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CLIMATE CHANGE AND FUTURE ADAPTATION

LUČKA KAJFEZ BOGATAJ*

ABSTRACT: *This paper provides a summary of the current scientific understanding of the International Panel on Climate Change (IPCC) on the natural and anthropogenic drivers of changes in global climate. It presents an overview of observed changes in the climate system and their relationships with physical processes as well as an overview of projections for future climate changes. A summary of observed climate changes in Slovenia in the last decades is given and future projections are discussed. Europe has warmed by almost 1°C in the last century, faster than the global average. Precipitation has significantly increased in northern Europe, whereas drying has been observed in the Mediterranean. Continuing the observed trend, average precipitation as well as extreme precipitation are very likely to further increase in most of northern Europe whereas precipitation is very likely to decrease in the Mediterranean. The reduction of precipitation in summer in Slovenia is expected to have serious effects, e.g. more frequent droughts, with considerable impacts on horticulture and the availability of water. Adaptation can reduce vulnerability to climate variability and change. This paper also discusses the appropriate responses to climate change from the mitigation and adaptation points of view.*

Key words: *IPCC; Future projections; Mitigation: External costs; Ecosystem services*

UDC: 502:33

JEL classification: Q57

1. INTRODUCTION

Climate affects ecosystems' development, water sources, food production, the production and use of energy, traffic, industrial activity along with the people's health. In the last few decades we have been witness to ever more obvious changes to the climate (Luterbacher et al., 2004). The most obvious changes are seen in the heating of our planet, which has been proven by physical measurements. The last 15 years have been the warmest since at least 1850. Climate change will continue even more clearly and changes will occur in the global climate system, which is made up of the atmosphere, hydrosphere, the surface of the earth (covered by ice and snow), the biosphere, and their interaction (IPCC, 2007).

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It not only involves rising air, ground, and ocean temperature, but also with changes in humidity, clouds, rain patterns, the strength and frequency of weather events (fog, snow, storms), and the damage done by weather. The consequences of climate change can strongly affect the earth's ecosystems (EEA, 2004; Schröter et al., 2005).

With better knowledge of the subject, our data on the climate now stretch far back into history. Although the climate of our planet has changed and sometimes drastically so in the past, the changes we see today are due to mankind. Humankind is quickly changing the composition of the atmosphere by emitting more and more greenhouse gases (GHG) and is doing so through changes in land use, deforestation and the characteristics of the terrestrial surface. The amount of CO_2 in the atmosphere today is the highest in the last 650,000 years. GHG cause the greenhouse effect and, because we are increasing their presence in the atmosphere, we are decreasing the permeability of the atmosphere in relation to surface radiation. This increase in the surface's temperature then also causes a greenhouse effect.

Climate change presents a double challenge today. First, severe climate change impacts can only be prevented by early, deep reductions of greenhouse gas (GHG) emissions. Second, with climate change already happening societies around the world face the parallel challenge of having to adapt to its impacts as a certain degree of climate change is inevitable throughout this century and beyond, even if global mitigation efforts over the next decades prove successful.

2. FINDINGS OF THE IPCC (INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE)

The amount of CO_2 in the atmosphere has been growing for the last 200 years due to human activity. The increased amount of CO_2 in the last 5 years amounts to 3.3 ppm per year. In the last few years, anthropogenic emissions of carbon have risen from 6.4 to 7.2 gigatons of C per year. Methane emissions are rising a little less quickly than in the past (0.8 ppb per year). Methane is the second most important greenhouse gas. The increased amount of GHG that has affected the climate system since 1750 is at least five times higher than the rate of natural changes in climate drivers such as the activity of the sun. In the last 10 years alone the effect of CO_2 on the radiation balance has risen by 20%.

The air and the oceans are warming, snow and ice is melting, and water levels are rising. The increase in temperature on land and in water from 1906 to 2005 was $0.74 \pm 0.18\ ^{o}C$. The most prominent rise, twice larger than in 100 years) came in the last 50 years and amounts to $0.13\ ^{o}C$ for every 10 years. The ocean has heated down to the depths of 3,000 metres. The melting of ice and the expansion of seawater have already led to a rise in sea levels. In the first half of the 20^{th} century, the trend was a sea-level rise of about 1.8 mm per year, while since 1993 it has grown by 3.1 mm a year. Satellite pictures reveal that since 1978 the Arctic ice cap has been contracting by 2.7% every 10 years, and in the summer by 7.4% per 10-year period. Permafrost in the Arctic has warmed to $3\ ^{o}C$ and today in the northern hemisphere there is 7% less seasonally frozen terrain compared to 1900. Explicitly on the mainland, at central latitudes the number of cold days per year has decreased, especially the minimum night air temperatures. In the summer time the number of warm nights has gone up.

Due to the higher air temperature and ocean temperature humidity in the air has increased. For example, specific humidity (the relationship between the mass of moisture and the mass of air) above the oceans rose in the period between 1988 and 2004 by 1.2%. Due to these events, there has been an increase in the frequency and abundance of rainfall and other such events. This has occurred in areas where the projected and tabulated annual trend of rainfall was decreasing. The shifts occurring in the amount and distribution of precipitation are more diverse than the changes in temperature. Globally, annual rainfall in the period between 1901-2004 increased by 11-21mm every 100 years. These trends vary greatly among regions. Even though there has been a global increase in rainfall there have also been more droughts, mostly as a result of the change in air circulation. These changes are reflected in stronger westerly winds and in the shifting polar fronts. Therefore, the western parts of continents are becoming warmer than the eastern parts, which is especially noticeable in winter. Since 1970 it has also become more arid, mostly in the Sahara, Mediterranean, Middle East, South Africa and South Asia. However, it is becoming wetter in the eastern parts of North and South America, in northern Europe, and in northern and central Asia.

