Economic Evaluation of Climate Change Impacts and Adaptation in Italy

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Summary

The paper deals with the social and economic dimensions of climate change impacts and adaptation in Italy. The ultimate aim of the paper is to provide policy makers and experts with a conceptual framework, as well as methodological and operational tools for dealing with climate change impacts and adaptation from an economic perspective. In order to do so, first a conceptual and theoretical framework of the economic assessment of climate change impacts is presented and the state of the art about impact assessment studies is briefly analysed. Then, the Italian case is taken into account, by underlying the main impacts and adaptation challenges that are likely to be implied by climate change in the next decades. The analysis of the Italian case is particularly addressed through the description of the methodology and results of two case studies. The first one, dealing mainly with impact assessment, is carried out at the national level and is part of a EC funded project on *Weather Impacts on Natural, Social and Economic Systems* (WISE). The second one is carried out at the local level and focuses on sea level rise impacts and adaptation in a plane south of Rome. The two case studies allow to propose simple and flexible methodologies for the economic impact assessment and the economic valuation of adaptation strategies.

Keywords: Climate change, Economic impact assessment, Adaptation, Cost benefit analysis

JEL Classification: Q25, C5, C42

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Introduction

Climate change is no more an issue that involves only the scientific community and high level international negotiations. The civil society, local administrations and institutions are at the stake, since at this point it is undeniable that climate anomalies can deeply influence natural and socio-economic equilibria at a local level.

The direct involvement of local communities is particularly true for adaptation issues. In fact, while mitigation efforts can have a real effect only whether globally undertaken, adaptation can be effective even if led by local initiatives. On the other hand, local adaptation is broken by several reasons, mainly the uncertainties about qualitative and quantitative effects of climate change at local level and its timing, and the lack of methodological and procedural means for the identification and the analysis of adaptation options.

The present study is part of a wide effort, funded by the Italian Ministry for the Environment and Territory and jointly led by ENEA and FEEM, addressing climate change vulnerability, impacts, adaptation and mitigation options in Italian regions. In particular, the paper deals with social and economic dimensions of climate change impacts and adaptation. The ultimate aim of the paper is to provide policy makers and experts with a conceptual framework as well as methodological and operational tools for dealing with climate change impacts and adaptation from an economic perspective. The latter objective is addressed through the description of the methodology and results of two case studies.

The first one is the Italian case study of a EC funded project on *Weather Impacts on Natural, Social and Economic Systems* (WISE), which develops both a qualitative and a quantitative analysis of climate change impacts on vulnerable sectors in Italy. The WISE case study provides some interesting evidence on the individuals' perception of climate change and on the magnitude and costs of climate change impacts on the Italian economy. A survey conducted in two Italian regions, Lombardy and Sicily, shows that individuals are well aware of the effects of climate extremes on their daily habits and on their quality of life, and that they tend to respond to climate extremes through some adaptive behaviour, which varies between the North and the South. Indeed, the quantitative analysis on the impacts of climate change by sector, based on econometric modelling, provides results generally consistent with the IPCC regional projections, in particular with regard to the direction of the impacts, which however appear to be characterised by a high intra-annual and inter-regional variability.

The second case study, addressing the problem of sea level rise in the Fondi plane, focuses on adaptation and has been chosen as a pilot study for the socio-economic evaluation of the adaptation options to the sea level rise in Italian coastal areas. In particular, it provides an economic assessment of different options of adaptation to an expected sea level rise in the Fondi plane, south of Rome, by using a Cost Benefit Analysis framework. The economic value of the areas at risk of flooding is calculated, and compared with the costs of two alternative measures of land protection, i.e. respectively the improvement of the existing inland water drainage system and the reconstruction of a pre-existing dune along the coast. The study highlights the relevance of the social dimension of adaptation, whereby the social costs of local interventions can be very high and the social acceptability of the options proposed becomes a pre-requisite for adaptation. Results from this quantitative exercise, aimed at assessing the economic efficiency of adaptation to climate change, therefore suggest the need to complement the economic analysis not only with a technical feasibility study, but primarily with a social and political analysis of the local context.

The organisation of the article is as follows. The first chapter outlines the conceptual and theoretical frameworks of the economic assessment of climate change impacts. Next, the second chapter points

out the state of the art about impact assessment studies. From the following chapter the focus is on the Italian case. Chapter 3 allows for some socio-economic considerations on climate change vulnerability and impacts, by presenting the main results of the WISE project. The fourth chapter is devoted to the economic aspects of adaptation and describes the case study on the Fondi plane, for the assessment of adaptation options by means of a cost-benefit analysis. Finally, the conclusions underline policy implications.

1. Economic assessment of Climate Change's impacts: overview

What follows is a brief overview of the main ideas that underlie the issue of economic impact assessment of Climate Change. The first paragraph is introductory, while the second addresses economic concepts more explicitly.

1.1 Conceptual framework

Impacts due to Climate Change have been a task which arose much interest since the beginning of the debate on greenhouse gases. Nevertheless, the first attempts to provide a monetary evaluation of such impacts have started only recently, i.e. since the 90s. This delay can be attributed to two main reasons:

- An economic valuation requires a fine knowledge of physical impacts. This knowledge is, nowadays, still limited: the process which leads from anthropogenic emissions to the increase of the earth's temperature, to the effects on natural and human systems is still uncertain. Besides, when dealing with climate changes we have to consider the large temporal lag between causes and impacts. Hence, in assessing impacts we have to take into account the modifications which could interest these systems during the next decades, both as a response to climate change and to other sources of pressure.
- Many objections have been made with respect to the idea of assessing some non marketable goods, like human health and biodiversity, by using monetary units.

