, euphoria, good moods) that can help to enhance the sensation of enjoyment. Conversely, weather conditions can make the generate negative psychological reactions (such as pessimism and bad moods). A number of studies[29] have highlighted the links between weather and human behaviour. These links can be analyzed at various levels. At the symbolic level, different atmospheric conditions (in particular those associated with sun hours and temperature) are associated with the possibility of carrying out certain activities.

At the aesthetic level, different atmospheric conditions produce chromatic and light variations that can be valued in terms of their aesthetics. At the physiological level, different atmospheric conditions trigger certain biological/physiological processes that can condition the individual's physical and mental state. Tourists, consciously or otherwise, usually chooses their holiday destinations by selecting so that all the elements of the product purchased, including its climatic elements, promote a sensation of enjoyment from symbolic, aesthetic, and physiological perspectives. Any atmospheric situation that differs from what was expected (idealized or wished for) can cause tourists to feel unhappy, aggrieved or pessimistic and make them feel that they have squandered their short, expensive holiday.

Ninth, climate and weather combine to form environmental conditions that have a direct bearing on the tourists' perceptions of comfort (sense of well-being) and their health. The human body is constantly subjected to weather influences. To attain the biological balance needed for survival, the body has to fight against the aggressions of this environment. The more the weather differs from the optimum levels required to maintain homeostasis, the more organisms have to fight, which can give rise to feelings of discomfort. Climatic or meteorological conditions that generate constant situations of discomfort can convert an initially healthy state into a dangerous pathological condition.

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[29] Campbell and Beets 1977; Cunningham 1979; Tromp 1974; Williams, Dossa and Hunt 1997

This is why tourists seek climates that can guarantee minimum levels of comfort and which pose no threat to their health (WHO 1966–1967).

While the demands for comfort and health are universal among tourists, for certain groups or types these demands are more important. Thus, elderly tourists often place great value on climate in terms of comfort and health, because they do not adapt as quickly as the young to the imbalances caused to their organism by brusque changes or extreme atmospheric conditions. Furthermore, at these ages, the risk of illness is much greater and extreme climatic situations aggravate illnesses.

There are many examples of this at this period of life: the cases of heart attacks caused by brusque, marked variations in the chill effect of the air or gusts of violent winds (Besancenot 1986, 1991), the cases of brain vascular accidents during intense summer heat and humidity or winds charged with water vapour (Besancenot 1974, 1991), and cases of embolism following sharp drops in barometric pressure.

Health tourists also place considerable value on the climate in terms of comfort and health. In this type of tourism, the climate acts as the raw material that cures or prevents the appearance of certain illnesses. An example of this is thalassotherapy, the use of the properties of sea water and a coastal climate for curative purposes, particularly in treating lung complaints, such as tuberculosis or bronchitis, rickets and psoriasis (Escourrou 1980). Thus, while certain atmospheric conditions and elements can help to maintain or improve health, it is also true that the ill-advised use of these elements, owing to a lack of information or lack of care, can be particularly harmful. Perhaps the best known example of this is sun bathing, which can be beneficial if proper caution is exercised but which is particularly harmful when the sessions in the sun become abusive (leading to solar erythema, skin cancer, premature ageing of the skin, cataracts, macular degeneration, melanomas in the uvea, etc.). For this reason, in recent years, efforts have been made to make tourists more responsible when using certain atmospheric elements and to adopt healthier habits. Information and awareness campaigns play an important role in achieving these aims.

Tenth, climate and weather influence the degree of satisfaction, allowing tourists to enjoy their holiday activities safely and comfortably, helping them fulfil the desires that originally brought them to the resort and, consequently, raising their satisfaction levels. This is significant for a number of reasons, especially the economic repercussions, since satisfaction should influence future visits: satisfied tourists tend to return to a resort, whereas dissatisfied tourists seek new destinations.

In conclusion, this chapter highlights the close relationship between climate, weather, and tourism, and shows the need to understand the nature of these relationships, in order that tourism planning might be more effective. Further, it asserts that tourism planning should incorporate more than simple, general descriptions of the climate, which are often unconnected to the needs of tourism. The analyses required should be more closely focused on the climatology of a particular space and linked to the many facets of tourism: the attractiveness and functionality of the destination; the seasonality of activities; the programming of activities; the safety of tourists and infrastructure in view of climatic risks; the design of accommodation and constructions; the mobility of tourists and the design of transport and communication systems; the enjoyment, comfort, and health of tourists; the level of satisfaction and the influence on future visits, among others. All these useful planning questions have to be considered under the dynamic paradigm of climatic change.

It is clear that planning in the tourism sector must take into consideration climate change factors and at the same time the tourism sector must be mindful of climate change concerns and contribute in its activities to this global environmental challenge.

Nowadays the basic concepts of sustainable tourism are well known at the international level and they represent a starting point for a general shift in the approach to tourism.

The World Tourism Organization (WTO) in 2004 defined that sustainable tourism should:

- Make optimal use of environmental resources that constitute a key element in tourism development, maintaining essential ecological processes and helping to conserve natural heritage and biodiversity;
- Respect the socio-cultural authenticity of host communities, conserve their built and living cultural heritage and traditional values, and contribute to inter-cultural understanding and tolerance;
- Ensure viable, long-term economic operations, providing socio-economic benefits to all stakeholders that are fairly distributed, including stable employment and income-earning opportunities and social services to host communities, and contributing to poverty alleviation.

Therefore, sustainable tourism development requires the informed participation of all relevant stakeholders, as well as strong political leadership to ensure wide participation and consensus building. Achieving sustainable tourism is a continuous process and it requires constant monitoring of impacts, introducing the necessary preventive and/or corrective measures whenever necessary. Sustainable tourism should also maintain a high level of tourist satisfaction and ensure a meaningful experience to the tourists, raising their awareness about sustainability issues and promoting sustainable tourism practices amongst them.

While sustainable tourism is becoming a reality, only recently its strong link to climate change issues has become evident and important steps at the international level have been taken.

The global issue of climate change has become the most important environmental problem of our days and it has gained the highest position in the international political agenda. In fact, only with a strong broad political commitment such a global problem can be tackled effectively. If governments would implement rigorously international agreements such as the Kyoto Protocol and commit to more ambitious objective for its successor in a future climate change regime post 2012, this would have virtuous effects on sustainable development and on sustainable tourism.

A discussion on the international response to climate change is the focus of the next chapter.

CHAPTER III

THE INTERNATIONAL RESPONSE TO CLIMATE CHANGE

3.1 Introduction

As indicated in the first chapter the world's climate has always varied naturally but compelling evidence from around the world indicates that a new kind of climate change is now under way, foreshadowing drastic impacts on people, economies and ecosystems. Levels of carbon dioxide and other ‘greenhouse gases’ in the atmosphere have risen steeply during the industrial era owing to human activities like fossil fuel use and deforestation, spurred on by economic and population growth. Like a blanket round the planet, greenhouse gases trap heat energy in the Earth's lower atmosphere. If levels raise too high, the resulting overall rise in air temperatures – global warming – is liable to disrupt natural patterns of climate.

In its Fourth Assessment Report, the IPCC concluded that the evidence that climate change is already occurring is unequivocal and is due in large part to human activity.

The IPCC says the world faces an average temperature rise of around 3°C this century if greenhouse gas emissions continue to rise at their current pace and are allowed to double from their pre-industrial level. The impacts of this climate change, particularly temperature increases, are already being witnessed on natural and human systems around the world and are very likely to increase.

People in some areas may benefit from climate change, but many more will struggle to cope. Developing countries will suffer more than others, as their lack of resources makes them especially vulnerable to adversity or emergencies on any major scale. Yet on a per person basis, people in developing countries contribute only a small proportion of greenhouse gas emissions.

The particular need of developing countries in adapting to climate change is of critical importance. In many key ways, the problem of climate change is interlinked with development: economic growth is essential for developing countries to improve the health, economic livelihood and quality of life of their citizens. Economic growth is also essential to increase the capacity of developing countries to adapt to the negative impacts of climate change.

But historically, increased economic development and the corresponding increase in energy use have also led to increased emissions of greenhouse gases. The challenge of addressing climate change is to break the link between economic development and greenhouse gas emissions.

In this way, climate change is fundamentally a sustainable development issue.

3.2 The international process

Scientific evidence of human interference with the climate first emerged in the international public arena in 1979 at the First World Climate Conference.

As public awareness of environmental issues continued to increase in the 1980s, governments grew even more concerned about climate issues. In 1988 the United Nations General Assembly adopted resolution 43/53, proposed by the Government of Malta, urging: "… protection of global climate for present and future generations of mankind."

In the same year, the governing bodies of the WMO and UNEP created a new body, the IPCC, to marshal and assess scientific information on the subject. In 1990 the IPCC issued its First Assessment Report, which confirmed that the threat of climate change was real.

The Second World Climate Conference, held in Geneva later that year, called for the creation of a global treaty.

The General Assembly responded by passing resolution 45/212, formally launching negotiations on a convention on climate change, to be conducted by an Intergovernmental Negotiating Committee (INC).

3.3 *The climate change Convention*

The INC first met in February 1991 and its government representatives adopted the United Nations Framework Convention on Climate Change, after just 15 months of negotiations, on 9 May 1992. At the Rio de Janeiro United Nations Conference on Environment and Development (or Earth Summit) of June 1992, the new Convention was opened for signature. It entered into force on 21 March 1994. Thirteen years later, the Convention had been joined by 191 States and the European Community. This almost worldwide membership makes the Convention one of the most universally supported of all international environmental agreements.

Since it entered into force, Parties to the Convention – those countries that have ratified, accepted, approved, or acceded to the treaty – have met annually at the Conference of the Parties, known informally as the COP.

They meet to foster and monitor its implementation and continue negotiations on how best to tackle climate change. Successive decisions taken by the COP at its sessions now make up a detailed set of rules for practical and effective implementation of the Convention.

Even as they adopted the Convention, however, governments were aware that its provisions would not be sufficient by themselves to tackle climate change in all its aspects.
At the first Conference of the Parties (COP 1), held in Berlin, Germany in early 1995, a new round of talks was launched to discuss firmer, more detailed commitments for industrialized countries, a decision known as the Berlin Mandate.

3.4 *The Kyoto Protocol*

In December 1997, after two and a half years of intensive negotiations, a substantial extension to the Convention that outlined legally binding commitments to emissions cuts was adopted at COP 3 in Kyoto, Japan. This Kyoto Protocol sketched out basic rules, but did not specify in detail how they were to be applied. It also required a separate, formal process of signature and ratification by governments before it could enter into force.

A fresh round of negotiations launched in Buenos Aires, Argentina at COP 4 in November 1998 linked negotiations on the Protocol's rules to implementation issues – such as finance and technology transfer – under the umbrella of the Convention. In July 2001. Governments struck a political deal – the Bonn Agreements – signing off the controversial aspects of the Buenos Aires Plan of Action.

A third report from the IPCC, meanwhile, improved the climate for negotiations by offering the most compelling scientific evidence so far presented, of a warming world.

At COP 7, held a few months later in Marrakesh, Morocco, negotiators built on the Bonn Agreements and brought a major negotiating cycle to a close by adopting a broad package of decisions. The Marrakech Accords spelt out more detailed rules for the Protocol as well as advanced prescriptions for implementing the Convention and its rules. These rules were further elaborated by subsequent decisions at COP 8, 9 and 10.

The Protocol could only enter into force after at least 55 Parties to the Convention had ratified it, including enough industrialized countries listed in the Convention's Annex I to encompass 55 per cent of that group's carbon dioxide emissions in 1990. The first Parties ratified the Protocol in 1998. With the ratification by the Russian Federation on 18 November 2004, the prescribed 90-day countdown was set in motion: The Kyoto Protocol entered into force on 16 February 2005.