The consequences of the rise of CO_2 in both the atmosphere and surface waters are acidifying the surface layers of the oceans. In the last 200 years the average PH value has decreased by 0.1, which means 30% growth in the concentration of hydrogen ions whose consequences are very serious for sea ecosystems. Changes are also occurring in the salinity of individual oceans since the water cycles are being altered.

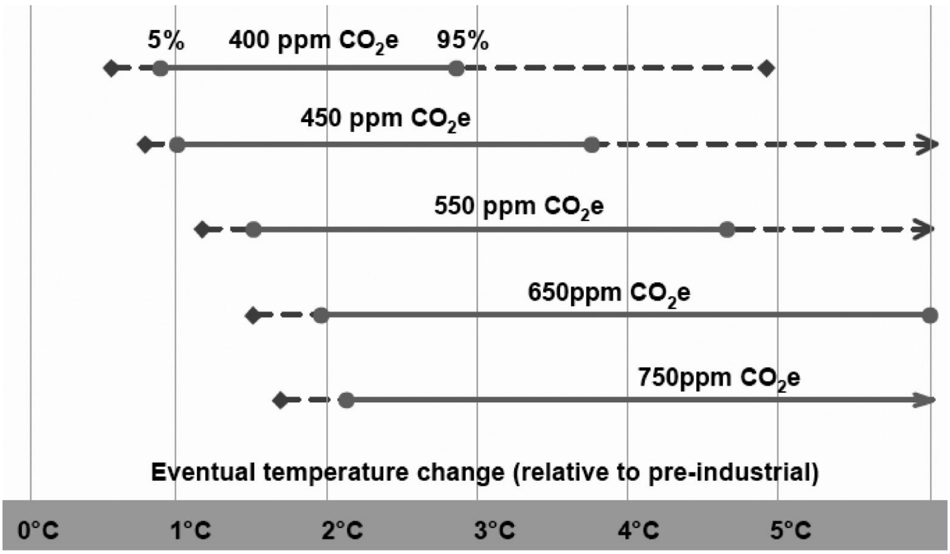
For certain parts of the ecosystem there is no hard evidence of statistically significant climate changes. Antarctica is a good example of this, yet the reason for this is a lack of data and measurements. Also, there are no fundamental changes in the circulation of the oceans. There is also too little evidence to claim that the features of tornadoes, hail storms, thunderstorms etc. are changing. In spite of improvements in meteorological measurements, the findings on climate systems are still scientifically uncertain as many regions do not have enough dense observation areas or sufficient satellite coverage.

3. HOW WILL THE CLIMATE SYSTEM RESPOND TO DIFFERENT NATURAL AND HUMAN IMPACTS?

To determine how the climate will react to different natural and human impacts we use different models of general circling, in which as a key variable we alter the amount of GHG emissions. The IPCC uses four scenario groups (A1, A2, B1 in B2) that differ due to future socio-economic actions and the final amount of GHG and aerosols in the atmosphere.

Scenarios from group A1 represent quick and global economic growth, while scenarios from group A2 foresee a diverse world with rapid population growth. The B1 scenarios introduce the idea of an early turnabout in the world's economic structure in the direction of a more cautious and information-based economy, the reduced consumption of raw materials and the introduction of cleaner and more efficient technology. In the B2 scenarios the top priorities are solutions for moderate economic growth, social equity and environmental sustainability. Most often we analyse scenarios from two groups – A2 and B2. The different scenarios of general modelling change depending on the components of the atmosphere, which shows the uncertainty of projecting future climate change.

FIGURE 1: *Time periods of rising temperature (considering preindustrial time) dependent on the amount of GHG in the atmosphere (expressed in CO_2 equivalent) adapted after Stern (2006)*



In Figure 1, an interval assessment of temperature change's dependence on GHG in the atmosphere (considering pre-industrial periods going until 2100) is shown. With GHG growing incrementally so do the degrees of future warming (Table 1). When GHG are 750ppm equivalent of CO_2 the upper bound of the global increase in temperature exceeds 7 °C. In the next 20 years we can expect with great certainty that there will be a further increase in global temperatures by at least 0.2 °C per decade. At the end of the century the increase in global temperature will depend on the amount of CO_2 in the atmosphere. In the best-case scenario that will be +1.8 °C (when looking at the time between 1961 to 1990), or in the worst-case scenario with the continued growth of GHG the average increase will be +4 °C with the upper bound being 6.4 °C.

TABLE 1: *Likelihood (in %) of a temperature rise dependent on a stable level of GHG produced (in ppm CO_2 equivalent)*

Stable Level (ppm CO2 equivalent)	**Rise in Global Temperature**					
	2 °C	**3 °C**	**4 °C**	**5 °C**	**6 °C**	**7 °C**
450	78	18	3	1	0	0
550	99	69	24	7	2	1
650	100	94	58	24	9	4
750	100	99	82	47	22	9

Regional samples of heating will be breaking the normal averages. Continental and northern latitudes will warm much more than the global average shows (EEA, 2005a and 2005b). Regional weather patterns will change. Although there are increases in global rainfall, droughts will increase, chiefly because of a change in the circulation of air which is arising due to northern winds and the shifting of the polar front. Due to drought in summer in the Mediterranean area, arguments will emerge over the division of rainfall (Eisenreich, 2005). Smaller glaciers will disappear and there will be less snow. Since there will be less snow, a positive feedback loop will occur due to the smaller albedo effect.