Nevertheless, as it became rather certain that climate change will have considerable impacts on human beings, even through the economic systems, an economic assessment was seen as extremely useful. Its function is to serve as a tool for policy makers to measure the phenomenon from an economic perspective, as well as to derive information about the opportunity to act in order to reduce negative impacts and to take advantage of positive ones.

Hence, the first models with the aim of giving an economic valuation of the damages of global warming were set up, initially focusing on the North American territory. The pilot study is the one of Nordhaus' (1991a, 1991b), who concluded that global warming causes a damage to be valued around 0.25% of the US's GDP. Subsequent studies (Cline 1992, Titus 1992, Tol 1993) arrived to a higher estimate, within a range of 0.25 - 2.5% of US's GDP. More recently, Nordhaus collected the opinions of experts of different fields of expertise and concluded that the economic damage should be included within an interval between 0.7% and 8.2%, with a 90% confidence and a median value of 1.9% of US's GDP. Even though these estimates are referred to the US, most authors affirm that such values can be generalised to most developed countries.

Figure 1 below shows the fundamental variables which concur to determine the impacts of climate change.

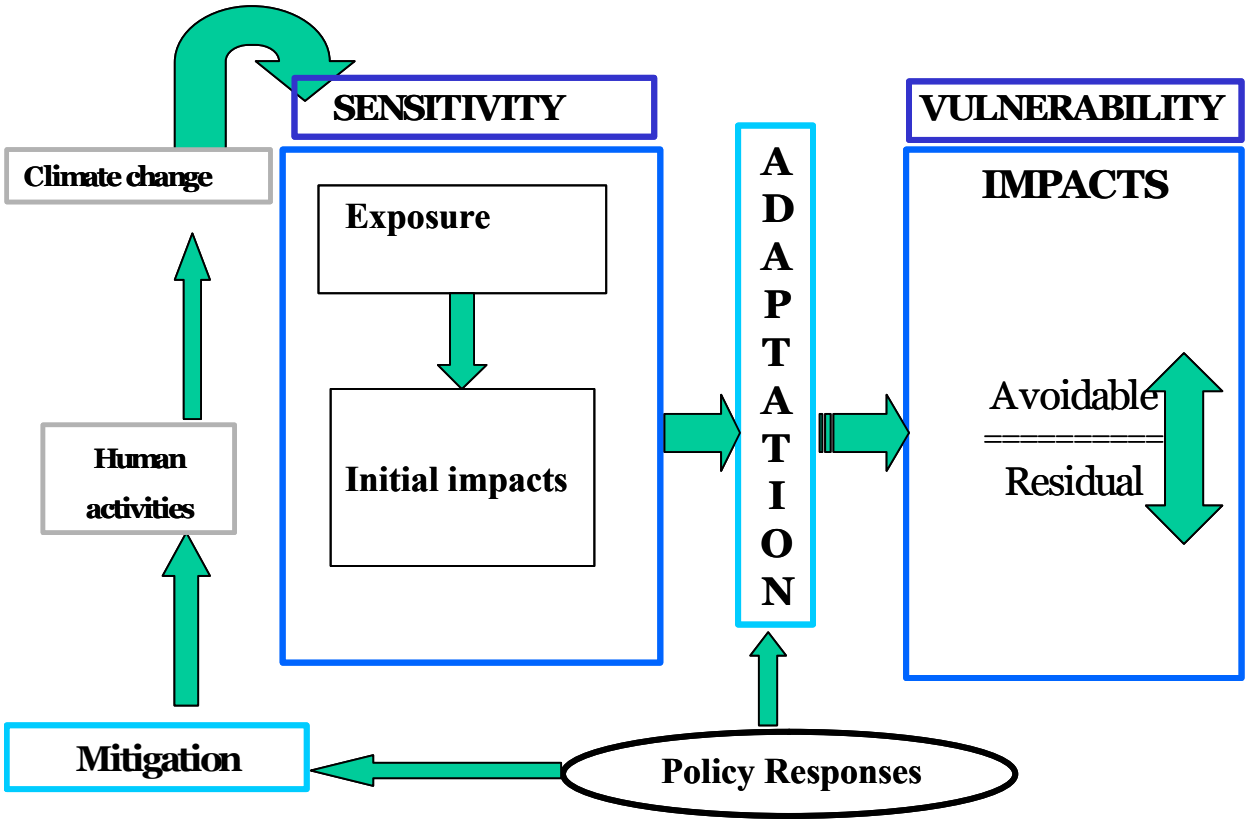

Figure 1 – Determinants of climate change's impacts (adapted from IPCC 2001)

The main definitions of the terms reported in the figure are as follows (IPCC 2001):

- *Sensitivity* is the degree to which a system is affected, either adversely or beneficially, by climate-related stimuli.
- *Vulnerability* is the degree to which a system is susceptible, or unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity.
- *Adaptation* is the degree to which a system adjusts to climate change, including climate variability and extremes, by moderating potential damages, taking advantage of opportunities, or coping with the consequences.

Figure 1 clearly shows the crucial role of adaptation in influencing climate change's vulnerability and impacts: vulnerability of natural and human systems to global warming is a function of both their sensitivity and their adaptive capacity to climate change. Adaptation can be either autonomous (i.e. the northward shift of ecosystems) or planned (i.e. coastal protection, information campaigns to farmers, vaccination against newly arisen illnesses). In order to reduce negative impacts of climate change, adaptation has to be considered as a complementary measure – and not an alternative – to mitigation policies. In fact, even though international environmental agreements will succeed in reducing greenhouse gases emissions, the effects of mitigation policies will arise only in the long term. In the meantime, natural and human systems are very likely to experience some major impacts (e.g. sea level rise, extreme weather events, etc.), which can only be lessened by adopting suitable adaptation measures. Since adaptive measures imply both costs and benefits, these should be taken into account when dealing with economic impact assessments.