3.5 *Emission targets and assigned amounts*

At the heart of the Protocol lie its legally binding emissions targets for Annex I Parties. These targets are listed in Annex B to the Protocol, which lists GHG reduction or limitation targets for 38 developed countries and for the European Community as a whole. The 15 member States of the European Community (prior to the EU expansion to 25 states in May 2004) agreed to redistribute their reduction targets among themselves, forming the so-called "EU bubble".

Annex B emission targets are set relative to each Party's GHG emissions in a specific reference year, called the base year. For most Parties, the base year is 1990. However, some EIT Parties, have another base year. In addition, any Party may choose a base year of either 1990 or 1995 for its emissions of HFCs, PFCs and SF6 (see page 27). The emission target covers the six GHGs from sources and sectors listed in Annex A of the Protocol. Annex A excludes emissions and removals from the LULUCF sector, which are treated differently than emissions from the other sectors.

The Protocol establishes a specific time frame, called the commitment period, for achieving emission targets. A five-year period was preferred to a single target year as a way to smooth out annual fluctuations in emissions arising from unforeseen factors such as economic cycles or weather patterns. During the commitment period, each Annex I Party must ensure that its total GHG emissions from Annex A sources do not exceed its allowable level of emissions. The allowable level of emissions is called the Party's assigned amount. For the first commitment period (2008 – 2012), the assigned amount of each Party is calculated by multiplying the Party's base year GHG emissions from Annex A, by its emission target, by five (for the five years of the commitment period.) The resulting quantity is denominated in individual units called assigned amount units or AAUs. Each AAU represents an allowance to emit one metric tonne of carbon dioxide equivalent over the commitment period.

Unlike other multilateral environmental agreements, the Kyoto Protocol allows Annex I Parties to change the level of their allowed emissions over the commitment period through participation in the Kyoto Protocol mechanisms and enhancement of carbon sinks. Through these activities, Parties may generate or acquire additional emission allowances, which are then added to the Party's assigned amount. Each of the mechanisms, and sink activities have a specific emission allowance associated with it, which are collectively referred to as Kyoto Protocol units and are subject to explicit rules for how they can be used.

3.6 The Kyoto Mechanisms

The Kyoto Protocol broke new ground with three innovative mechanisms (joint implementation, the clean development mechanism and emissions trading) designed to boost the cost-effectiveness of climate change mitigation by opening ways for Parties to cut emissions, or enhance carbon 'sinks', more cheaply abroad than at home. Although the cost of limiting emissions or expanding removals varies greatly from region to region, the effect for the atmosphere is the same regardless where the action is taken. Even so, concerns have been voiced that the mechanisms could allow Parties to avoid taking climate change mitigation action at home, or could confer a 'right to emit' on Annex I Parties or lead to exchanges of fictitious credits, undermining the Protocol's environmental goals. The Marrakesh Accords sought to dispel such fears, asserting that the Protocol creates no 'right, title or entitlement' to emit. They call on Annex I Parties to implement domestic action to reduce emissions in ways that could help to narrow per capita differences between developed and developing countries, while pursuing the Convention's ultimate objective.

The Marrakesh Accords imposed no quantitative limits on the extent to which the mechanisms could be used to meet emissions targets. Annex I Parties were obliged, however, to provide information in their national communication showing that their use of the mechanisms is 'supplemental to domestic action' and that domestic policies and measures constitute 'a significant element' of efforts to meet commitments.

To be eligible to participate in the mechanisms, Annex I Parties must have ratified the Kyoto Protocol and must meet specific eligibility criteria, based on the methodological and reporting requirements related to GHG inventories and tracking of assigned amounts. These eligibility criteria help to ensure that an Annex I Party is accounting accurately for its emissions and assigned amount, so that use of the Kyoto mechanisms will not jeopardize the Party's ability to meet its emission commitment. Each Party's eligibility to participate in each of the Kyoto mechanisms will be determined as a normal outcome of reporting, review and compliance procedures under the Protocol.

Kyoto Protocol units acquired from another Party under the Kyoto mechanisms are added to an Annex I Party's assigned amount, whereas units transferred to another Annex I Party are subtracted from the Annex I Party's assigned amount.

3.7 The Clean Development Mechanisms (CDM)

The CDM is a mechanism by which Annex I Parties can invest in emission reduction projects or afforestation or reforestation projects in developing countries and receive credit for the emission reductions or removals achieved.

These projects contribute to sustainable development of the host country and generate emission allowances, called certified emission reductions (CERs) that can be used by the Annex I Party in meeting its emission target.

Investments in CDM projects are to be additional to the finance and technology transfer commitments of Annex II Parties under the Convention and the Kyoto Protocol and must not result in a diversion of official development assistance. The CDM is generating significant investment in developing countries, especially from the private sector, to enhance the transfer of environmentally friendly technologies and thus promote their sustainable development. Already, the CDM has resulted in a significant flow of resources to developing countries. The World Bank reported that the overall carbon market continued to grow in 2008, reaching a total value transacted of about US$126 billion at the end of the year, double its 2007 value of which US$ 6,5 billion refer to CDM transactions alone on the primary market, meaning directly associated with GHG emissions reductions.

CDM projects must have the approval of all Parties involved. This must be gained from designated national authorities set up by Annex I and non-Annex I Parties.

Projects must lead to real, measurable and long-term climate benefits in the form of emission reductions or removals that are additional to any that would have occurred without the project. To demonstrate this, CDM projects must meet detailed requirements and procedures for registration, validation, verification, and certification to demonstrate that reductions or removals associated with the project are additional to what would otherwise occur in the absence of the project. The emission reductions or removals resulting from a CDM project must be calculated and monitored according to specific methodologies, including for project baselines (the starting point for measuring emissions and removals), and verified by designated operational entities (DOEs).

Additional rules apply to afforestation and reforestation projects, which generate two special types of CERs called temporary certified emission reductions (tCERs) and long-term certified emission reductions (lCERs). Annex I Parties are limited in how much they may use CERs from such ‘sink’ activities towards their targets – up to 1 per cent of the Party’s emissions in its base year, for each of the five years of the commitment period.

Under the prompt start of the CDM, CERs may accrue from projects from the year 2000 onwards if they meet CDM requirements. The CDM Executive Board was elected at

COP 7 and is guiding and overseeing practical arrangements of the CDM. Composed of 10 voting members, with 10 alternates, the Executive Board operates under the authority of the meeting of the Parties to the Kyoto Protocol. The Executive Board has defined procedures for accepting projects and encouraging the development of small-scale projects, notably for renewable energy and energy efficiency activities.

CDM projects must be based on appropriate, transparent and conservative baselines (the starting point for measuring emission reductions or removals) and must have in place a rigorous monitoring plan to collect accurate emissions data. These must be devised according to approved methodologies. If project participants wish to use a new methodology, it must first be authorized and registered by the Executive Board. The Board has accredited independent organizations, known as operational entities, to play a key role in the CDM project cycle.

CDM projects are subject to a levy to fund adaptation projects. Under this levy, two per cent of the CERs generated by a project (a 'share of the proceeds') will be paid into a fund to help particularly vulnerable developing countries adapt to the adverse effects of climate change.

Projects in LDCs are exempt from paying this share of the proceeds. Another small portion, yet to be determined, of the CERs from projects will be used to cover the CDM's administrative costs.

The CDM has evolved during its first years of operation. One early concern was that CDM projects were not equally distributed among non-Annex I Parties. To address this concern, the UNFCCC secretariat is cooperating with five other UN agencies United Nations Development Programme (UNDP), UNEP, the World Bank Group, and the African Development Bank to implement a capacity-building initiative to help developing countries, in particular those in Africa, to participate in and benefit from the CDM.

In addition, COP/MOP 2 agreed to allow project activities that are conducted under a policy programme to be registered as a single project. This development called Programme of Activities is expected to further expand the pool of CDM project activities, and to improve the efficiency of CDM operations.

3.8 The international carbon market

The implementation of the Kyoto Protocol has stimulated the development of national and regional GHG emission trading systems, as well as the emergence of multiple organizations and tools to facilitate the trading of emission allowances and credits. Even countries that are not Party to the Kyoto Protocol are seeing the emergence of emission crediting services and voluntary trading systems.

Collectively, these trading systems, and the organization and tools that support it, are referred to as ‘carbon markets’, in that the standard unit for measuring GHG emission allowances under the Kyoto Protocol is one tonne of carbon dioxide equivalent.

At the center of the international carbon market are the companies that are subject to GHG controls imposed by Parties to meet their Kyoto Protocol targets, or that anticipate future GHG controls. These companies are the end-users of emission allowances and credits, and as such, drive the overall volume and price of trades. But there are many other players in the carbon market: companies that verify and certify emission credits under the CDM, JI and the various voluntary offset programmes; trading exchanges, such as the European Climate Exchange and the Chicago Climate Exchange, which provide platforms for trading of emissions allowances and credits; and a whole host of brokerages, advisors and analysts to help companies find and manage their emission allowances and credits.

The carbon market is important for the international efforts to address climate change because it helps reduce the overall cost of reducing greenhouse gas emissions.

It does this in three ways: by enabling companies that can not reduce emissions cheaply to buy lower cost emission reductions elsewhere; by providing opportunities for companies that are cleaner, and more efficient to profit from their technologies and practices by selling excess allowances, and by making it easier for buyers and sellers to find each other, thereby lowering the transaction costs.

3.9 The future of the climate change process and the Copenhagen Accord

The UN Climate Change Conference in Copenhagen was, in many ways, an historic event. It marked the culmination of two years of intensive negotiations under the UNFCCC and the Bali Roadmap, which was agreed by the thirteenth Conference of the Parties (COP 13) in December 2007. Millions of people around the world hoped that "Hopenhagen" would be a turning point in the battle against climate change. The high-level segment brought together 115 Heads of State and Government, and was widely reported as one of the largest high-level gathering outside New York. More than 40,000 people applied for accreditation for the Conference. There is little doubt that the Copenhagen Conference left its mark in history never before has climate change featured so prominently on the international agenda. However, feelings about the outcome are, at best, mixed and some even consider the Conference to be a failure. It is clear that the formal process should reach a convergence at this year's conference in Mexico and that before it a lot of work has to be done by countries on getting closer on their position so that the future of the planet will be safer for the next generations.

The outcome of Copenhagen, described below, can and it is seen as a solid basis to work together and therefore expectations for the next months are very high.

3.10 The Copenhagen Accord

In terms of substance, the Copenhagen Accord immediately faced strong criticism. Others, however, argued that the agreement did include a 2°C target and many other important provisions. Indeed, many saw the Copenhagen Accord as a concise document containing an outline of a future framework to address climate change.

Nevertheless, its provisions on mitigation by developed countries are widely seen as “clearly weak” and “a step backwards from the Kyoto Protocol.” Developed countries do not commit themselves to legally-binding emission reductions. Similarly, there is no quantification of a long-term global goal for emission reductions, or specific timing for global emissions to peak. Instead, the agreement suggests a bottom-up approach whereby developed and developing countries submit their pledges for information purposes to the Convention, a method advocated most prominently by the USA.

With regard to mitigation actions by developing countries, the Accord does not contain any quantified emission reduction objectives and mainly elaborates on the measurement, reporting and verification (MRV) of developing country actions, one of the major stumbling blocks in the negotiations leading to Copenhagen. MRV of unsupported actions are suggested to be done domestically and reported to the Convention through national communications. The Accord, however, does contain some language, stating that there will be some provisions for “international consultations and analysis,” a concept yet to be defined. Those actions supported by international finance, technology transfer and capacity building will, however, be subject to international MRV.

What many characterized as “the most successful part of the Accord” relates to short- and long-term financing. Developed countries came to Copenhagen with clear promises to fund mitigation and adaptation actions in developing countries. According to the Copenhagen Accord, US$30 billion for the period 2010-2012 will be provided, and long-term finance of a further US$100 billion a year by 2020 will be mobilized from a variety of sources. The Accord also establishes four new bodies: a mechanism on REDD-plus, a High-Level Panel under the COP to study the implementation of financing provisions, the Copenhagen Green Climate Fund and a Technology Mechanism. Furthermore, the Accord contains a reference to possibly limiting temperature increase to below 1.5°C, although only with regard to the future assessment of the implementation of the Accord. After many long nights of tense negotiations many were, however, reluctant to analyze its legal and operational implications given the "exceptional procedure" through which the Accord was adopted. In particular, the basis for operationalizing the financing provisions in the text is uncertain, which many have pointed out is very unfortunate and detrimental to those developing countries that really need it. To delegates leaving Copenhagen the future also remained somewhat unclear.