The sea level will rise about 30 cm, in the worst-case scenario by 58 cm. The rise in the sea level will not be the same in all places. The seas will continue to become more acidic; the pH may fall by 0.35, which means that carbon sediments will melt in shallow waters. Oceanic ice will decrease in both the Arctic and in Antarctica. There will be more abundant precipitation and heat waves. The latter will be more intense and last longer. There may be fewer tropical cyclones, but they will be stronger and more destructive. The storms that are now frequent in the tropical belt will move towards the north (Goodess, 2005).

Slovenia is also warming more quickly (Figure 2). 1978 was the last very cold year in Slovenia, but the warmest till now was in 2000. It was hot and dry in the summer of 2003, the autumn of 2006, while the winter of 2006/2007 was the warmest to date since we have begun measuring air temperature here (ARSO, 2006). The most prominent heating occurs in the summer months while the least in the autumn ones. Heat waves are occurring more often and more intensely at the end of May and June. Table 1 shows a comparison of selected meteorological variables between 1961–1990 and 1991–2005 in absolute and relative terms for Ljubljana. Time changes in the annual rainfall are not statistically significant with the exception of Kočevje and Rateče. There has also been a slight increase in the intensity of showers. Although yearly rainfall is not diminishing, we are seeing more summer droughts. Of the nine worst droughts in the past 40 years in Slovenia, six of them have been in the past 15 years (Sušnik, 2006).

The general circulation model does a good job in simulating the fluidity of climatic circumstances on the global scale in the future. Yet, due to the poor spatial resolution and the direct use of the results of simulations with the general regional study, the effect on climate changes is not relevant (Räisänen et al., 2004). That is why we must adapt the scenario onto a smaller scale, such as regions or states (Bergant, 2003). Research shows (Bergant and Kajfež-Bogataj, 2004; Kajfež-Bogataj and Bergant, 2005a and 2005b) that air temperature in all of Slovenia will rise depending on the chosen scenario. Between 2001 and 2030 air temperature in Slovenia will most likely rise by 0.5 °C to 2.5 °C, in the time period from 2031 to 2060 by 1 °C to 3.5 °C and between 2061 and 2090 by 1.5 °C to 6,5 °C. Less definite are the forecasts for changes in annual rainfall, with the range falling between +10 to -30 %. Rainfall in summer will decrease by up to 20%.

FIGURE 2: *Increasing trend of annual air temperature (vertical axis in °C) in Slovenia from 1951 to 2008 (interrupted) and for the last 30 years.*

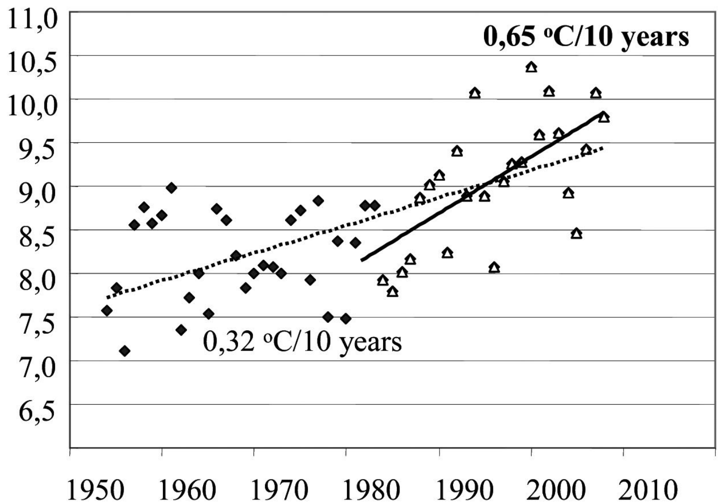


TABLE 2: *Comparison of the values of selected meteorological variables between 1961 and 1990 and 1991 and 2005 in absolute and relative terms for Ljubljana, Slovenia.*

	1961-1990	1991-2005	Change	% change
Average yearly temperature	9.8°C	11.0°C	1.2°C	
Avg. temp. of veg. period	16.1°C	17.4°C	1.3°C	
No. days with lower temp. ≤ 0.0 °C	89.6	78.8	-10.8	-12.1
No. days with higher temp. ≥ 25 °C	60.6	77.2	16.6	27.4
Average humidity at 2 p.m.	62.4 %	59.1 %	-3.3 %	
Sunshine hours (annual sum)	1,712 hrs	1,950 hrs	238 hrs	13.9
Annual rainfall	1,393 mm	1,356 mm	-37 mm	-2.7
No. of days with snow cover at 7 a.m.	64.9	49.0	-15.9	-24.5
No. of days with precipitation ≥1.0 mm	114.8	108.0	-6.8	-5.9

PRUDENCE (2005) is an EU project that projects future regional scale changes in climate. For Slovenia, the project predicts that the most noticeable change will be the rise in temperature in the summer months, especially in August. The smallest rise in temperature will happen in autumn. The change in the amount of rainfall is variable, although less rainfall in summer can be expected while in the winter just the opposite will occur. All four seasons will be warmer, winter by 3.0 to 5.1 °C (ensemble assessment 3.5 °C), spring by 2.9 to 5.7 °C (ensemble assessment 3.3 °C), summer by 4.1 to 8.6 °C (ensemble assessment 5.0 °C), and autumn by 3.6 to 5.7 °C (ensemble assessment 4.2 °C), 1 to 6.5 °C. Relative rainfall in the winter months will increase from 0 to 26% (ensemble assessment +20%), in spring the range of change is from increase by 2 % to decrease by -29% (ensemble assessment +8%), in summer it will decrease by 26 to 44% (ensemble assessment -17 %), while in autumn it could decrease from 2 to 13% (ensemble assessment -2%). In addition, the regional models are still fairly inconsistent about the relative change of the amount of precipitation in spring and summer; however, they will surely decrease strongly.