1.2 Theoretical framework

From a theoretical point of view, if adopting an economic efficiency framework (Fankhauser 1995), total costs due to climate change can be considered as the sum of three classes of costs, namely costs associated to mitigation measures, costs associated to adaptation measures and costs associated to residual damage. Among these components there exists trade-off relations, both between mitigation and adaptation costs (in general, the more the investments at a global level with the aim to reduce the concentration of greenhouse gases, the less the necessity of adaptation measure and *viceversa*), and between the sum of mitigation and adaptation costs and the residual damage (the more the investments in mitigation and adaptation, the less the costs associated to the residual damage and *viceversa*). The interrelation among the different classes of costs are shown in Figure 2.

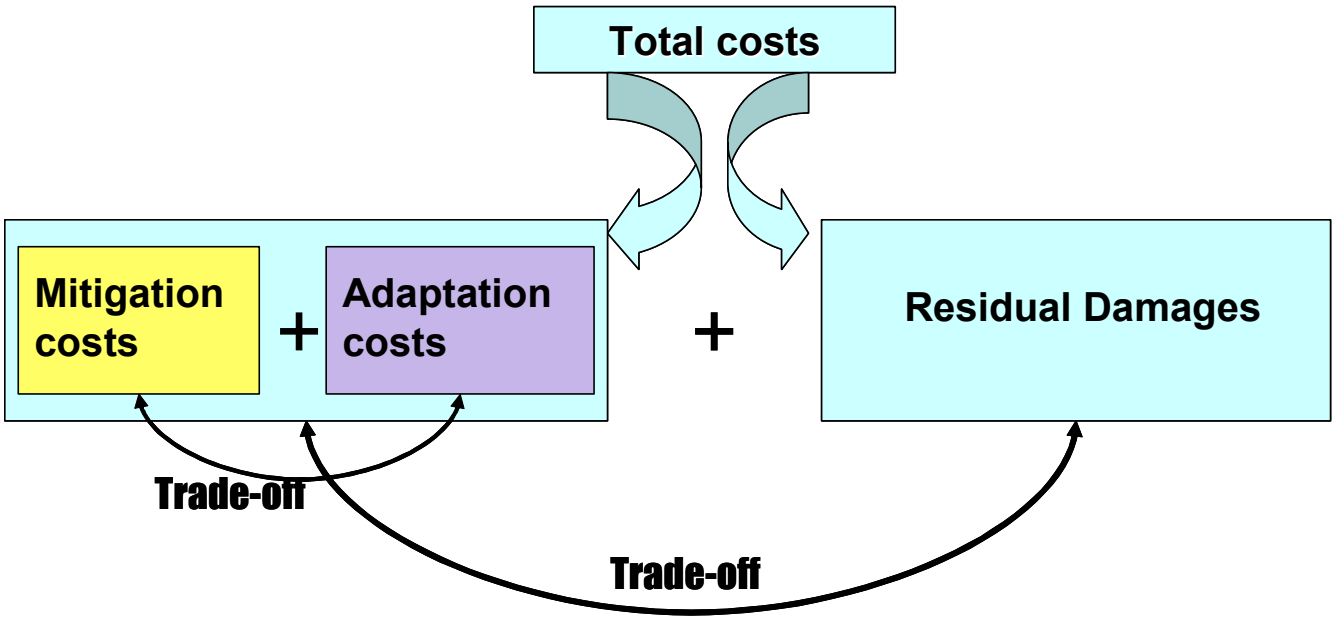

Figure 2 – Costs associated to climate change

Despite the clearness of the conceptual framework, the quantification of the residual damage and the comparison between costs associated to mitigation and adaptation measures on one hand, and the residual damage on the other constitute two not trivial problematic issues. In particular, the first obstacle – the quantification of the residual damage – is due to the difficulty of a physical assessment of the residual damage in the presence of mitigation or adaptation measures. The subsequent transposition of physical impacts into monetary terms is again a delicate step, given that in many cases impacts involve not marketable goods, i.e. human health. The second problem – the comparison between costs associated to mitigation and adaptation measures on one hand, and the residual damage on the other – is due to the consistent temporal lag between the moment in which mitigation and adaptation measures are undertaken, and the period, often uncertain and distant in the future, in which the benefits associated to those measures become clear. The comparison between two classes of costs which are so distant in time implies the crucial choice of an appropriate discount rate. Indeed, the discount rate can heavily influence considerations about the opportunity to undertake mitigation or adaptation measures.

Given the importance that decisions about mitigation and adaptation measures have on the total cost of climate change, the problem in a cost-efficiency perspective is to choose the optimal level of

mitigation and adaptation, which minimise the total cost. Formally speaking, this is a problem of constrained optimisation:

$$\min_{e,a} MC(e) + AC(a) + RD(T,a) \quad (1)$$

$$s.t.$$

$$T = f(e)$$

where:
MC = mitigation costs
AC = adaptation costs
RD = residual damage
e = emission abatement level
a = adaptation degree
T = global temperature

The application of such theoretical models can provide precious indications to policy makers for the design of norms and regulation such as to favour the achievement of the social optimum. Herein social optimum is seen as a solution which is economically efficient, given any kind of social constraints.