In conclusion, now the question remains of how the Conference and its outcome should be characterized in the larger scheme of things. Was Copenhagen a failure? There seems to be no question that the deep divisions and ill will that characterized the negotiations and the resulting Copenhagen Accord were disappointing to many negotiators and observers alike. However, when looking back through the history of the UNFCCC, there has been important progress in the past five years. In other words, long-term discussions have evolved from an informal one-day seminar for government experts in May 2005, through the Convention Dialogue and Bali Roadmap, to the Copenhagen Conference, where, for the very first time, the majority of the world's leaders gathered to frankly and seriously discuss climate change – now commonly recognized as a serious threat to humanity. Their discussions also covered a full range of formerly "unmentionable" issues, such as adaptation and mitigation by developing countries. Agreement was reached on mitigation actions by both developed and major developing countries, and billions of US dollars were pledged for short- and long-term finance. Had the threat posed by climate change not been so urgent and serious, delegates would therefore have had every reason to be satisfied with their achievements over the past few years. However, as things stand, the Copenhagen outcome highlights that an enormous amount of work remains to be done before people can safely believe that the world has seen a turning point in the fight against climate change. It remains to be seen whether the political and public profile created in Copenhagen can be translated into a binding and ambitious international agreement on climate change.

The future of the climate change process is at the moment a bit uncertain, while reaching the highest point on the political agenda in Copenhagen the distance among countries is still quite relevant. Now all the attention is to the next Conference in December 2010 in Cancun, Mexico and the negotiations that will take place before that to bring countries to reach a final meaningful agreement for the future of our planet.

Nevertheless, many other streams of actions are taking place in the international arena some of which are focusing on the tourism sector and its role in fighting climate change and in responding to the threats of climate change. The next chapter will zoom on these aspects relating to the tourism sector.

CHAPTER IV

THE INTERNATIONAL RESPONSE TO CLIMATE CHANGE AND THE TOURISM SECTOR

4.1 Tourism and Climate Change

Tourism and travel is one of the largest global economic sectors and is a significant contributor to many national and local economies around the world. In 2008, there were 922 million international tourist arrivals with tourism receipts of US$944 billion[30]. It is estimated that the global travel and tourism industry contributed 9.6 per cent of global Gross Domestic Product (GDP) and 7.9 per cent of worldwide employment in 2008. However, tourism demand has slowed substantially over the last year as a result of the global economic crisis. International tourism and travel is a vital contributor to the economy of many developing countries. Between 1995 and 2007, tourism and travel in emerging and developing markets grew at twice the rate of industrialized countries. Tourism and travel is a primary source of foreign exchange earnings in 46 out of 50 of the world's LDCs. With international tourist arrivals projected to reach 1.6 billion by 2020, tourism will continue to have an important role in contributing to the UN Millennium Development Goals, particularly the alleviation of poverty in developing countries.

Climate change is thought to be one of the most serious threats to society, the economy and the Environment.

The environmental and economic risks of the magnitude of climate change projected for the 21st century are considerable and have featured prominently in recent international policy debates. The IPCC concluded, with very high confidence, that climate change would impede the ability of many developing nations to make progress on sustainable development by mid - century and become a security risk that would steadily intensify, particularly under greater warming scenarios. The Stern Review similarly concluded that the costs of taking action to reduce GHG emissions now would be much smaller than the costs of economic and social disruption resulting from inaction on climate change. While additional

[30] All references for this Chapter can be found in the reference section at the end

warming cannot be avoided, future temperature increases will heavily depend on global emission pathways over the next four decades.

With its close relationship to the environment and climate, tourism and travel is considered to be a highly climate‐sensitive economic sector. Tourism destinations and tourism operators are affected by climate variability in a number of ways:

- Climate defines the length and quality of tourism seasons (e.g. winter sports) in different regions. Some tourism destinations are climate‐dependent; since climate is the principal resource upon which the tourism industry is based (e.g. many tropical small island developing states).
- Climate directly affects various facets of tourism operations (e.g. water supply and quality, heating‐cooling costs, snowmaking requirements, irrigation needs, pest management, evacuations and temporary closures) that affect profitability.
- Moreover, a wide range of the environmental resources that are critical attractions for tourism in many destinations are sensitive to climate variability, such as wildlife and biodiversity, water levels and quality, and snow conditions and glacier extent.
- Climate also influences environmental conditions that can deter tourists, including infectious diseases, wildfires, algal blooms, insect or water‐borne pests (e.g. jellyfish), and extreme events such as hurricanes, floods or heat waves.
- Climate is also a crucial determinant of tourist decision‐making. Seasonal climate fluctuations at tourism destinations and at major outbound markets are key drivers of tourism demand at global and regional scales. Weather is an

intrinsic component of the travel experience and also influences tourist spending and holiday satisfaction.

As a consequence, the integrated effects of climate change are anticipated to have far‑reaching impacts on tourism and travel businesses and destinations. Indeed, climate change is not some distant, future threat to tourism and travel, as the varied impacts of climate change are increasingly becoming evident in various destinations around the world and affecting the tourism and travel industry and the communities who depend upon it. Climate change is also already altering the decisions of travellers in terms of the destinations they choose and the timing of their trips. Climate change will result in both negative and positive impacts for the tourism and travel sector and its impacts will vary substantially by geographic region and sector. There are four broad pathways by which climate change will affect the global tourism and travel sector:

- Direct climate impacts: Changes in the length and quality of climate‑dependent tourism seasons (i.e. sun‑and‑sea or winter sports holidays) could have considerable implications for competitive relationships between destinations and intra‑regional tourism flows. Other impacts will include increased infrastructure damage, additional emergency preparedness requirements, higher operating expenses (e.g. insurance, backup water and power systems, and evacuations), and business interruptions. Similarly, key cultural heritage assets that are also important attractions for tourists are also increasingly threatened by extreme climatic events and projected climate change.
- Indirect environmental change impacts: Tourism is often based on a high quality natural environment. Changes in water availability, biodiversity loss, reduced landscape aesthetic, altered agricultural production (e.g. wine tourism), increased natural hazards, coastal erosion and inundation, damage to

infrastructure and the increasing incidence of vector - borne diseases will all impact tourism to varying degrees. In contrast to the varied impacts of a changed climate on tourism, the indirect effects of climate induced environmental change are likely to be largely negative. Mountain, island, and coastal destinations are considered particularly sensitive to climate - induced environmental change, as are nature - based tourism market segments. Visitors may be deterred from visiting if the quality of the attractions decreases markedly.

- Impacts of mitigation policies on tourism mobility: national or international policies to reduce GHG emissions will potentially impact tourism flows by causing an increase in transport costs and fostering environmental attitudes that lead tourists to change their travel patterns (e.g. shift transport mode or destination choices).
- Indirect societal change impacts: The impacts of, and adapting to, climate change will have an economic cost. If not tackled, climate change may also threaten future economic growth and even the political stability of some nations. Any reduction of global GDP due to climate change would have negative implications for anticipated future growth in tourism. Tourists are averse to political instability and social unrest, and there would be negative repercussions for tourism in the climate change security hotspots.

The tourism and travel sector is characterized by considerable diversity and consequently, there are extensive differences in the nature of climate sensitivities and adaptive capacities of tourism and travel operators and destinations. Furthermore, the implications of climate change for any tourism business or destination will also partially depend on the impacts on its competitors, with a negative impact in one part of the tourism system constituting an opportunity elsewhere. Assessments by different groups of international experts have consistently identified developing nations in the Caribbean, Small Island Developing States (SIDS), Southeast Asia, and Africa as the most at - risk tourism destinations, because of their high exposure to multiple climate change impacts that will affect key tourism products, distance to major markets (long - haul travel greater than five hours) and consequent exposure to increasingly stringent emissions policy on aviation, lower overall adaptive capacity, limited domestic markets and a high economic dependency on international tourism and travel.

Regardless of their relative vulnerability to climate change, all tourism and travel businesses and destinations will need to adapt to climate change in order to minimize associated risks or capitalize upon new opportunities, in an economically, socially and environmentally sustainable manner. Considering that the large information requirements, policy changes and investments required for effective adaptation by tourism and travel destinations will require decades to implement in some cases, the process of adaptation must commence now for destinations anticipated to be among those impacted by mid - century.

With their high capacity to adapt to the effects of climate change by substituting the place, timing and type of holidays in their travel decision - making, tourists will play a pivotal role in the eventual impacts of climate change on the tourism and travel industry and destinations. Tourists are also increasingly willing to pay a premium for sustainability or environmentally - friendly practices and operators are responding with new products and services.

Tourism and travel also contributes to climate change through the emission of GHG. Tourism and travel accounts for approximately five per cent of global carbon dioxide emissions. The transport of tourists to and within destinations accounts for 75 per cent of all carbon dioxide emissions by the tourism sector, with air travel making up about 40 per cent of the total. It has also been predicted that, under a "business as usual" scenario, carbon dioxide emissions from the global tourism sector will increase by 130 per cent by 2035. Most of this growth was attributed to air travel. This projected growth in emissions from tourism is inconsistent with the deep emission reductions needed to address climate change; the pledge of the tourism sector to substantially reduce emissions in the decades ahead is discussed below.

4.2 The United Nations, climate change and tourism

A crucial interdependence exists between the climate, the environment, tourism and communities.

In the year 2000, world leaders gathered in New York to adopt the United Nations Millennium Declaration which committed them to a series of time - bound targets with a deadline of 2015. These development objectives, with an overall focus on reducing extreme poverty, became known as the Millennium Development Goals (MDGs).

The world's poorest people are the most vulnerable to the impacts of climate change such as floods, water shortages and changes in biodiversity. Countries that are perhaps least prepared to deal with the effects are already suffering the more serious impacts of climate change. However, tourism is one of the best known ways of redistributing wealth from rich nations to poor nations and from urban areas to rural areas. It is also an effective catalyst for gender equality, cultural preservation and nature conservation.

As a result of the economic and social benefits of tourism, the sector is increasingly being promoted as contributing to, and being a vital element in, the alleviation of poverty in Least Developed Countries as one of the UN Millennium Development Goals. In addition, tourism and travel also contributes to the environmental sustainability and gender equality goals. As a result, in 2002, the United Nations World Tourism Organization (UNWTO) launched a programme on Sustainable Tourism - Eliminating Poverty (ST - EP). UNWTO have also adopted the strap line: “committed to tourism, travel and the Millennium Development Goals”.

UNEP has launched a Green Economy Initiative which aims to revive the global economy and boost employment, whilst simultaneously accelerating the fight against climate change, environmental degradation and poverty. Within the Green Economy Initiative report, UNWTO and UNEP will jointly work on how investment in sustainable tourism and travel solutions can contribute to sustainable development and to a green economy.

4.3 Agreements on GHG emissions reductions and their impact on tourism

Action to reduce current levels of greenhouse emissions will not only minimize the threat of climate change but will also provide an opportunity to develop a sustainable global economy. Any mitigation policies should be developed and implemented in a considered way so as not to negatively disadvantage the least developed countries and the tourism industry contributing to poverty reduction and economic development. The tourism and travel community must be fully engaged in, and supportive of this process. There are also a number of mechanisms that could be used for addressing greenhouse gas emissions including:

- Reducing energy use. This should be the starting point and is the most essential aspect of mitigation. It could be achieved through a shift in transport use or changing management practices.
- Improving energy efficiency. Technological developments will help reduce emissions from, for example, aviation as it may reduce fuel use and improve aircraft performance.
- Increasing the use of renewable energy. This is an area that, with the right investment, could be very applicable to tourism especially solar panels, water recycling or passive heating ‑ cooling.