4. ANTICIPATED CONSEQUENCES OF CLIMATE CHANGE

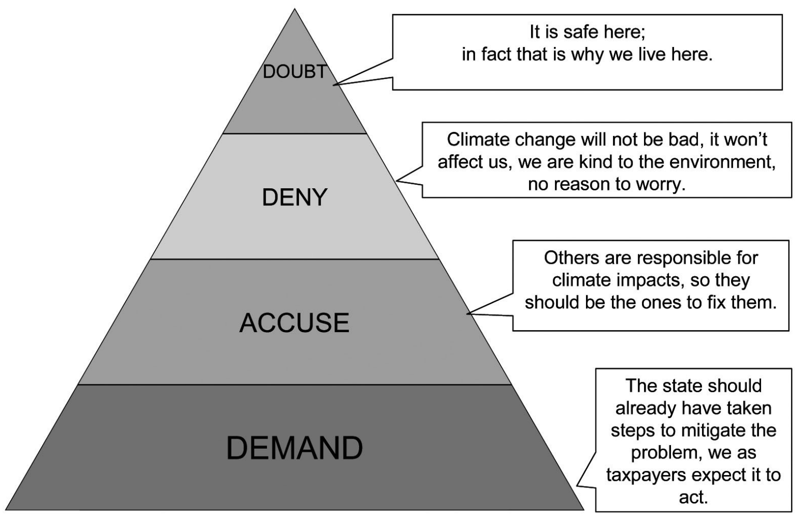
In the last three decades climate change has clearly affected several physical and biological systems around the world and it will exert an even stronger effect in the next 10 years. At first, it will prevent access to clean drinking water. Glacier water is currently the source of clean water for more than one billion people; when that disappears, they will be forced to move to different parts of the world and general uncertainty and panic will arise as a result. Most likely the number of areas experiencing drought will increase. Due to climate change a more people will be threatened by starvation; over 100 million people could suffer. Presumably around 20-30% of plant and animal life is doomed to extinction if the world temperature rises by more than 1.5-2.5°C. The rising sea level will endanger the deltas of the Nile, Ganges, Brahmaputra and the Mekong leading to more than one million people having to move from each region. Small island countries are already being affected. Climate change will have a direct and indirect effect on the health of both people and animals. The biggest dangers we must take into account are the greater number of infectious diseases and natural disasters. Diseases related to the climate are the most lethal of all.

Climate change will not spare Europe as it will affect the natural surroundings as well as every social and economic field. Because of the non-linearly of climate impacts and the sensitivity of ecosystems, small temperature changes can have big consequences. In northern Europe there is more snowfall, yet in southern Europe there are more draughts. More than half of plant life in Europe could be threatened or endangered by 2080. The most sensitive areas in Europe are southern Europe and the whole Mediterranean region in general because of the simultaneous effect of higher temperatures and smaller amounts of rainfall in areas that are already dealing with a lack of water. For example, in mountainous regions like the Alps where due to high temperatures snow and ice are melting and changing the flow of rivers. Another example can be seen in costal areas because of the rise in sea levels and a greater chance of storms. The densely populated flood plains are also at risk as a result of the high risk of storms, fierce rain and flash floods that can damage infrastructure. The two regions that will be most affected are Scandinavia where the precipitation increase will be greatest (rain not snow) and in the Arctic where the temperature difference will be larger than anywhere else in the world.

5. SOCIO-POLITICAL AND ECONOMIC ACTIVITIES CONCERNING CLIMATE CHANGE

Although we are hearing the words climate change ever more often now, they are not new. At the first conference on the climate in 1979, climatologists wrote that a rise in temperature is threatening human life and will have consequences. In 1988 the Intergovernmental Panel on Climate Change (IPCC) was formed. Yet, only in 1992 did climate change become part of other fields such as economics and politics. It was then that the UN accepted the Framework Convention for Climate Change (UFCCC) and in 1997 it ratified the Kyoto Protocol to the convention. During this time it began to form a supreme body of the UNFCCC whose responsibility was to fix concentrations of GHG in the atmosphere to a level that would counter the negative anthropogenic effect on the climate and which would work with the Conference of the Parties (COP) that takes place every year. At the same time, due to advances in climatology and because of the observed weather anomalies greater attention is being paid to climate change. It is not a problem of the distant future but the first real global environmental challenge. Humankind has experienced similar challenges. At first, doubt always prevails. It is then quickly overtaken by denial or even accusation (Figure 3). It was the economic policy of the Great Powers – chiefly the US – that was so uninterested in these happenings, unlike Europe which publically and openly discussed how to deal with climate change.