The literature often focuses on determining the optimal abatement measure, generally by applying cost-benefit analysis to different abatement levels scenarios and choosing the scenario with the higher net benefit (Hope at al. 1993). Only a few studies, on the contrary, consider adaptation within a perspective of economic efficiency, hence adopting a correct specification of the total cost function. As a consequence, the estimate of the economic impact of climate change can be biased. In particular, if the monetary assessment does not take into account adaptation, the resulting outcome is generally an overestimation. For the previous reasons, the Third Assessment Report of IPCC (2001) recommends that impact assessment studies consider carefully both autonomous and planned adaptation. In order to obtain reliable results, a better knowledge of adaptation policies has to be achieved, by exploring the alternatives in relation to criteria such as costs, benefits, equity, efficacy and technical and social feasibility. Some publications – such as the Handbook on Methods Of Climate Change Impact Assessment and Adaptation Strategies, edited by the UNEP (Feenstra et al. 1998) – propose methodologies for the assessment of adaptation options. The case study on the Fondi Plane described in Paragraph 4.2 is an attempt to contribute to the issue of the economic assessment of adaptation strategies.

2. Literature review

This chapter reviews the international literature regarding vulnerability to climate change, impact assessment and adaptation. Some information concerning the European area are underlined, in order to introduce economic considerations about the most relevant impacts and adaptation measures for Italy, which will be discussed later in Chapter 3.

2.1 Scientific evidence on vulnerability to climate change

The latest IPCC Report (2001) gathers the most exhaustive scientific evidence available on impacts, vulnerability and adaptation to climate change on a global scale, providing forecasts on climate change impacts on the most vulnerable sectors, as well as a regional distribution analysis.
The expected impacts of climate extremes in Europe, particularly in Southern Regions, can be summarised as follows:

- an increase in death and serious illness among the elderly and the poorest people in urban areas, a change in tourist destinations, an increase in the risk of damage to several crops, an increase in energy demand for cooling, are expected due to an increase in maximum temperatures and in the frequency of hot days and heat waves;
- a decrease in cold-related human morbidity, an increased variability in agricultural productivity and a decrease in energy demand for heating are expected due to an increase in minimum temperatures and a decrease in the frequency of cold days and cold waves;
- an increase in floods, landslide, avalanche, mudslide damage, soil erosion, recharge of floodplain aquifers due to increased flood runoff, higher pressure on governments, on private flood insurance systems and disaster relief are expected due to more intense and frequent rainfalls;
- a decrease in agriculture productivity, in water availability, a water quality impoverishment, a decrease in the hydro-power potential, and an increase in the risk of forest fires are expected due to higher summer temperatures and to the associated risk of drought;
- an increase in the risks to human life and health, property and infrastructures losses, damage to coastal ecosystems, are expected due to an increase in storms' frequency.

With respect to vulnerability, the scientific evidence provided by the IPCC suggests that Europe has a good adaptive capacity, although Southern Regions show a higher vulnerability. With high confidence in Southern Europe summer runoff, water availability and soil moisture are likely to decrease, whereas increases are likely in winter. With medium confidence half of alpine glaciers and permafrost areas could disappear by the end of the 21st century, and river flood hazard will increase. In coastal zones the risk of flooding, soil erosion, and wetland loss will increase with strong implications for human settlements, industry, tourism, agriculture and coastal natural habitats. With medium confidence productivity in agriculture will decrease; higher summer temperatures and heat waves may change traditional summer tourist destinations, and poorer snow conditions during the winter season may carry out negative impacts on winter tourism. Agriculture, tourism, industry, human settlements and health appear to be the most vulnerable socio-economic sectors.

Economic assessment studies of climate change's impacts can be essentially classified with respect to the type of model on one hand and to the underlying assumptions on the other. With respect to the first aspect, it can be distinguished between *partial equilibrium models* (or *enumerative studies*) or *general equilibrium models* (or *integrated assessments*). Partial equilibrium models analyse climate change's impacts separately for each socio-economic sector and consider the total damage as the sum of single impacts on the different sectors. On the contrary, general equilibrium models analyse the repercussions of climate change (Roson et al. 1994) or policy responses (Kemfert 2001)

on a system of interconnected markets, taking into account direct as well as indirect effects and spill over among various economic sectors. With respect to the models' assumptions, differences can concern the scale (global or local), the endpoints on which the impact is assessed (i.e. the specific cultivations in the agricultural sector) and whether or not they consider adaptation.

2.2 Impact assessment studies considering adaptation

Despite the crucial role of adaptation in assessing climate change's impacts is widely recognised, most impact assessment studies do ignore or deal only briefly with the analysis of adaptation actions. Tol et al. (1998), after reviewing the existing literature on adaptation, conclude the following:

- The hypotheses about adaptation which underlie impact assessment models are often not much realistic, changing from the *dumb farmer* assumption (no planned adaptation at all), to scenarios assuming arbitrary measures, or too radical changes in infrastructures, institutions and individuals' behaviour.
- Adaptation has a great influence on the sign and the weight of estimated impacts: several studies demonstrate that a negative effect of climate change on a specific sector (particularly agriculture) can become positive if adaptation is accounted for.
- Adaptation costs are very seldom taken into account. Generally, a comprehensive measure of climate change associated costs is provided, that not clearly distinguishes between adaptation costs and residual damage.
- For all the previous reasons, information derived from these works are seldom useful for policy makers to inform them about the opportunity of adapting to climate change.

Despite all these limits, some authors tried to derive a rough estimate of adaptation costs with respect to the total cost (Cline 1992, Tol 1995, Fankhauser 1995). Estimated adaptation costs result to be around 7-25% with respect to the total cost of climate change, that is – as mentioned in chapter 1 – some 2% of GDP for most developed countries. It is important to highlight the limited reliability of such kind of estimates, due to their abstraction from the specific features of each country, as well as the non inclusion of the entire set of necessary adaptive measures. In particular, within the majority of impact assessment studies, only coastal protection, conditioning, migration and settlement of communities are explicitly considered among adaptation costs. When other types of adaptation are taken into account, such as in the agricultural or health sectors, it is implicitly assumed that these policies do not generate any costs for the society.