- Sequestering carbon through sinks (often forestry schemes) and the use of carbon compensation or offsetting. These schemes are currently voluntary and UNEP has suggested that are unlikely to have a major impact on the reduction of aviation greenhouse gas emissions.

Addressing GHG emissions from the transport sector is a critical aspect of national and international mitigation policy negotiations. Consequently, it is anticipated that climate change mitigation policy will have both near ‑ term and long ‑ term implications for the costs of transportation that are fundamental to tourism (automobile, air travel, and cruise ships in particular).

International aviation is critical to tourism with 52 per cent of travellers reaching their destination by air. As indicated, it is also the dominant contributor to GHG emissions from travel and tourism (40 per cent of the industry's carbon dioxide emissions). Currently international aviation emissions are excluded from the Kyoto targets. Nonetheless, Article 2, paragraph 2 of the Protocol does say that Annex 1 Parties (industrialized countries) are committed to pursue limitation or reduction of GHG emissions. So whilst there may not be specific, measurable targets, there is already a requirement for industrialized nations to implement measures to reduce emissions. Within Europe, the Emissions Trading Scheme (ETS), which has been operational since 2005, will begin to include air carrier operations to, from and within Europe in 2012.

A number of studies have examined the potential impact of a range of aviation sector ‑ targeted climate policies on the future of international tourism. There is no evidence to suggest that climate policies or international aviation industry initiatives, as currently proposed, would have any substantial impact on the growth of tourist arrivals through 2020. Even with, for example, ticket price increases, many people will still want or need to travel and as tourism is such an important economic sector, especially for developing countries, operators will try to encourage tourism even with industry climate policies.

There has been considerable dialogue on future policy frameworks to manage emission reductions in the transportation sector. The role the International Civil Aviation Organization (ICAO) has in providing leadership on reducing greenhouse gas emissions within the aviation sector resulted in the formation of the Group on International Aviation and Climate Change (GIACC). The treatment of greenhouse gas emissions from international aviation is one of the most contentious issues within the UNFCCC process. The GIACC have adopted the aspirational goal of annual improvements in fuel efficiency of 2 per cent up to the year 2050 and also developed a Programme of Action that includes strategies to achieve reductions in emissions.

In February 2009, the ICAO organized an international Workshop on Aviation and Alternative Fuels. There was general agreement that alternative fuels can be a win - win solution for reducing aviation's dependence on fossil fuels and a key element to help reduce the impact on climate change. It was also suggested that the adoption of alternative fuels by the aviation industry may be simpler than in other sectors due to the relatively small number of fuelling locations. Various blends of alternative fuels have been tested and progress is being made in development.

The International Road Transport Union (IRU) represents the passenger and goods road transport industry. In November 2009, the IRU adopted the "30 - by - 30" resolution, which includes a voluntary commitment by the road transport industry to reduce its CO2 emissions by 30 per cent by 2030 (with a base year of 2007). The IRU is also promoting the change from dependence on fossil fuels to also using alternative energy and fuel sources.

Whilst not a big contributor to tourism directly, the international shipping industry is responsible for transporting about 90 per cent of world trade. For over 50 years, the UN International Maritime Organization (IMO) has provided the global regulatory framework within which the shipping industry operates. Whilst it is already the most carbon efficient mode of commercial transport, the sector is committed to reduce their GHG emissions. However, shipping companies can choose the ‘flag state’ in which to register their vessels and emissions cannot be attributed to any particular national economy. As a result, multilateral cooperation is required.

Clearly, any global emission policy for aviation and other transport sectors would have considerable consequences for destinations depending on tourism and travel, including, for instance, many small island developing states. Tourism and travel - related mitigation initiatives must mediate between the conflicting objectives of the need to reduce contribution to global warming whilst not adversely impacting tourism’s role in sustainable development and poverty alleviation. UNWTO has called for preferential treatment for air services that support the development of tourism in the least developed countries.

All countries and those within the tourism industry should be encouraged, regardless of economic status, to work with the UNFCCC process to ensure that poverty and promoting the development of tourism - dependent poorer nations are also considered. In 2007, UNWTO suggested it would be possible to reduce greenhouse gas emissions from air transport without affecting the socio - economic benefits tourism provides. This is also dependent to some extent on behaviour change with tourists being encouraged to reduce the number of shorter trips they take. However, constraints on leisure time within Europe are actually leading people to go on more, but shorter visits. Developing alternative modes of short haul transport is one approach that could be implemented without reducing the number of visitors.

4.4 UNWTO responses to climate change

The Secretary General of the United Nations has been tasked with developing a global response to the challenge of climate change, coherent with the Millennium

Development Goals. As a result, the United Nations has, for many years, been developing a framework designed to establish a long‑term post‑Kyoto roadmap, which includes targeted milestones. The tourism and travel sector, given its hugely important economic and social value, its role in sustainable development and its relationship with climate, has a significant role to play in the UN's overall framework. UNWTO has been studying the issue for many years as part of its contribution to sustainable development and the Millennium Development Goals. UNWTO is actively working to raise awareness on climate change issues in the tourism sector and on integrating tourism into the United Nations and other international policy processes on climate change.

In April 2003, UNWTO, together with several other United Nations agencies, convened the first International Conference on Climate Change and Tourism in Tunisia. The resulting Djerba Declaration on Climate Change and Tourism signified the importance of climate change for the sustainability of the global tourism industry, urged the formulation of appropriate adaptation plans, recognized the two‑way relationship between tourism and climate change, and highlighted the obligation of the tourism industry (including transport companies, hoteliers, tour operators, travel agents and tourist guides, and consumers) to reduce their GHG emissions and subscribe to all relevant intergovernmental and multilateral agreements to mitigate climate change. The conference was pivotal in highlighting the issue of climate change within the tourism and travel sector and sought to raise awareness and strengthen collaboration between public and private sector players.

Since that first conference, the complex relationship between the tourism and travel sector and climate change has increasingly been studied. As a result, in 2007, UNWTO, together with UNEP and WMO with the support of the World Economic Forum, organized the Second International Conference on Climate Change and Tourism in Davos, Switzerland. The multi‑stakeholder event attracted more than 400 participants from over 80 countries, representing the public and private sector, academia and civil society. Stakeholders and interested parties were reunited to review developments and incorporate increasing global awareness and market place reality into revised guidance.

The outcome of the conference was the Davos Declaration. The Declaration not only acknowledged the reality of climate change and the interrelationship with tourism and travel but also that a long - term strategy is required to reduce greenhouse gas emissions from within the sector. The Declaration outlines firm recommendations and a clear commitment for action, by the key interest groups involved in tourism, to respond to the climate change challenge. It called for the urgent adoption of a range of sustainable tourism policies and also provides global guidance on the issue.

The goals included within the Declaration are not only achievable but provide a link to the interrelated poverty agenda. Four key areas that will require action were agreed upon:

- Mitigate greenhouse gas emissions from the tourism sector (especially from transport and accommodation activities)
- Adapt tourism businesses and destinations to changing climate conditions
- Apply existing and new technologies to improve energy efficiency
- Secure financial resources to assist poorer regions and countries.

During the conference in Davos, and in the subsequent discussions, one of the main points reiterated was that special consideration should be given to the least developed countries and small island developing states in the provision of financial, technical and training support to tourism destinations and operators. However, UNWTO cannot tackle climate change and tourism issues in isolation. UNWTO and partner organizations markedly increased their effort on the climate change and tourism issue. UNWTO Secretary General attended the UN Leadership Summit on Climate Change on 22 September 2009 in New York, delivering a "UNWTO Climate Commitment" message. "Sustainable tourism and travel is important for all countries and pivotal for the world's poorest states. It provides jobs, trade and development. It must be a pillar of the Green Economy with the active engagement of all tourism stakeholders. The World Tourism Organization is committed to working across the industry, both in the public and private domains, to advance a coherent response to Climate and Development imperatives, placing businesses at the heart of the transformation to a low carbon economy.". A timetable of selected climate change and tourism initiatives is presented below.

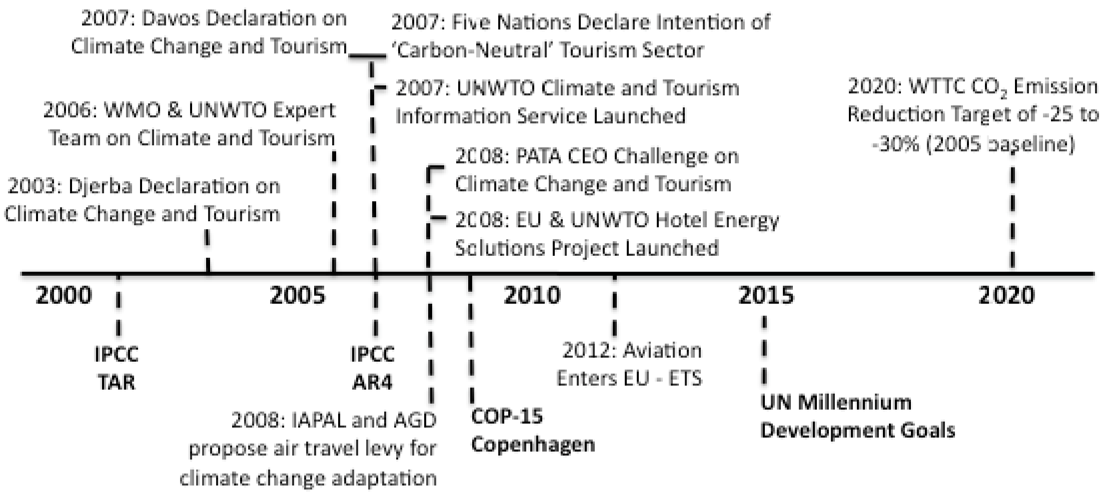


Figure 24: Key climate change and tourism initiatives

4.5 *The response of the private sector to the challenges that climate change poses to tourism*

The private sector has a significant role to play in addressing the challenges climate change poses for tourism and travel. However, they cannot implement these alone. Governments need to be engaged and encouraged to develop and implement regulatory policies and offer economic incentives.

Together they have a crucial role to play in tackling climate change and its impact on tourism and travel. In synergy with the UNWTO many tourism and travel organizations have embraced this challenge and opportunity.

The World Travel and Tourism Council (WTTC) produced a report in 2009, which sets out a vision for tackling GHG emissions. It includes a commitment, endorsed by more than 40 of the world's largest Travel and Tourism companies, to cut by half carbon emission levels of 2005 by 2035 (lx). There is also an interim target of achieving a 30 per reduction by 2020 in the presence of an international agreement or 25 per cent reduction in the absence of such an agreement. The WTTC's report also acknowledged that the goals of industry leaders, customers and policy - makers need to be aligned and that partnerships can play an important role. The WTTC has also identified a series of commitments, which the Council itself will use to track and measure its own efforts and success. These include working with governments to align frameworks; share information and best practice examples; support aviation's progressive carbon dioxide emission reduction strategies and encourage airlines to halve carbon emissions levels by 2050; and assist local communities in adopting practical mitigation and adaptation strategies.

In June 2008, CEOs from across the world, representing every industrial sector, submitted a set of recommendations to the G8 leaders for inclusion within a post - Kyoto climate framework. In March 2009, in response to the recommendations and to elaborate on how they should be implemented, a World Economic Forum (WEF) Task Force on Low - Carbon Prosperity was launched. In May 2009, the WEF, in collaboration with UNWTO, ICAO, UNEP and travel and tourism business leaders, produced the Towards a Low Carbon Travel and Tourism Sector report. Within the document, a number of ways to mitigate transport and accommodation greenhouse gas emissions are proposed. Both short - and long - term solutions are identified including market mechanisms such as global emissions trading schemes. The study also highlights how governments, industry and consumers can collectively improve the sustainability of travel which will ensure the continued growth of the sector.