FIGURE 3: *Typical social reactions to important changes that start with doubt and end with demands*



Economists have been dealing with climate change for a while. However, it was the Stern Review on economic climate change in 2006 that helped lift the subject to new heights as the report was written with other economists in mind (Stern, 2006). The author is the well-known, distinguished British expert Sir Nicholas Stern, Head of the Government Economic Service and former Chief Economist of the World Bank. The government, more specifically the Ministry of Finance, commissioned the report. The first half of the Stern Review focuses on the findings of the IPCC and has a lot of credibility in academic circles. The report finds that the costs of extreme environmental happenings including floods, droughts and storms are rising across the board, including for rich countries. He warns that climate change will affect the basic elements of our lives – access to water, food production, health and the environment. Most of the Stern Review concentrates on the economic consequences of climate impacts; the exact economic damage that will be done to different sectors. To evaluate the costs and risks many different methods were used, including macroeconomic models, especially integrated socio-economic models. These take into account not only the economic damage of changes in the climate but also the cost of mitigating the size of climate change. This is the price of stopping the growth of GHG in the atmosphere, or ceasing to increase their concentration. Or, to put it differently, it is the price of lowering GHG emissions. By employing the results of the economic model we can assess that the total cost and risks in the event that no steps are taken to combat climate change will amount to at least a 5% loss of world GDP every year from now until forever. If we take a wider spectrum of costs and risks into account, we could estimate the damage as growing to a dizzying 20% of global GDP or more.

On the other hand, Stern measures the costs of decreased emissions of GHG. To prevent the worst consequences of climate change from occurring it would take 1% of world GDP per year. Investment in the next 10 to 20 years will have a huge affect on the climate in this and the next century. The measures we take now and in the next decade can help stop big disturbances in the world's economic and social activities much like those that occurred between the world wars and the financial crisis of the first half of the 20th century. It would be hard but not impossible to start making changes now. Briefly put – the benefits of early and resolute measures will be much greater than any later economic damage. If we act decisively, we still have time to avoid the worst consequences of climate change.

The preliminary assessment of adaptation costs in the Stern Review for building infrastructure shows that, with an average rise in world temperature of 3 to 4 °C, the additional costs needed to adapt the infrastructure and buildings in OECD countries would be 1 to 10 % of the total amount invested in construction. Additional costs for building new infrastructure and buildings that would be better suited to climate change would cost in the OECD countries anywhere between USD 15 and 150 billion per year (0.05–0.5% GDP). If we allow global temperatures to rise by 5 to 6 °C the costs of adaptation would be very high, but their relative efficiency would be lower. Financial services and insurance markets will have to find innovative ways to respond efficiently to the increasing exposure to climate-related risks.

The resolution of the Stern Review is that changes in the climate are both a global phenomenon and global problem so the answer must be an international one. All countries will be affected. The most vulnerable – the poorest countries and people – will be affected first and in the worst way even though they contributed the least to the climate change problem. Immediate and resolute actions are urgent, as are long-term goals and visions. The world needs to agree on a framework that will accelerate action in the next decade on the national, regional and international levels. The key elements of the future international framework will need to have four components. The first is the spreading of emission trading for all countries, including the USA, China and India. Second, co-operation in the field of technology where there is a desperate need for efficient investment in innovation around the world. Another key component will be to stop the destruction of forests, in Brazil for example. Finally, the fourth component of the frameworks is adaptation. This includes rich countries helping the poorest ones that will be the most affected by climate change. Also international financing should support better regional notification of the consequences of climate change and research into new crops that could be more resistant to drought and floods.

6. VIEW ON MITIGATING AND ADAPTING TO CLIMATE CHANGE

Today climate change represents a dual challenge. First, the real consequences of climate change can be prevented with the early and thorough reduction of GHG. A quick shift to a world economy that is based on low emissions of carbons is urgent for us to counter the possibility of temperatures rising by more than 2°C in comparison to the time before industrialisation. Were temperatures to change by more than 2°C there are risks that cannot be identified and the costs of adaptation would rise to frightening heights. That is why a new international treaty is needed as the Kyoto Protocol did not create a big shift in this direction. In Europe, the Heads of State and the Government of the EU said in their spring session 2007 that they are unanimously announcing that GHG emissions must be lowered by 20% by 2020. In the event that a new international treaty is agreed then they would further reduce emissions by 3%. In addition, the EU is calling on the international community to cut emissions by 50% by 2050, returning then to 1990 levels.

6.1 The Possibility of Mitigation

In the opinion of the IPCC (2007), in all business sectors there is economic potential to limit emissions of greenhouse gases. The higher the cost per tonne of CO_2, the less emissions of CO_2 into the atmosphere there will be. The price of up to USD 50 per tonne equivalent of CO_2 allows for levels to reach 550 ppm CO2. If the price were USD 100 dollars per tonne equivalent of CO_2 it would allow for levels of between 450 and 550 ppm equivalent of CO_2. This would lead to a global air temperature rise of 2-3°C compared to the time before industrialisation. In theory the higher price of fossil fuels would trigger bigger demand for alternative energy. The market potential for lower emissions is below market levels but a mixture of different political measures could help fill in the gap. The

IPCC judges that the biggest potential lies in savings via energy production: greater efficiency, more combinations of heat and strength, renewable energy, a transition from gasoline to gas. Higher energy efficiency standards of buildings are seen as being in second place by the IPCC.

The macroeconomic costs of establishing the content of greenhouse gases at a level of between 445 and 535ppm equivalent of CO2 are thought to be 1-2 % (at most 3%) of global GDP. Put differently, the costs of restraining global warming are still acceptable at 2 to 2.4 °C, each year costing less than 0.12 percent of world gross domestic product. So we could stop the worst consequences of global warming and limit the growing temperatures, but the emissions of greenhouse gases must stabilise in the next eight years, by 2015. Before the middle of this century emissions must drop in comparison to 2000 by 50 to 85 percent. The costs of climate change are not manageable. Costs could be smaller in an economic sense if politics were to encourage technological change. Middle-term goals like the modernisation of energy infrastructure in developing countries could develop a path to the long-term reduction of greenhouse gases. Renewable resources and higher energy efficiency could lead to better energy security, employment, and air quality. Renewable resources could represent 30 to 35% of all energy production by 2030, even when it comes to the prices of emissions of USD 20 to 50 per tonne equivalent of CO_2. It is becoming clear that the rise in emissions caused by traffic is the biggest. The market will not stop such growth, especially when it comes to air traffic. What is needed here is government action.