In the comprehensive review of studies on adaptation carried out by Tol et al. (1998), sea level rise, impacts on agriculture, thermal comfort, migration and resettlement are considered. Besides, there exist some works which analyse the expected impacts of climate change on health of vulnerable populations and suggest proper adaptation measures (Department Of Health UK, 2001). A project funded by the EC – Climate Change and Adaptation Strategies for Human Health in Europe – to be completed by 2004, aims at analysing adaptation strategies, even from a cost-efficacy point of view. Finally, some works address autonomous adaptation by considering the macroeconomic system, i.e. those spontaneous mechanisms which would be generated by an external pressure (i.e. the impact of climate change on yields' productivity) and would involve the global markets, through diminishing supply of certain products, changes in relative prices, resources reallocation within the agricultural sector, indirect effects on the other sectors and the international trade. Among all, Deke et al. (2001) aim at assessing the final consequences of agricultural impacts on the economic welfare of macro-areas in the world.

A conclusion can be derived about the scientific literature dealing with impact assessment and adaptation carried out during the last years: although the approaches used are scientifically sound and provide interesting results on the magnitude of expected impacts with and without adaptation, they are often not very useful in suggesting feasible and economically efficient adaptation measures. Hence, the analysis of possible policy responses needs to be improved, specially at the local level, which has been recognised as the mosty appropriate level to deal with adaptation. There exist some case studies which consider well defined adaptation policies (i.e. the mobile gates in the lagoon of Venice), but they are generally very specific with respect to the geographical area or to the type of impact, so that they do not permit to derive any replicable methodologies or generalizable results. Hence, the need of looking for methodologies and approaches, that can be easily applied to different sectors and geographical areas is of outstanding importance. The following description of the two case studies aims at contributing to fill this gap.

3. The Socio-economic dimension of vulnerability in Italy

The next two chapters describe the two Italian case studies, respectively on the issues of vulnerability and adaptation. In both cases first a general overview of the issue is provided, then the case study is analysed. The proposed methodologies are suitable to be applied to different contexts of impact assessment and adaptation studies.

3.1 Overview

The characteristics of vulnerability to climate change, considering a system's capacity to tackle stress factors and to restore a balance situation, respond to both environmental, social and economic criteria: a poor economy will show a low capacity to react to the effects of climate change, both from the institutions/ market supply side and from the demand side. Furthermore less developed societies are characterised by a lower degree of co-ordination and integration among the most relevant social and economic actors, which exacerbates their vulnerability. A higher vulnerability is then likely to enhance social and economic fragility, increasing inequalities and fragmentation. The ability of a social and natural system to adjust to climate change thus depends on several factors, including income and its distribution, technology, education, knowledge, infrastructure, availability and access to resources, management capacities, level of integration and social cohesion.

Following a classification introduced by Burton et al. (1993)[1], it can be noticed that different levels of economic development of a country or region allow to adopt specific measures of adaptation to climate change, making the country or the region more or less vulnerable. Poorer regions will be more vulnerable since they have less capacity to bear losses developing measures to respond to climate change, to re-locate economic activities, to invest in research in favour of new technologies and other adaptive measures, to diffuse knowledge and information to modify local production and consumption patterns.

Addressing the case of Italy, high development and economic inequalities across Italian regions, besides geographical and territorial diversity, can induce different degrees of vulnerability to climate change; in 2000, 62.7% of poor households[2] were concentrated in the South and in the Islands, compared to 15.3% in the Centre and 22% in the North.
The sectors generally identified as most vulnerable are: agriculture, forests, water, tourism and health. The most vulnerable areas are coastal areas and arid and alpine zones, exposed to sea-level rise and changes in the hydrological cycle. The islands and southern regions, essentially devoted to agriculture, characterised by water scarcity and a high vocation for tourism, therefore tend to associate to their economic vulnerability a high risk of exposure to climate change.

3.2 Case study: Weather Impacts on Natural, Social and Economic Systems in Italy

Various studies provide estimates on the magnitude of climate change impacts in Italy. Very few studies however explore the socio-economic dimension of these impacts, which is needed to address vulnerability and to implement adaptation policies. In this regard some interesting results emerged from the EC funded project WISE (Weather Impacts on Natural, Social and Economic Systems), conducted in Italy by Fondazione Eni Enrico Mattei between 1997 and1999. The project's aim was

[1] Adaptation measures are grouped in eight categories, according to their capacity to bear losses, share losses, modify the 'threat', prevent the effects, change the use of goods and services influenced by climate change, relocate productive activities, invest in research, educate, inform and encourage different behaviours

[2] These percentages measure the relative poverty, calculated on a yearly basis with respect to the average monthly pro capita consumption expenditure of Italian families (amounting to 1.569.000 £ in 2000).

to evaluate the impact of climate change, in particular of extremely hot summers and mild winters, on the natural, social and economic systems of some European countries, providing where possible a monetary evaluation of the impacts.

Following a commonly agreed methodology country studies were conducted in all countries partner in the project: Italy, U.K., Germany and the Netherlands. All country studies include a qualitative analysis aimed at investigating through surveys the individuals' perception of climate change impacts on their daily life, and a quantitative analysis aimed at estimating climate extreme impacts on some economic sectors, through econometric models and national statistics data covering all country regions for the last three decades.