A number of governments have announced their intention for their nations, including their tourism and travel sector, to become carbon neutral. Sri Lanka announced its initiative "Earth Lung – Carbon Free Sri Lanka" during the Davos Conference in 2007. Three other countries have announced their intention to have a "carbon free" or "carbon neutral" nation, including their tourism and travel sector (Norway, Costa Rica and the Maldives).

UNWTO is providing 'in - kind' support and support aimed at raising funds for governments and regional initiatives for climate change adaptation and mitigation projects in the tourism sector for key regional initiatives involving governments of numerous countries. The CARIBSAVE Partnership, formed in 2008, between the Caribbean Community Climate Change Centre (CCCCC) and the University of Oxford, and supported by a range of international partners including UNWTO, UNEP, UNDP, the World Bank, WWF, and other international and regional partners is addressing the impacts and challenges surrounding climate change, tourism, economic development and community livelihoods across the Caribbean Basin. The Caribbean is a highly tourism - reliant region and also highly vulnerable to the impacts of climate change. The CARIBSAVE Partnership, which includes representatives from both the public and private sector, is providing practical strategies, assisting in capacity building and facilitating skills transfer across the region.

CHAPTER V

CAN THE CDM UNDER THE KYOTO PROTOCOL ACHIEVE MULTIPLE OBJECTIVES?

5.1 The success of the CDM in the world

In Chapter III the Clean Development Mechanism has been introduced and explained in its purposes and scope, now a more detailed analysis of this market instrument is presented linking it, to the extent possible, to the tourism sector with the objective to answer the question: Can the CDM achieve multiple objectives?

The CDM has been a tremendous success in the recent years and in a very short period of time. Figure 25 below indicates the growth of registered CDM project activities from the year 2005 to the end of last year as well as the projects in the pipeline, meaning those activities that are in the finalization stage before they can be submitted for registration and start the implementation phase. The figure also indicates the expected Certified Emission Reductions (CERs) in USD billion from those projects, registered and in the pipeline, before the end of the first commitment period of the Kyoto Protocol in 2012.

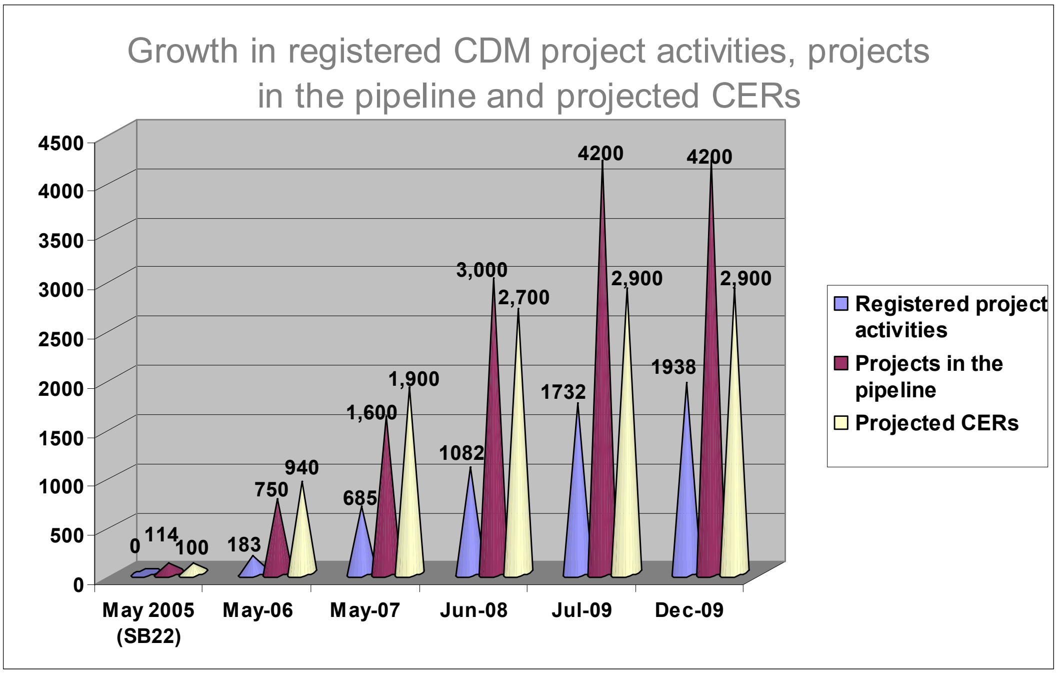


Figure 25: The evolution of the CDM in the recent years.

This trend is in continuous evolution and statistics have to be updated on a daily basis. In fact, as of 9 March 2010 there are 2080 registered CDM project activities, which have generated already 390,112,916 CERs credits, each equivalent to one tonne of CO2.

CDM projects are present in all regions of the world, however there is a clear unbalanced situation with regard to the regional distribution of these projects. Figure 26 provides a visual demonstration of the distribution of registered projects around the globe which clearly indicates the concentration of projects in certain regions and within these regions in certain countries. The Asia and the Pacific Region accounts for 73% of all projects, followed by Latin America and the Caribbean with 24%, Africa with 2% and other 1%. This situation is far from being acceptable considering that above all climate change is a global issue that requires global concerted response.

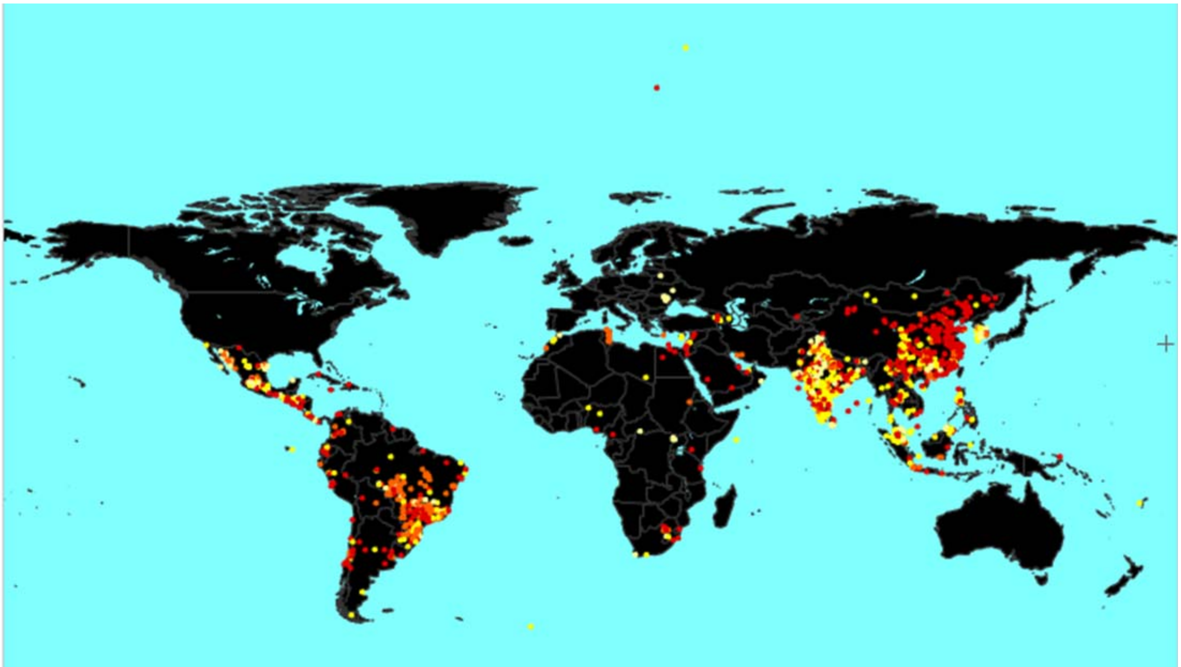


Figure 26: Regional distribution of registered CDM project activities
(red dots refer to large scale projects, yellow dots to small scale projects).

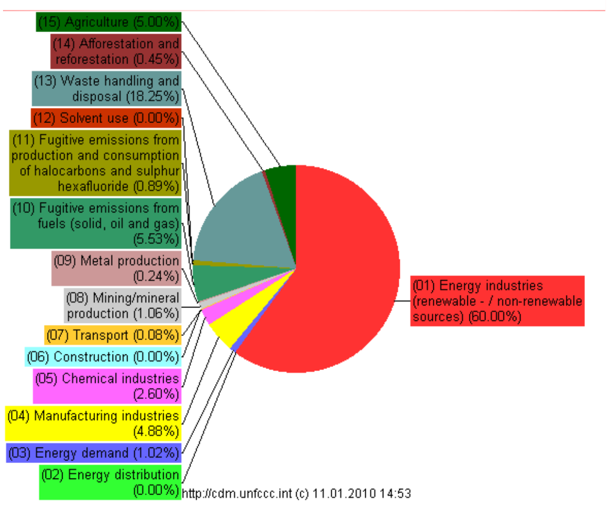
Still, host-country statistics make clear that much remains to be done to spread the benefits of the CDM. For example, the top hosting country has about 650 projects, 10 times more than the fifth highest hosting country. Some 40 countries have 10 projects or less, and 15 countries have just one project. In particular, China is hosting 36% of the projects, India 24%, Brazil 8%, Mexico 6%, Malaysia, Indonesia, the Philippines and Chile are the remaining countries which still have a significative number of projects.

To assess and discuss the reasons for this situation would require a diversion from the scope of this research, nevertheless it is worth to mention that the CDM being a market mechanisms it is following certain dynamics well consolidated in international markets and therefore financial flows to CDM projects follow in general the same path of foreign direct investments and are directed to those countries that have created a proper enabling environment that facilitates such investments.

5.2 Types of CDM project activities

The CDM project activities cover 15 broad project types or scopes which are based on the list of sectors and sources contained in Annex A of the Kyoto Protocol. This sectoral scopes range across different economic sectors and imply the utilization of a diversity of technologies. This classification is done with reference to those sectors which have a clear potential for reduction of GHG emissions, and associated with these scopes, there are a number of approved methodologies which are the standards to be used by project developers in determining and calculate their emission reductions and against which they will be checked by independent entities to ensure that projects achieve real, measurable and verifiable emission reductions that are "additional" to what would have occurred without the project. Before a project can qualify to earn CERs, it must first be validated by an independent third-party certifier accredited by the Executive Board, called DOEs. Later on during the implementation phase of these projects DOEs are responsible to verify emission reductions over specified periods of time. These entities, companies that specialize in quality standard assessment, are a key feature of the CDM and represent the safeguard of independency throughout the lifecycle of the CDM project activity[31].

In Figure 27 below, the total registered CDM project activities at the end of last year is broken in the 15 sectoral scopes, to show which are the most utilized. The sector which alone accounts for 60% of the projects is the Energy industries which includes both renewable and non-renewable sources. The predominance of the energy sector is quite natural since it is in these activities that there is more potential for GHG emission reductions. Other important sectors are: waste management; fugitive emissions from fuels, agriculture and manufacturing industries. However the number of projects in a sector does not equally mirrors the amount of emission reductions achievable by those projects.



Sectoral Scope*	Registered Projects
(01) Energy industries (renewable - / non-renewable sources)	1476
(02) Energy distribution	0
(03) Energy demand	25
(04) Manufacturing industries	120
(05) Chemical industries	64
(06) Construction	0
(07) Transport	2
(08) Mining/mineral production	26
(09) Metal production	6
(10) Fugitive emissions from fuels (solid, oil and gas)	136
(11) Fugitive emissions from production and consumption of halocarbons and sulphur hexafluoride	22
(12) Solvent use	0
(13) Waste handling and disposal	449
(14) Afforestation and reforestation	11
(15) Agriculture	123

Figure 27: Distribution of registered project activities by scope

From the analysis of the Figure 27 it can be seen that the tourism sector per se it is not included in the list of scopes relating to the CDM and therefore CDM project activities cannot be directly linked as implemented in or originated from the tourism sector. The reasons for this go back at the time of the negotiations of the Kyoto Protocol, when countries have

[31] A CDM project activity can last either for a period of 10 years or for three periods of 7 years each.

identified those sectors which have the highest potential for reduction of GHG emissions on the basis of statistical data on actual emissions and projected emissions trends. At the time, and this is an assumption, the tourism sector was not perceived as an homogenous sector where it is possible to clearly identify GHG emissions attributable to it but rather a cross-cutting set of activities which involves different sectors of the economy and a set of human behaviours.