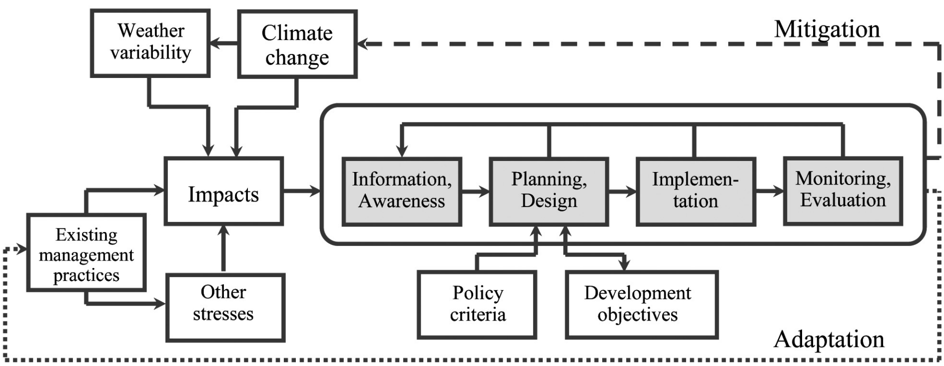
Global emissions of GHG must begin to decrease right after 2030. The next 20 years will decide how large the rise in average world temperature will be and what the consequences of climate change will be or how much damage we can avoid. If we limited GHG to 445 to 490 ppm equivalent $CO_{2,}$ the global temperature would rise by between 2.0 and 2.4 ^{o}C, although emissions must begin decreasing in 15 years and by 2050 they must be 50% less than they are today. If we constrained GHG emissions to 535-590 ppm equivalent CO_2 then the global temperature would rise from 2.8 to 3.2 ^{o}C, but at the emissions rate of 590-710 ppm equivalent CO_2 the global temperature would rise from 3.2 to 4.0 °C. The effects and consequences will be disproportionally bigger, especially with the sea-level rise. In any case, the costs of taking steps now are still smaller than the damage that would result from the effects of global warming.

In terms of concrete steps that must be taken, the first is to determine the right price for CO_2 emissions so that it will make sense to invest in the technology of low-emission products. The role of government, public investments and new laws is indispensible here (GHG taxes, standards, global emissions trading scheme, permits for emissions, voluntary agreements etc). Countries in development need new technology. It would help fulfil the Kyoto protocol (of which the price is thought now to be lower), especially to promote new international treaties. Also, we have to keep in mind that the measures for lowering green house gases have additional positive effects, including better energy safety, new investments, employment, and bigger air quality which means fewer heath problems.

6.2 Adaptation

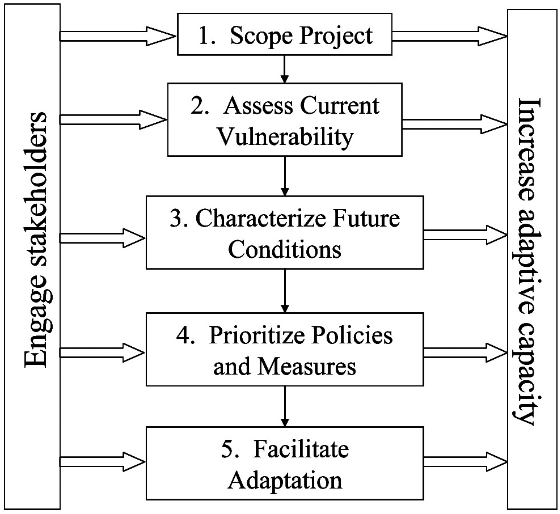
As the climate is already changing, communities all over the world have to fight the challenge of adapting to the consequences. Even if we start to act to change our activities and they prove to be successful, they will not be able to stop the climate change that is currently occurring. Adapting to climate change is becoming inevitable and necessary and it is a good supplement to mitigation. However, adaptation is not a good alternative to cutting greenhouse gas emissions. It is limited and when a certain temperature is reached some consequences of climate (i.e. human migration) will become serious and irreversible. It would be ideal for the result to apply to both goals, meaning also to lowering the emissions of GHG. Adaptation can be understood as an adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. Various types of adaptation can be distinguished, including anticipatory and reactive adaptation, private and public adaptation, and autonomous and planned adaptation. Adaptation, like mitigation, has to take into account not only climate change but also other stresses and environmental issues while having clear policies and development goals (Fig. 4). Immediate benefits can be gained from better adaptation to climate variability and extreme events, as well as by removing maladaptive policies and practices (Klein, 2006).

FIGURE 4: *Adaptation and mitigation have to take into account not only climate change but also other stresses, and environmental issues while having clear policies and development goals (Klein, 2006)*



When preparing projects for adapting to climate change we must taken some international experiences stimuli (Lemmen and Warren, 2004; Smith and Pilifosova, 2003, Jones and Mclnnes, 2004). The project-planning stage must at the beginning include different interdisciplinary fields such as commerce, agriculture, insurance, politics and other fields (Figure 5). This type of approach ("bottom-up" method) would better connect contributors and the overall process with the project. The participants would probably be more interested in the results of a project if they worked on it since the beginning than if they were just told to deal with the new rules put in place.