3.2.1 Methodology and results from the qualitative analysis

With regard to the survey analysis (Galeotti et al. 2004a), in Italy phone interviews were carried out on a stratified sample of 300 individuals selected from two regions, Lombardy and Sicily, located respectively in the North and in the South. The two regions differ considerably because of geographical and climate characteristics, as well as because of economic and cultural features. Lombardy is a flatland and mountain region, characterised by a continental climate, endowed with a highly productive economic activity, concentrated mainly in the industry and service sectors. Sicily, a beautiful and renowned island in South, is indeed characterised by a Mediterranean climate; its beautiful setting, and its historical and cultural richness, represent a big attractiveness for tourism: its economy is mainly based on agriculture and tourism activities. These two regions were thus selected to represent respectively the North and the South, since they exemplify the main differences in terms of economic, cultural, geographic and climate characteristics between the North and the South of Italy. The sample was stratified by age, sex and city size. In the sample individuals were identified as well by income level, occupation, education, province and city of residence.

The survey results show that generally people identify negative effects of extremely hot and dry summers and mild winters on their quality of life, in terms of weather impacts on their comfort, work, leisure, health, commuting and transport patterns, as well as household activities. Impacts vary between the two regions. Individuals are particularly concerned about the extreme seasons' impacts on air quality and this concern is definitely stronger in the North. Energy and water consumption seem to be quite sensitive to climate extremes, particularly in the South, where water and energy consumption tend to increase during hot and dry summers.

Regional differences between the North and the South induce people to favour different adaptive behaviour to climate extremes in their daily lives, such as enjoying more activities to the beach and sea-side, abandoning indoor activities, in Sicily, or being more in the nature, going to the swimming pool, using considerably less public transports and private cars in favour of motors and bicycles in Lombardy. One side of individuals' adaptive behaviour which seems to be not too sensitive to climate extremes is tourism: in both regions vacation patterns do not change neither due to unusually hot and dry summers, nor due to mild winters. Other interesting results emerge from the individuals' evaluation of the prospect of climate change which is considered to be very worrying, or worrying, for the majority of interviewees. Overall the survey results suggest that individuals are aware of the effects of climate extremes on their daily habits and on their life's quality, and that they tend to respond to climate extremes through some adaptive behaviour.

3.2.2 Methodology and results from the quantitative analysis

The methodology adopted for the quantitative analysis is based on the estimation of the effects of weather extremes on various socio-economic sectors identified as most vulnerable to climate

change in European countries (Galeotti et al. 2004b). Indicators of productivity in the economic sectors of interest, as well as key variables in the social sectors of interest, are expressed as a linear function of weather parameters. A linear estimation procedure is then applied to estimate the weather impacts on the socio-economic sectors of interest over the years and across regions.

In the most simple case, where we use annual and national observations, the general model is:

$$X_t = \alpha_0 + \alpha_1 X_{t-1} + \alpha_2 T + \alpha_3 W_t + \alpha_4 W_{t-1} + u_t \quad (2)$$

Where:
t expresses the time-series dimension of the model.
X denotes the index of interest (i.e. number of fires, death rates, per capita gas consumption, etc…). *X* depends on its lagged value to indicate that most influences other than weather (income, technology, institutions) are much the same now and in the past.
T denotes time: for annual observations T indicates the year of observation. Time is taken up as an explanatory variable to capture all unexplained trends.
W denotes the weather variable that is hypothesised to influence *X*. *W* is a vector including only those climate variables which are supposed to have an influence on *X*: the climate variables selected vary depending on the core sector under analysis. The weather variable consists of the average value over the time dimension *t* of the climate variable under consideration; when yearly observations on *X* are available, the weather variable *W* generally consists of the yearly average of the climate variable. However, when specific seasons during the year are thought of having a stronger influence on the dependent variable, the average value of the climate variable over that season in each year will be used in the regressions. For instance summer temperature or rainfalls in each year are used as explanatory variables when the model is applied to estimate the yearly number of fires. The lagged value of *W* is taken up to address a dynamic dimension in the model, and because past weather may influence current behaviour, particularly in some sectors, such as tourism and agricultural yields production.
Finally, **u** denotes the error term and the intercept is included assuming that at least one of the variables is not expressed in deviations from its mean.

Under the assumption that *u* is i.i.d. and has a normal distribution, we estimate the model by ordinary least squares (OLS) estimators. We run a first estimation by OLS, and we check for the significance of the parameters' estimates; we then remove insignificant explanatory variables and re-estimate, checking whether the residuals are stationary. hen monthly and regional observations are available, the general model is applied to a panel data structure, covering the time series and cross-section regional data. As a further step in the econometric analysis, in the panel estimation of our general model we use dummies for the years showing patterns of extreme weather to capture the effect of extreme seasons on the dependent variable, as well as dummies for regions or macro-regions in order to identify specific regional effects on the dependent variables.

Following the estimation, a direct cost evaluation method is used to assess the impact of climate sectors on some of the core sectors identified. The direct cost method assumes that the welfare change induced by the climate extremes can be approximated by the quantity change in the relevant variable times its price. The direct cost thus imputed would be a fair approximation of the change in consumer surplus if the price does not change much. The use of dummy variables for extreme seasons in the time-series and panel estimations allows us to evaluate in monetary terms the relative

impacts of those extreme seasons on the various sectors, exploiting estimates of quantity changes in those seasons and the corresponding seasonal prices.

The main results from the quantitative analysis can be synthesised as follows. In Italy outdoor fires result to be the most vulnerable sector to climatic variation; it is followed by tourism, energy consumption and agricultural production, which however show a high intra-annual and inter-regional variability. The Italian study hasn't been able to measure the impact of climate extremes on the insurance sector, due to lack of data, and on water consumption, due to the highly fragmented nature of the available data; however various case studies recently developed in Northern regions show that climate variations have severely threatened the capacity of alpine water basins to guarantee a minimum constant vital flow[3] in out-flowing rivers.