This question remains valid also today, is it possible to define how many tones of CO_2 are emitted by the tourism sector in a given year in each country? Much progress has been done in this area in recent years which offers now a much clearer picture about the contribution of the tourism sector to climate change. According to UNWTO-UNEP-WMO (2008), emissions from tourism, including transports, accommodation and activities (excluding the energy used for constructions and facilities for example) account for about 5% of global CO2 emissions. However, other greenhouse gases also make significant contributions to global warming. In the tourism sector, this is particularly relevant for emissions from aviation. In 2005, tourism's contribution to global warming was estimated to contribute between 5% and 14% to the overall warming caused by human emissions of greenhouse gasses. Of the 5% of the global total of CO2 emissions contributed by tourism, transport generates around 75%, and in terms of the radiative forcing specific to transport, the share is significantly larger ranging from 82% to 90%, with air transport alone accounting for 54% to 75% of the total (UNWTO-UNEP-WMO 2008). Looking into the future, by 2035, tourism's contribution to climate change may have grown considerably.

It is clear that there is a great potential for emission reduction in the tourism sector at present and in the future, even if the majority of the emissions are coming from the aviation sector which is dealt as a separate issue in the climate change negotiation process due to its complexity and transboundary aspects. Nevertheless, even without the aviation component the tourism sector can greatly contribute to mitigate[32] climate change by reducing GHG emissions. Mitigation can be achieved by reducing energy use, for instance through changing travel behaviour, by improving energy efficiency, increasing the use of renewable energy, carbon offsetting strategies, sustainable destination planning and management, tour operators' choice of destinations and packaging of travel products, as well as other changes in business practices. Behavioural changes (tourists) as well as structural change (tourism industry) will thus be of importance in reversing the trend of growing greenhouse gas emissions in tourism.

The tourism sector is in need of adequate mitigation tools to contribute to the overall objective of responding to the threats of climate change and the CDM has demonstrate its effectiveness over the years. There are obviously untapped opportunities to link the two.

5.3 Linking the CDM with the tourism sector

The CDM is seen by many as a trailblazer. It is the first global, environmental investment and credit scheme of its kind, providing a standardized emissions offset instrument, CERs that allows emission-reduction projects in developing countries to earn CERs. These CERs can be traded and sold, and used by industrialized countries to a meet a part of their emission reduction targets under the Kyoto Protocol.

The CDM stimulates and contributes to the sustainable development goals of host countries, incentive action on climate change and contribute funds for adaptation. In fact, for a project to be considered for registration, project participants must first receive a letter of approval from the host country, stating that the project assists the host country in achieving its sustainable development goals. It is clearly a prerogative of each country to determine whether or not a project is contributing to sustainable development and these assessments vary from country to country and from region to region, nevertheless the contribution that CDM project

[32] Climate change mitigation includes technological, economic and social changes and substitutions that can help to achieve reductions in greenhouse gas emissions

activities are bringing to sustainable development activities in developing countries is unquestionable. CDM projects also raise awareness on sustainability issues, facilitate and stimulate technology transfer both North-South and South-South, favor the uptake and implementation of new practices and create new jobs while changing consumption patterns.

Therefore seeing a wide range of opportunities to link the CDM with the tourism sector is quite immediate.

So far, there are only a few examples of CDM project activities that are clearly linked with the tourism sector and the next chapter will present them, but there are also other situations where a clear link can be made and a special case will be introduced.

In all these cases though, tourism is not the main driver of these projects and, as indicated earlier, the scope of the CDM is to address those sectors which have the higher GHG emissions, however since now the “low hanging fruits” have been more or less exhausted it is time to look into other ways to reduce GHG emissions, contribute to sustainable development and participate in the global fight against climate change.

CHAPTER VI

CASE STUDIES

EXISTING CDM PROJECT ACTIVITIES IN DIFFERENT SECTORS AND EXAMPLES OF CDM PROJECT ACTIVITIES RELATED TO THE TOURISM SECTOR

6.1 The flexibility of the CDM as a mitigation instrument

The examples of CDM project activities illustrated below[33] are included as case studies to provide an overview of how variegate and creative can the CDM types of projects be. For some of the official sectoral scopes a few projects are described by indicating their key elements and more importantly by describing their contribution to sustainable development and their social impacts.

These examples offer just a limited indication out of the more than two thousand project registered of the flexibility of the CDM as a mitigation instrument in responding to different needs and situations around the world. The benefits to all involved in a project have been already highlighted, it is absolutely clear that the same principles of flexibility can and should accommodate more activities linked to the tourism sector and only with more examples implemented on the ground the possibility and interest in replication can grow exponentially in the near future.

Energy industries (renewable -/ non-renewable sources)

Project 0182

Title: "Photovoltaic kits to light up rural households in Morocco"[34]

Host Country: Morocco; **Other countries:** France; **Registration date:** 28 Apr 06

Description: The objective of the project is to provide 101,500 rural households in all regions of Morocco with photovoltaic kits to enable them to meet their basic energy needs. These households will be equipped with individual photovoltaic kits along with the basic installation for domestic electricity use, such as bulbs and plugs. Average daily solar radiation in Morocco is quite high and so photovoltaic and solar energy devices have clear potential.

[33] The description of each project is taken by the CDM Fact sheets publication of the UNFCCC secretariat, 2009.
[34] http://cdm.unfccc.int/Projects/DB/TUEV-SUED1134746545.91/view

Sustainable Development: Photovoltaic systems use solar energy which presents various environmental benefits. In contrast to the energy sources used to generate electricity in Morocco, solar energy is readily available most of the time and does not result in emissions of pollutants into the atmosphere, nor does it emit residuals that can have an impact on soil and water. The net result is a reduction of fossil fuel consumption. At the same time, solar energy is an infinite source. So it does not endanger the supply of energy for future generations.

Project 2711

Title: Efficient Fuel Wood Stoves for Nigeria[35]

Host Country: Nigeria; **Other countries:** Germany; **Registration date:** 12 Oct 2009

Description: The purpose of the project is to disseminate up to 12,500 efficient fuel wood stoves and heat retaining boxes – known as "Wonderboxes" – to households in various states in the Guinea Savannah Zone of Nigeria, at subsidized prices. The new wood stoves save up to 80 per cent of fuel wood and are suitable for cooking, frying, heating and sterilizing water, and baking flat bread. After reaching the boiling point, food can be transferred to the heat retaining box, where it will continue to simmer until it is well cooked. Deforestation and desertification have become a major concern in the area, as wood demand for household energy largely exceeds the available renewable woody biomass.

Sustainable Development: By reducing fuel wood consumption, the project reduces greenhouse gas emissions from the use of non-renewable biomass, and allows natural recovery of forests or reforestation to take place. The project also helps to reduce indoor air pollution from wood smoke and its harmful health consequences.

Project 0279

Title: Lihir Geothermal Power Project[36]

[35] https://cdm.unfccc.int/Projects/DB/RWTUV1245685309.5/view
[36] http://cdm.unfccc.int/Projects/DB/DNV-CUK1143246000.13/view

Host Country: Papua New Guinea; **Other countries:** UK; **Registration date:** 29 May 06

Description: The project involves the construction of a Geothermal Power Plant on Lihir Island, Papua New Guinea. Like many of the island nations within the Pacific islands, Papua Nea Guinea is subject to substantial volcanic and seismic activity which provides an abundance of geothermal energy resources which can be used as an alternate source of energy. By utilizing the existing geothermal resources of Lihir Island to generate electricity, this project will displace most of the existing diesel generation on the island driven by the combustion of carbon-intensive heavy fuel oil.

Sustainable Development: Apart from its benefits on the global environment, further environmental benefits will be achieved though the reduction of air-based pollutants, such as oxides of nitrogen, oxides of sulphur, carbon monoxide and fine particles, being emitted into the atmosphere due to the reduced combustion of fossil fuels. Additionally, the project has the potential to contribute to the long term general economic and social development of Papua New Guinea by demonstrating the use of renewable energy and alternative technology that could be applied on a larger scale throughout the Pacific.

Project 0295

Title: A retrofit programme for decentralized heating stations in Mongolia[37].

Host Country: Mongolia; **Other countries:** None; **Registration date:** 28 Jul 06

Description: The objective of this project has been to retrofit a bundle of four heating stations in Ulaanbaatar and the wider suburban areas of Mongolia's capital by replacing the technologically outdated and inefficient boiler units with modern, high-efficiency ones. The retrofit measure provides for a significant reduction of air pollutants and CO_2 emissions and further increases operational safety in the facilities. The technologically outdated boilers consume thousands of tons of coal per heating season. The implementation of the project will lead to a major reduction of CO_2 and fly ash.

[37] http://cdm.unfccc.int/Projects/DB/RWTUV1150300431.15/view

Sustainable Development: The new boiler units reduce the fuel consumption by employing energy efficiency measures, increase the quality of heat service and improve the working conditions in heating stations while reducing health damaging air pollutants, such as fly ash. Furthermore, the project supports Mongolia's economy, as the heating season in the country lasts 7 months per year.

Project 2444

Title of project: ADFEC 10 MW Solar Power Plant[38]

Host Country: United Arab Emirates; **Other countries:** None; **Registration date:** 08 June 2009

Description: The purpose of the project is to build a solar Photovoltaic (PV) power plant that will be connected to a grid. The project activity, which is the first of its kind in the region, will use a state-of-the-art, environmentally friendly technology for power generation. The implementation of the project will reduce the emissions that would have occurred from the electricity generation in the gas and oil based power plants connected to the grid.

Sustainable Development: The project will generate employment opportunities for professional, skilled and unskilled labour in sectors such as development, engineering, procurement, construction, operation and maintenance of the project facilities. Apart from reducing greenhouse gas emissions, the project will be reducing harmful pollutants and suspended airborne particulate matter.

Moreover, it will encourage and promote the deployment of power generation plants that use efficient renewable energy.

[38] http://cdm.unfccc.int/Projects/DB/SGS-UKL1237544831.86/view

Sector: Energy demand

Project 0173

Title: Moldova Energy Conservation and Greenhouse Gases Emissions Reduction[39]

Host Country: Republic of Moldova

Other parties: Canada, Netherlands, Italy, Denmark, Finland, Sweden, Luxembourg, Switzerland, Austria, Germany, Belgium, Japan, Norway, Spain

Registration date: 29 Jan 06

Description: This project aims at greenhouse gas emission reductions as a result of efficiency improvements and fuel switching measures for a series of public buildings, such as kindergartens, schools, vocational schools, hospitals, clinics etc. The project was designed to address rehabilitation and upgrade of the deteriorated heating systems of public buildings.

Sustainable Development: The main benefits of the project include the reduction of fuel consumption through energy efficiency measures and the improvement of the heating service quality.

Moreover, the project makes hot water available and affordable in buildings such as hospitals, clinics, schools and orphanages. Furthermore, it improves room heating temperature and increases duration of the heating period.

Sector: Manufacturing industries

Project 0930

Title: Energy Efficiency Improvement Project At A Beer Brewery In Lao PDR[40]

Host Country: Lao People's Democratic Republic; **Other countries:** Japan;

Registration date: 07 Apr 07

[39] http://cdm.unfccc.int/Projects/DB/DNV-CUK1134568842.81/view
[40] http://cdm.unfccc.int/Projects/DB/DNV-CUK1171447004.47/view

Description: The purpose of the proposed project is to improve energy efficiency of a beer brewery of in Vientiane, Lao People's Democratic Republic. Beer production process - brewing and bottling lines in particular - requires a lot of steam and hot water. There are four boilers in the brewery that burn heavy oil to produce steam. The project introduces three facilities that are designed to improve energy (fuel) efficiency.