FIGURE 5: *Chart of the adaptation policy framework*



Another essential aspect is that when dealing with future climate change we look into the past and present and see the damage done to certain branches of business. The job of meteorologists is to first rate the current exposures (e.g. to various natural disasters). In the same way it is possible to assess with what type of adaptation options we are working with. This is the job of professional departments such as the Sectors' Ministry and general governmental policy. Only then can we analyze future exposure and adaptation abilities or rather future vulnerability of the economy or other fields. However, even in the field of adaptation to climate change there are numerous business opportunities. On the forefront are fields related with deterring the consequences of possible natural disasters.

When determining our vulnerability (on both the state and local levels) we first assess the exposure and sensitivity of our actions to already existing weather patterns. Only in the second step do we determine how current dependence and vulnerability will deepen or lessen the circumstance of climate change. When we conclude the aforementioned analysis, we will begin to ponder how to optimally adapt to change, again on both a state and local level. Special attention must be given to educating people. This must be done by professional staff especially in areas with a conservative and traditional background and to economic players who may not know enough about the problems that are arising.

In June 2007 the European Commission ratified the first political document on adapting to the consequences of climate change. The Green Paper on climate change adaptation in Europe – options for EU action is based on the work and findings of the European programme for climate change. The Green Paper makes four important points: developing strategies early for adaptation in fields where we have enough knowledge; including global adaptation to EU international relations (policy) and creating new partnerships around the world; filling in gaps where we do not know enough about adaptation by doing research and search information on the EU level; and, developing a EU consulting group for adaptation to climate change to analyse the harmonisation of strategies and measures.

To sum up; adaptation aims at reducing the risk and damage from current and future harmful impacts cost-effectively or by exploiting potential benefits. While adaptation action has therefore become an unavoidable and indispensable complement to mitigation action, it is not an alternative to reducing GHG emissions.

7. ARE THERE WINNERS & LOSERS?

Climate change will strongly affect global and local business. The vulnerability of every activity is a function of three elements: exposure to the effects of climate change, sensitivity, and ability to adapt. The concept of vulnerability is not simple and we therefore need to apply an interdisciplinary approach to understand it. Climate change will deepen regional differences in the EU, mostly between the North and the South. Northern European businesses will have an advantage in the first decade when compared to the Mediterranean states, which will have water shortages.

Obviously different fields will be affected differently. All of them will feel the pressure of climate change mitigation as well as adaptation. But, for many sectors, the opportunities presented by climate change may outweigh the risks. A study conducted by the German bank (Heymann, 2007) shows that different economic and political actions are urgent if we want to ease the pressure. Those less effected will be civil engineers and connected fields, mechanical and electrical engineering and the chemical industry. The industries that will be most effected by climate change will be the automotive industry and traffic in general and in all forms. Business practices tied to fossil fuels will also be negatively affected unlike those that deal with renewable sources of energy. Agriculture and forestry will be most dependent on the right political and governmental actions. Regulation in the market and policies of governments would allow for certain activities to better deal with the consequences of climate change. So climate change has not just an environmental-climatic dimension but also a regulatory-market economy dimension. Policymakers are responsible for creating planning reliability for all economic players by announcing climate policy measures as early as possible. This is essential for all the sectors that are affected since they will then be able to gear up for the coming tasks much more easily and efficiently.

8. INTERNALISING EXTERNALITIES FOR ACTIVITIES THAT CAUSE CLIMATE CHANGE

Where should the economy and politics look for a path towards solving climate change? One option is to internalise external costs for activities that cause climate change. Practically all business activities have an affect on the environment, most also add to (if not directly) climate change. Subsidies for farming, energy and transport are additional factors that hide true costs. The mixed signals of market prices of natural resources stimulate non-sustainable production and use. The most obvious and well studied of these are energy and traffic, followed by farming, tourism and others.

As participants in traffic, we cause many externalities because we do not always have good market values. Examples of this are lateness due to road congestion, health issues due to noise and air pollution, expenditure on police, management of infrastructure, hospital costs and public health expenditures and, lastly, the diminishing quality of life. We pay for all of this through taxes, but not only drivers, also those who go by bike or walk. For every 1,000 kilometres driven in the average Slovenian car we cause about €55 to €75 of external costs, of which the external costs of climate change are between €2 and €19. If we travel by train our total cost is €17 to €22, and of this we contribute €4 to climate change (Mesarec and Lep, 2006).

The production of electrical energy also has a large effect on climate change and public health. Externalities differ depending on the production methods and location of the electrical energy plant. The costs also depend on the amount of CO2 emitted from the plant, and on the amount of damage done to materials, public health and farm crops. In electrical production, the following pollutants are released into the air: nitrogen oxide, sulphur dioxide, small particles, ammonia, and easily volatile organic pieces. Based on an Externe project (Bickel and Friedrich, 2005), the costs due to climate change are €50 per tonne of CO_2 for electrical energy that is produced for 4.3 eurocents per kWh (or 73% of 5.9 eurocents per kWh of total external costs). For gas power plants the costs are around 2 eurocents per kWh (or 85% of 2.3 eurocents per kWh of total external costs). Interestingly enough, costs for hydropower are just 0.2 eurocents per kWh (or 61% of 0.3 eurocents of total external costs). Total external costs in Slovenia for 2005 are 3.5 to 10 eurocents for every kilowatt-hour. One-third of electrical energy is produced from coal, and externalities of coal are even larger at about 7.3 to 23 eurocents per kWh. Electricity from renewable resources costs about 0.1 eurocent per kWh. For nuclear energy the costs are about 1.9 eurocents per kWh but, that of course, does not take any big nuclear spills or accidents into account.