With respect to outdoor fires, estimates suggest that in 1985, identified as an extremely hot summer season, the summer dryness index may explain 328 more fires on average in each region. Operators from the Forestry and Environmental Protection Regional Corp in Sardinia reported an anticipation of the anti-fire campaign due to the increasing number of fires during summer in the last four-five years. In 1985 and 1994, both years showing extremely hot summers, restoration expenditures for fires' damages considerably increased if compared to previous years: in 1994 expenditure on fire damages amounted to 86 billions it £, at 1999 prices, i.e. 44,415 millions Euro, showing an annual increase of 26,3%.

With respect to tourism, estimates show that domestic tourism is sensitive to climate variations, although the nature of changes in tourism demand varies over the year and with regard to the characteristics of the regions considered, with overall compensating effects. Extremely hot summers tend to reduce seasonal tourism flows by 39.494 bed-nights on average per region, corresponding to 1,22%. However, the regional distribution of increased temperature's effects is not homogeneous: summer tourism towards coastal areas increases during extremely hot summers, showing a change of destinations in domestic tourism towards cooler areas. A 1° temperature increase in summer in coastal areas would imply an increase of 62.294 bed-nights. In alpine regions indeed higher winter temperatures and lower rainfall carry out a negative impact on winter tourism, probably due to their effect on winter sports. A 1° increase in temperature would explain a decrease in local domestic tourism equal to 30.368 bed-nights, carrying out negative welfare changes.

Clearer effects of climate extremes can be observed in the energy sector, where extremely hot seasons determine a welfare increase. Estimates show a downward trend in gas and energy consumption for domestic use in very hot years, both in summertime and in wintertime, with greater reductions in mild winter seasons than during extremely hot summer seasons. In 1994, where extremely high temperatures were recorded, winter gas consumption for domestic use decreased by 510.000.000 oet (oil equivalent tonnes), that is a reduction of 414 millions £ at 1999 prices, i.e. 213. 810 Euro.

With respect to health, the climate impact on cardiovascular and respiratory disease, particularly affected by climatic parameters, has been evaluated. Estimates show that high temperatures in summer months tend to increase mortality, whereas higher average temperatures in winter months tend to reduce it. According to estimates the exceptionally hot summer of 1994 caused an increase of 63 deaths.

[3] As established in the D.Lgs. 183/189.

In agriculture only a few products are susceptible to temperature increases with consequent economic damages: the exceptionally hot and dry season of 1985, for instance, caused a reduction of 13q/ha in average regional potato crops, that is a monetary loss of 376.346 £/ha, at 1999 prices, i.e. 194 Euro/ha. Equally, the extreme 1994 season caused a reduction of 519.000 hl in average regional wine productions, with a total monetary loss of 44.677, 4 millions £ at 1999 prices, i.e. 23 millions Euro. The scenario of the agricultural effects of climate change however is not homogeneous: temperature increases seem to favour fruit production both in the North and in the South, whereas corn production does not seem to be particularly affected.

These results are generally consistent with IPCC regional projections, in particular with regard to the direction of the impacts, and suggest the relevance of the socio-economic dimension of climate change impacts, particularly in some sectors of the economy. However the poor data access and availability hasn't allowed yet to develop a comprehensive and exhaustive picture of the socio-economic dimension of climate change. Our analysis, provided its limits in the econometric estimation and in the economic assessment proposed, highlights the variability of climate change effects on the territory in relation with different levels of economic development, extending the vulnerability concept to its socio-economic dimension and setting the scope for further research and investigation to address adequate adaptation options.

4. The socio-economic dimension of adaptation in Italy

This chapter deals with adaptation issues in Italy. First, an overview of the economic implications of adaptation with reference to the main impacts to be expected in Italy is presented. Then, the case study about the sea level rise in the Fondi plane is briefly described, in order to propose a methodology for the economic assessment of adaptation measures, which can be applied to different contexts.

4.1 Overview

The IPCC Third Assessment Report on Impacts, Adaptation and Vulnerability (2001) affirms that the adaptation potential of socio-economic systems in Europe is rather high, given the overall good economic conditions (high GDP with a constant rate growth), the stability of population and well developed political, institutional and technological systems. On the other hand, the report underlines the vulnerability to climate change of Southern regions of the Mediterranean, with particular reference to coastal zones and to the most poor areas.

Given the topography of the country and the strong presence of both residential and industrial areas along the coasts, an important source of potential risk is the sea level rise. Hence, it is in the country's interest to invest in research on the opportunity to defend the most vulnerable coastal zones, which have been individuated in a recent study carried out by Antonioli and Leoni (2001). Economic assessments on coastal protection options in Italy are still lacking, with the exception of very special cases, like the Venice lagoon, where the growing frequency of high water events implies the need to act opportunely in order to protect a world's heritage. Special cases like this, given the *ad hoc* solutions proposed to solve the problem, have an enormous value at the local level, but cannot be extended to other, more ordinary coastal lengths.

The necessity to find common methodologies for coastal protection assessment and to carry out evaluations for all coastal areas at risk is confirmed by the result of a work by Fankhauser (1995). By using a modelling approach based on the minimization of the total cost, he aimed at deriving the optimal percentage of coastal protection for different countries, including Italy. Results indicate that the influence of the sea level on the optimal protection share cannot be defined *a priori.* In fact, given a certain sea level rise, there is a stimulus for strengthening protection in order to reduce expected damages on the one hand, but on the other hand adaptation costs arise. The final protection degree depends on the relative importance of these two contrasting effects.