Sustainable Development: Lao People's Democratic Republic has no indigenous oil resources and is suffering from surging oil prices. Therefore, energy conservation and reduction of oil imports are some of the country's priorities. The project will demonstrate a good example of technology transfer to Lao People's Democratic Republic from Japan and trigger more investment and efforts in technology development. Burning fuel causes emissions of gases such as SOx and NOx into the air. The project activity will help reduce these emissions and improve the quality of environment.

Sector: Waste handling and disposal

Project 2250

Title: Abidjan Municipal Solid Waste-To-Energy Project[41]

Host Country: Côte d`Ivoire; **Other countries:** Switzerland; **Registration date:** 24 Jun 09

Description: This is the first CDM project ever registered in the West African Economic and Monetary Union (UEMOA). The project owner will collect and treat 200,000 tons of urban waste per year in a new facility located in Bingerville, north of Abidjan. After collection and sorting, waste will be treated through anaerobic digesters. The resulting biogas will be used to produce electricity while residual waste will be transformed into compost and sold to local farmers. The technology is provided by an Italian manufacturer specialized in engineering, planning & turnkey building of urban and industrial waste treatment plants. The project is expected to avoid more than 71,000 tons of CO2 eq. per year.

[41] http://cdm.unfccc.int/Projects/DB/TUEV-SUED1222949156.26/view

Sustainable Development: The project will reduce GHG emissions as it produces electricity from a renewable source and thus displaces fossil fuel-based grid electricity generation. The treatment plant is expected to create more than 210 jobs (140 the first year of operation) including high qualified positions such as engineers. The company plans to hire a significant part of graduates. The project will also provide compost to local farmers. This compost will replace the use of chemical fertilizers in the local agriculture. The technology selected for the project activity is the most advanced and innovative municipal waste management system to be implemented in West Africa so far. It will be the first of its kind within the whole region.

Project 2527

Title: Co-composting of EFB and POME project[42]

Host Country: Guatemala; **Other countries:** None; **Registration date:** 18 Jul 09

Description: The main objective of the project is to reduce the pollution potential of organic agricultural waste to surface and ground water by implementing an aerobic composting process of its waste streams.

It consists of co-composting Empty Fruit Bunches (EFB), a solid waste generated during the palm oil extraction process that would have been left to decay anaerobically in an unmanaged and uncontrolled disposal site along with Palm Oil Mill Effluent (POME) that is treated in existing anaerobic lagoons before discharge. The project activity will result in the avoidance of large quantity of methane that would have been released in an uncontrolled manner into the atmosphere from the anaerobic decay of EFB and POME in the disposal site and lagoons respectively.

Sustainable Development: This is the first composting plant of agricultural waste in Guatemala. It will lead the way for ‘best waste management practice’ in the palm oil industry, transfer new technology and develop know-how. The project will reduce green house gas emissions by avoiding the release of methane from the disposal of EFB in an unmanaged and

[42] http://cdm.unfccc.int/Projects/DB/DNV-CUK1239834511.65/view

uncontrolled disposal site and from the anaerobic lagoons for the POME. The reduction of anaerobic lagoons usage will reduce health and safety problems associated with uncontrolled release of biogas into the atmosphere. Furthermore, the project will provide a sustainable way to produce natural compost rich in nutrient elements (like nitrogen, phosphorous, potassium), humic acid and organic matters that will be absorbed into the soil.

Sector: Afforestation and reforestation

Project 1578

Title: Uganda Nile Basin Reforestation Project No.3[43]

Host Country: Uganda; **Other countries:** Italy; **Registration date:** 21 Aug 09

Description: Uganda has to expand its wood resources substantially to meet the growing demand of wood products and to reduce the strong pressure on the remaining natural forests. According to FAO, Uganda has one of the highest deforestation rates in the World with 2.7% per year. Due to investment barriers tree planting for timber production is only viable if public incentives are provided. This small-scale project is part of a project cluster of 5 similar projects aiming at providing a new financing mechanism to overcome the current barriers, increase timber plantations in Uganda and allow communities to benefit from the CDM. The main investor is responsible for 93% of the investor shares and proportional area. Community groups will manage the remaining 7% of the project area.

Sustainable Development: The project is expected to remove 29,795 tCO2 by 2012. Community groups will be paid for the carbon sequestered by the main investor up-on delivery. They will also have the opportunity to gain advanced know-how of reforestation, forestry management and agro-forestry through the project.

[43] http://cdm.unfccc.int/Projects/DB/JACO1200649370.95/view

Project 2694

Title: Reforestation of croplands and grasslands in low income communities of Paraguarí Department, Paraguay[44]

Host Country: Paraguay; **Other countries:** Japan; **Registration date:** 06 Sep 09

Description: The purpose of the project is the reforestation of lands that are currently croplands and grasslands under poor soil conditions. The project area is fragmented in small parcels of land located in low income communities. The land owners are low-income, small-scale farmers that have limited knowledge on more appropriate soil management practices. The Project will be developed by the Japan International Research Center for Agricultural Sciences (JIRCAS), an agency affiliated with the Japanese Ministry of Agriculture, Forestry and Fisheries, in cooperation with Instituto Forestal Nacional (INFONA), an institute specialized in forest management.

Sustainable Development: Environmental Benefits The project will reduce the amount of GHG in the atmosphere by CO_2 capture through the tree growth. The project will also contribute to prevention of soil erosion by planting trees on areas that were under-utilized or mismanaged. Furthermore, the project will contribute to poverty alleviation and improvement of environmental conditions (biodiversity conservation and soil erosion control). The planting of trees will also protect the farms and homes from strong winds.

Sector: Agriculture

Project 0363

Title: Angkor Bio Cogen Rice Husk Power Project[45]

Host Country: Cambodia; **Other countries:** Japan; **Registration date:** 10 Aug 06

[44] http://cdm.unfccc.int/Projects/DB/TUEV-SUED1245074838.6/view
[45] http://cdm.unfccc.int/Projects/DB/DNV-CUK1144657688.42/view

Description: The project is designed to use for electricity generation rice husk that would otherwise be left to decay. It involves the construction and operation of new rice husk power generation plant adjacent to a rice mill in Kandal province in Cambodia. The rice mill has been using diesel oil to generate electricity for the rice mill operation. The project will displace the use of diesel oil for power generation at the rice mill and will also avoid methane emissions that would be produced from rice husk left to decay in the absence of the project.

Sustainable Development: The project reduces GHG emissions by utilizing renewable energy sources that would have been abandoned. Furthermore, it leads to technology transfer to Cambodia, displaces the use of diesel oil and contributes greatly to decreasing dependency on fossil fuel and imported oil.

Project 0452

Title: Lusakert Biogas Plant (LBP), methane capture and combustion from poultry manure treatment[46]

Host Country: Armenia; **Other countries:** Denmark; **Registration date:** 11 Sep 06

Description: The purpose of this project is to mitigate animal-effluent related GHG emissions, by improving practices of animal waste treatment. The project consists of an advanced improvement to the common practice of poultry waste treatment, reducing a significant volume of greenhouse gases. The expected result from this project activity will be a significant reduction in the volume of methane (CH_4) emissions compared to those emissions that would otherwise occur in a scenario with traditional poultry manure treatment systems.

Sustainable Development: The project will effectively mitigate odor from treatment of the poultry manure through the use of digesters as opposed to anaerobic lagoons. The total estimated reduction of GHG emissions is 63,000 tonnes per year of CO_2 equivalent.

6.2 CDM project activities in the tourism sector

[46] http://cdm.unfccc.int/Projects/DB/DNV-CUK1149167618.2/view

The few case studies presented in this section are the only CDM project activities, registered or in the process to be, that have a clear link with the tourism sector even if for most of them is not direct, however in a couple of projects the situation is different, the clear link is there and the main purpose is to integrate CDM opportunities into tourism business operations.

The first four projects are all owned by the same company active in the tourism sector. The Sun-n-Sand Hotels Pvt. Ltd. is the flagship Company of the Sun-n-Sand Group. The Company was incorporated on 29^{th} June 1961 in Maharashtra with the main object to carry on hotel and resort business.

The CDM project activities, all of small scale, proposed by the Sun-n-Sand Hotels involves construction and operation of wind mills which are proposed to generate and supply power to Maharashtra State Electricity Distribution Company Limited as well as to supply all the power needs of the Hotels to which they are connected to. They hence displaces the electricity which would have other wise been generated from the power plants connected to the grid. The power plants connected to the western regional grid are predominantly fossil-fuel fired.

These projects while being an interesting and clear example of the tourism sector working towards the objective of fighting climate change they are not yet fully the expression of the potential of the tourism sector to incorporate in its activities practices that would achieve multiple objectives, in fact for these projects the main business goal and profit is the generation of clean energy to be then sold to the grid.

The details of the four project are below.

Project 0559

Title: “Generation of electricity from 4 MW capacity wind mills by Sun-n-Sand Hotels Pvt. Ltd. at Supa, Maharashtra”[47]

Host Country: India **Registration date:** 24 Sep 06

Project 0447

Title: “Generation of electricity from 6.25 MW capacity wind mills by Sun-n-Sand Hotels Pvt. Ltd at Soda Mada Rajasthan ”[48]

Host Country: India **Registration date:** 29 Sep 06

Project 0560

Title: “Generation of electricity from 1.2 MW capacity wind mills by Sun-n-Sand Hotels Pvt. Ltd. at Satara, Maharashtra”[49]

Host Country: India **Registration date:** 01 Oct 06

Project 1542

Title: “Generation of electricity from 9.6 MW capacity wind mills by Sun-n-Sand Hotels Pvt. Ltd. at Bhambarwadi, Maharashtra”[50]

Host Country: India **Registration date:** 17 Jun 08

Description: The Sun-n-Sand group is a hotel chain in India that has invested in the renewable energy market by setting up wind mills in Maharashtra, a state located on the western coast of India. There are now four projects registered under CDM, supplying electricity either to third parties or the state grid. The projects involve the installation of several wind turbine generators, which produce power from a cleaner and greener source.

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47 http://cdm.unfccc.int/Projects/DB/RWTUV1155574931.3/view
48 http://cdm.unfccc.int/Projects/DB/RWTUV1148677512.84/view
49 http://cdm.unfccc.int/Projects/DB/RWTUV1155575551.27/view
50 http://cdm.unfccc.int/Projects/DB/RWTUV1200565962.09/view

Sustainable Development: The projects aim to reduce greenhouse gas emissions and other air pollutants occurring from fossil fuel extraction, processing and burning. They are also expected to help meet the electricity demand in Maharashtra, pave the way for rural and infrastructural development of the surrounding areas, and encourage other entrepreneurs to adopt new technologies and invest in wind energy.

A fifth project of the same kind and approach, but with different ownership, is currently still in the validation phase and once all the official steps are concluded it can be submitted for registration and therefore once received start the implementation phase and the generation of credits. The details of the project are below.

Title: "1.2 MW Wind Power Generation Project in Gujarat for Hotel Golden Emerald"[51]
Host Country: India
Description: Hotel Golden Emerald is part of a business group involved in sectors such as construction, power generation and hospitality services. The promoters of the company decided to invest in the renewable energy sector by setting up wind mills as a corporate commitment towards sustainable development. The project involves the installation of several wind turbine generators in some villages in the state of Gujarat. The purpose of the project is to produce power from a cleaner and greener source. The project participants have signed a power purchase agreement with Gujarat Energy Transmission Corporation Ltd. (GETCO).
Sustainable development: The project reduces the consumption of fossil fuels for electricity generation, assists in the economic development of remote villages in Gujarat and supports the rural and infrastructural development in the areas around the project. As a result of the investment, many utility units have opened up in the area, providing employment opportunities

[51] http://cdm.unfccc.int/Projects/Validation/DB/8OVQKEZZQE8ZI5S60GDQG0YRDJLIH1/view.html

to local people. It is expected that the successful implementation of the project will encourage other entrepreneurs to adopt new technology and invest in wind energy.