Politics and business have to begin to understand externalities (or external costs) that cause climate change and charge those responsible. The EU believes internalisation must trigger various measures that will in turn increase the elasticity of demand by: changing customers' price-sensitivity, increasing the attraction of certain services, and boosting technological innovation. To decrease external costs there must be a strategy that encompasses not only the internalisation concept but other elements too: providing infrastructure, stimulating technological innovation, making competitive policies/laws, and designing standards.

One of the more complicated ways to internalise externalities is a green public funding reform which would mean the transfer of tax burdens from taxes on work to takes on the environment, especially the use of energy and other natural resources, environmentally harmful substances and products (Stritih et al., 2007). This type of reform would also need to include stopping environmentally harmful subsidies and introducing other accompanying measures (such as policies that limit undesirable social effects, efficient energy policies, tax breaks for protecting the environment). A component of a green public financing reform is almost financial neutrality. It is important that the implementation of new environmental taxes does not just raise taxes in general but that taxes are redistributed, meaning that other taxes, like taxes on work, become lower. The effect of this type of reform is that work would be cheaper which would thus produce a better working environment. With the help of a green public financing reform we would reach a level of sustainable development and mitigate climate change.

9. THE SEARCH FOR NEW ECONOMIC PARADIGMS THAT RELATE TO CLIMATE CHANGE

The core value of the new paradigms is based on the fact that nature is the inheritance and capital of every human being. In 2005, the World Resource Institute prepared a report on the state of ecosystems at the start of the millennium (Millennium Ecosystem Assessment). It stated that in the last 50 years we have changed the ecosystem more quickly and on a greater scale than ever before. Although altering nature may have helped humankind develop, it has not done so without consequences. These consequences mean higher and higher costs to mitigate the effects, unseen risks, and startling occurrences that in the end worsen the environment for future generations. Conditions can even deteriorate due to the persistence of processes. The state of the ecosystem can only get better if we consider changing our actions and attitudes towards nature. Paying the right price for the environment is a new paradigm, but it is also a mechanism to improve future business. Constanza et al. (1997) assessed the economic worth of 17 ecosystem "services" in different ecosystems to be between USD 16 and USD 54 trillion per year. The same group states that the role of wetlands in balancing gases is worth USD 133 /ha/year. When they took into account all other processes and assets that wetlands possess, the number jumped to USD 15,000 /ha/year. They came to similarly high numbers for other ecosystems such as forests, rivers, and lakes. The unsustainable economisation of natural systems substantially lowers their value (Gaberščik 2007). A study done on the economic value of world environmental assets (natural capital) showed that its total financial value (USD 33 trillion) in 1997 was 1.8 times greater than total global GDP in that same year. The latest research in the EU shows that, due to degradation of the ecosystem, there is a yearly loss of USD 2 to 5 trillion dollars in natural capital (TEEB, 2008; Braat and ten Brink, 2008). In 2010 the damage will reach 1% of world GDP, without a change in 2050 there will be damage worth 7% of GDP. The cost of rescuing failed financial institutions is something the world economy is dealing with currently; however, this crisis pales in comparison to how much is lost each year due to the environmental damage done. We urgently need to adopt adequate indicators to address global challenges such as climate change and resource depletion.

To restrain climate change it would be necessary to add ecosystem services to world business (Plut, 2008). In the free market financial system the value of a source is determined by the price that is paid for it by an individual or a group (Kemp, 2004). Many natural resources that are important for ecosystem services are not included in this type of logic because they are financially underappreciated. Were ecosystem services to be added into the world of business the global system would look different than the current one. The payment structure, including wages and revenues, would dramatically change. World GDP would change in terms of its size and scope if eco-services were included. This maybe the only long-term plan for humankind to keep natural processes going and to fix the damage done, even in the light of climate change. Fortunately, there are already numerous international organisations and global partnerships dedicated to developing indicators for measuring progress, true wealth, and well-being beyond GDP (Beyond GDP, 2009).

10. CONCLUSIONS

The climate is already changing and in the future there is no doubt that there will be rising air temperature and changes in water circulation. The impacts of climatic changes will hit locally and regionally in different ways. Their consequences will affect every aspect of out lives. Climate change today brings a two-level double challenge. First, the affects of climate change can be prevented with an early and thorough reduction of GHG emissions. However, as the climate is already changing, the world has to deal with the challenge of adapting to the consequences. Timely and well-thought-out adaptations are more efficient and cheaper than adapting at the last moment. In every business sector there is a sustainable economic potential for limiting GHG emissions. It is clear that the higher the price per tonne of CO_2, the fewer emissions there will be.

When adapting to climate change it is necessary to have efficient co-operation between participants, familiarity with decision-making, and an understanding of the potential adaptation possibilities. The majority of adaptation actions will need to be decided and to be undertaken at the local, regional and national levels. Priorities are to integrate climate change impacts and adaptations into sector planning, to improve capacities to address extreme weather events, and to include climate change aspects into long-term investments. Adaptation needs the participation of all stakeholders who are involved in the policy, business or service that is or will be affected by climate change. The scientific community should help in this process. They will be able to deal with the misconception that adaptation strategies and subsequent actions are always expensive to implement and that non-action is a cheaper alternative. Consideration should be given to setting up innovative financing arrangements dedicated to supporting the implementation of co-ordinated adaptation strategies, especially in the most vulnerable regions of society. In many states there is a lack of institutional organisation in the field of decision-making on adaptation to climate change, and a lack of properly trained personnel.

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