If for the five projects above the link with the tourism sector was indirect, the situation is completely different for the project below which worth to be analyzed in much more details after the introductory facts are presented.

Project 0686

Title: “Improvement in Energy Consumption of a Hotel”[52]

Host Country: India; **Registration date:** 18 Nov 06

Description: The project aims to implement and encourage energy efficiency measures at the business resort ITC Hotel Sonar Bangla Sheraton & Towers at Kolkata, India. The hotel was designed to meet all levels of occupancy and restaurant activities. The hotel launched a series of energy studies, which identified areas of possible energy savings. Those areas required additional investment and the adoption of new energy saving technologies in the heating, ventilation and air conditioning system of the hotel. In 2004, the hotel embarked upon a voluntary initiative to reduce energy consumption across various sections of the hotel, with an objective to contribute towards the cause of greenhouse gas reduction, wherever possible.

Sustainable Development: The project essentially reduces electricity consumption by the hotel and thus allows the electricity to be used for other important activities in the state. The project also leads to reduction of greenhouse gas emissions and pollution associated with extraction, processing and transportation of the fossil fuels. It is expected that this could set an example in the hospitality sector to adopt small but effective energy efficiency measures.

[52] http://cdm.unfccc.int/Projects/DB/DNV-CUK1160721623.56/view

Photo 1: The hotel premises

This project aims to implement and encourage energy efficiency measures both at the generation and demand side of energy being consumed by the new hotel unit (commercial building(s)) and thus **reduce greenhouse gases emissions directly or indirectly attributed** to the business activities being carried out **within the hotel facility**.

In the year 2002, the ITC Welcomgroup - Hotels, Palaces and Resorts, unveiled one of the Asia's finest business resorts, the ITC Hotel Sonar Bangla Sheraton & Towers, at Kolkata, India http://www.itcwelcomgroup.in/Hotels/itcsonar.aspx . The hotel building(s) has been designed with modern-day architectural concepts and building technology. Most recently, the Association of British Travel Agents (ABTA) in the April 2004 issue of its magazine Business and Travel, declared ITC Hotel Sonar Bangla Sheraton & Towers, Kolkata as one of the best hotels in the world. At the time of construction all architectural specifications were perceived with environmentally responsive sustainable building designing concept and followed laid down guidelines from India National Building Codes. The hotel has been designed to meet all level of occupancy and restaurant activities. However, as is often the case, hospitality industry has its own idiosyncrasies in operation and thus has every hotel has its own unique energy consumption pattern along with load flux and seasonal variations. To understand such consumption pattern and the factors that influence such behaviour requires intensive study with considerable effort and investment. Similarly, Hotel Sonar Bangla launched energy studies to understand the behavioural energy load pattern of the hotel and identified the influencing features. A third party energy audit team conducted energy audit across the hotel along with in-house engineers. The study unfolded many opportunities wherein excess energy was being consumed as the design specification could not envisage the existing energy load pattern of the hotel business and did not incorporate certain seasonal variations. The study also identified areas of possible energy savings that required additional investment and the adoption of new energy saving technologies in the heating, ventilation and air conditioning system of the hotel. In the year 2004, Hotel Sonar Bangla embarked upon a voluntary initiative to reduce energy consumption across various sections of the hotel, wherever possible with an objective to contribute towards the cause of greenhouse gas reduction.

Photo 2: The hotel exterior

It is clear that in this case, the CDM project activity and the benefits associated with it are directly related to tourism activities. In addition, the energy produced and not utilized in situ is sold to the local grid, therefore increasing the revenues of the project activity in addition to the CERs generated.

The project activity has also identified its contribution to the sustainable development goals of the country and the region where it is located. These can be summarized as follows:

Social well being: The CDM project activity essentially reduces electricity consumption by the Hotel Sonar Bangla thus allows the electricity to flow to other important activities in the state. Electricity is one of the basic amenities always in demand due to lack of supply, hence the project contributes towards meeting the electricity needs of the people to the extent the electricity displaced for coming 10years in the state and thus leading to improvement of quality of life of the people in the state.

Economic well being: The CDM fund expected from the project activity will encourage Indian hotels for investing in energy efficient projects/ initiative and contribute towards meeting the energy demand of the people in the country.

Environmental well being: As an objective of all CDM project activity, the project also leads to reduction of GHG emissions from anthropogenic sources. None of the measure included as a part of the CDM project activity leads to depletion of natural resource or environmental degradation. Instead, the project activity leads to direct and indirect savings of fossil fuels (such as HSD at hotel site and coal at thermal power plants connected to the local grid – which are non-renewable resources) and reduction in pollution associated with extraction, processing and transportation of the fossil fuels. Thus the project leads to overall improvement of environment due to reduced usage of fossil fuels in anthropogenic activities directly or indirectly attributed to the project.

Technological well being: The CDM project activity will encourage other similar facilities in the hospitality sector to adopt small but effective energy efficiency measures to save energy and become green in operations.

In conclusion, it appears evident that this example itself answers the underlying question of this research in a positive way. Yes, the CDM can achieve multiple objectives. A flexible instrument created under the Kyoto Protocol with the main purpose of fulfilling the needs of countries in addressing the global issue of climate change and which has fully demonstrated to be a power tool to reduce GHG emissions, contribute to sustainable development and generate financial benefits for those implementing it can become also the right instrument to be applied in the tourism sector with proven success and ready to be replicated in other part of the world

6.3 A special case

The following case study is of a different nature from the previous ones and so far an unique case in combining a CDM project in the energy sector with clear social benefits in a source of financial returns, sustainable development benefits and a tourist destination in itself. The basic elements of the project are reported below, followed by a more detailed analysis.

Project 0079

Title: Kuyasa Low-cost Urban Housing Energy Upgrade Project, Khayelitsha (Cape Town)[53]

Host Country: South Africa; **Other countries:** None **Registration date:** 27 Aug 2005

Description: The residents of Khayelitsha, a low-income housing development on the outskirts of Cape Town, have turned to the sun to provide for their heating needs in Africa's first project registered under the Clean Development Mechanism. The project improves thermal performance, lighting and water heating efficiency of the housing units, which have been equipped with insulated ceilings, solar water heaters and energy efficient lighting.

Sustainable development: The families in Kuyasa have not only managed to cut their electricity costs, but are also doing their bit to reduce harmful greenhouse gas emissions. Each

[53] https://cdm.unfccc.int/Projects/DB/DNV-CUK1121165382.34/view

solar water heater helps save around 1.29 tonnes of carbon dioxide per household annually from being emitted. Other co-benefits of the project include a reduction in local air pollution with subsequent decreases in pulmonary pneumonia, other respiratory illnesses and carbon monoxide poisoning.

The Kuyasa CDM Pilot Project involves the retrofitting of solar water heater (SWHs), insulated ceilings and energy efficient lighting in over 2 300 low-cost homes in Khayelitsha, Cape Town, South Africa. The project will see an immediate impact on the social, health and economic well-being of the targeted beneficiaries. It is South Africa's first internationally registered CDM project and was the first Gold Standard Project to be registered in the world.

The project has generated substantial interest locally and internationally as a pilot for the energy-efficient adaptation of South African low-cost housing.

The Kuyasa project was developed by the nongovernmental organisation (NGO) SouthSouthNorth (SSN) for the City of Cape Town's Environmental Resource Management Department and Urban Renewal Programme. Ten pilot houses were adapted 6 years ago, providing the practical data for an efficiency measuring system. Now, with funding from the Department of Environment and Tourism's (DEAT's), Social Responsibility Programme and Provincial Government's Department of Housing, the retrofitting of 2,300 houses started in August 2008 and is scheduled to be completed soon. http://www.kuyasacdm.co.za/index.php

Photo 3: The suburb of Khayelitsha in Cape Town which became part of the CDM project

The link to the tourism sector is in this case quite exceptional, in fact **it is the CDM project itself which became a tourist attraction**. Visitors interested in getting to know more about the project and the community, Kuyasa CDM, the company responsible for the implementation of the project, is offering guided tours through Kuyasa.

Kuyasa CDM is offering tours for individuals, school classes, conferences and workshop groups. Their guides have been working with tourists for a couple of years now and have a great sense of the interests and needs of people coming as visitors to a low-income settlement. Their guides live in the area with their families and are extremely knowledgeable about the community and the project. They also have a lot to share about South African and Xhosa culture.

They have coined a very appealing slogan which is more future looking than many developed world initiatives and in one sentence it includes all the messages about the benefits of the CDM to the point that it became a tourist attraction: **"Come and see how Carbon**

Finance is making a real difference to people's lives, alleviating poverty and addressing pro-poor development".

Photo 4: The interior of a house after the switch to modern energy source

The standard tour they are offering includes the screening of a 6 minute video about climate change and the projects contribution to addressing this. Visitors then move from the site office by foot on a 30 minute walk through the community. Visitors will see the technology and material used in the project and be able to watch work currently in progress on some of the homes. Visitors will be able to speak to residents of houses with completed installations, about the impact on their lives and experience Kuyasa with all its faces. After the tour time is allocated for questions and discussions.

Photo 5: The CDM, changing lives and becoming a welcoming tourist attraction

If this example is a unique case or the beginning of a virtuous trend of new tourist attractions around the world is too early to be assessed and only time will tell however it is a clear demonstration that multiple objectives can be achieved if the proper tools are available, incentives are provided and creativity has space to grow.

CONCLUSIONS

The underlying question which was at the basis of this research work was: "Can the Clean Development Mechanism (CDM) achieve multiple objectives?"

This research has demonstrated that this powerful tool to reduce GHG emissions created by the Kyoto Protocol under the United Nations Framework Convention on Climate Change has still a huge untapped potential to achieve other objectives beyond those for which it was established to address climate change.

The main purpose of the CDM is to help countries under the Kyoto Protocol to meet their emissions reduction targets and therefore to mitigate the effects of climate change. In addition, it contributes to the achievement of sustainable development goals of host countries, facilitates international cooperation, provides opportunities for technology transfer and generates a set of green practices and measures at the national, local and individual levels.

Given the above purpose the CDM covers a broad range of sectors in which project activities can be implemented, mainly in the energy sector. However, it was never explicitly linked to activities pertaining to the tourism sector.

In these days climate change is the biggest global environmental concern and this issue has permanently reached the highest levels of the international political agenda as it has been demonstrated at the Copenhagen conference in December 2009 when more that one hundred Heads of State participated in person to the negotiations in order to reach an agreement for a future climate change regime that would substitute the Kyoto Protocol at the end of 2012.

The tourism sector is both suffering from and contributing to climate change and the shift towards a more sustainable tourism has now become an imperative for tourism stakeholders in a broad sense.

What it is crucial now is to ensure that tourism stakeholders integrate climate change into their broader institutional, industry, sectoral, policy and national goals and programs, i.e., ‘mainstreaming’ climate change into all institutional, private, and not-for-profit tourism development and planning strategies and tourism business strategies.

Mainstreaming climate change in the tourism sector is challenging and often seen not as a priority, however recently, through intense activities and campaign at the international level the operationalization of this concept has made substantial progress.

What the tourism sector perhaps needs, in addition to existing policies and practices already available, is an innovative tool which can bring multiple benefits, including the provision of additional financial resources to those implementing these activities.

As the case studies presented in this research have indicated the CDM can serve these purposes and this is already happening in different and creative ways. The results are quite promising and looking into the future it would not be surprising to see a large number of CDM project activities implemented in the tourism sector.

Sustainable development has been defined in many ways, but the most frequently quoted definition is from Our Common Future, also known as the Brundtland Report: "Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs”.

All definitions of sustainable development require that we see the world as a system, a system that connects space; and a system that connects time. With this in mind, the link to the tourism sector is immediate. We are all involved in the global fight against climate change and the tourism sector has and will have a crucial role to play.

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Chapter II

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