Following the model's outcomes, given the hypothesis of a 100 cm sea level rise in 2100, for Italy it would be convenient to almost entirely protect its coasts, due to their high economic value. In particular, in correspondence of towns and harbours the optimal protection degree is almost 100%, while for open coasts the percentage is around 95% (OECD average: 80%). Finally, the model's output indicates that around 90% of the beaches should be put in safety (OECD average: 57%). The work also provides an estimate of the total cost implied by the sea level rise, explicitly including protection costs.

Moreover, if we account for extreme weather events, like coastal or rivers' floods, that are likely to become more frequent as an effect of global warming, it is clear that a strategy of postponing protection actions till events come to a head is not successful, given the high economical losses generally implied by such events. The same conclusion on the opportunity to anticipate the arrangement of adaptation measures – specially if lasting and non recoverable - has been reached by Fankhauser et al. (1999), who proposed a formal economic demonstration. Besides, a pro-active behaviour with respect to adaptation to increased extreme events could greatly benefit the insurance

sector, by limiting the trend, that can be observed in the last years, of rising premia in the property branch.

With respect to impacts on water sector and agriculture, that are expected to be of great importance in the next decades, adaptation strategies are even more urgent, as it becomes clear during the relatively long drought events that Italy is experimenting with increasing frequency during the last years, with particular – but not exclusive - reference to the Southern regions. Besides environmental and climatic conditions, also a lack of infrastructures and bad management practices greatly contribute to worsen the situation, specially in those regions – like Sicily - which are already experiencing a desertification process (Sciortino, 2002). Projects of primary importance for the Southern agricultural areas, as the restoration or substitution of lengths of the water network or the construction of water pipes or pumps, involve huge capital investments. In a strict sense, however, these are to be only partly considered as adaptation costs, since they are necessary, independently on climate change impacts, so that they are referred to as *no-regret actions*. Other useful suggestions on how to deal with diminishing water resources come from the experience of Middle East countries, which have traditionally coped with water scarcity for centuries. For example, El-Fadel and Bou-Zeid (2001) propose either policies which aim at enhancing water supply, like water harvesting, water re-use and sea water desalinisation, and options to control the demand side, as water pricing policies. The authors report daily costs of some of these options.

In the Northern regions, where the quality of infrastructures is generally higher and aridity and drought events are not so common, less expensive investments should be sufficient to assure a good adaptation degree. It is recommended to partly modify water management systems (i.e. irrigation systems) and some agricultural practices (i.e. anticipation of sowing and harvesting times), with limited interventions on infrastructures. As was previously mentioned, suitable adaptation policies could even make it possible to take advantage of climate change. Major problems to agriculture could derive from rivers' flooding events. In order to face great losses of production, massive banks' protection measures and emergency plans should be arranged in the most at risk areas.

Another useful way of adapting consists in informing farmers on climatic trends and on cultivation and management practices, that are suitable to the changing climate. This would let reduce expected monetary losses in the transition period towards new climate patterns. Finally, it is very important to use market incentives properly, both for water and for agricultural products, in order to enhance adaptation, while avoiding mistakes due to biased market signals. A classical example of the latter is given by financial aid or minimal price decks with respect to certain agricultural products: if a financial benefit provided by the government causes suppliers to ignore negative market signals with respect to some products, the adaptation process will be slowed (Fankhauser et al., 1999). With respect to market signals for re-allocating water resources, the World Bank has recently established a research area devoted to the study of economic incentives for water[4].

Besides the most commonly cited impacts due to the sea level rise and effects on agricultural production, also expected impacts on economic sectors like tourism, energy and insurance should be carefully analysed, in order to propose new rules for coping with coming challenges driven by climate change. Finally, it is recommended to consider the new problems that the health sector is likely to face, with the increasing number of cases of certain diseases and the rising of new kinds of illnesses, that did not exist in Italy till now. To this regard, the previously mentioned European project on adaptation to climate change in the health sector (EC, 1999) is considering Italy as one of the case studies.

[4] World Bank, Rural Development Research Program: Economics and Institutions of Water (http://econ.worldbank.org/programs/rural_dev)

4.2 Case study: sea level rise in the Fondi plane

The analysis of adaptation options at the local level implies a qualitative and quantitative assessment of expected impacts in the interested areas. On the other hand, carrying out *ad hoc* studies for each vulnerable area and for different impacts is not free of difficulties, among which long time spans and high costs. Hence, it is important to draw pilot studies for the main impacts, by choosing representative areas of the Italian territory and proposing a methodology which can be applied as well to other areas.

The herein presented case study deals with an expected sea level rise in a plane south of Rome. This plain is characterised by some common features – both geomorphic and socio-economic - with other vulnerable areas along the Italian coasts, so that the proposed methodology is suitable to be very easily applied to the valuation of many other cases. Besides, the general framework, namely a cost-benefit analysis, can also be adapted to many different contexts, addressing impacts other than the sea level rise.

The economic valuation of different adaptation options is based on a scenario of expected sea levels at various instants in future time derived from a geological study carried out by Antonioli (2000). Data on sea levels have been geo-referenced and overlapped on land use maps by using GIS tools (Caiaffa and Leoni, 2002). Therefore, this can be considered a multi-disciplinary – i.e. a geological-economic - study. Besides, in order to better understand the local specificities of the area and to select proper adaptation strategies, some local actors, both from the political and economic arena, have been interviewed. This process, even if far from being a participatory one, has let the researchers to better fit technical and methodological features to the real socio-economic context, as well as to involve the local community in the process of the study.

4.2.1 Theoretical framework

This case study aims at the assessment of the economic efficiency of adaptation actions in response to sea level rise in the Fondi plane. This exercise is conceptually referable to the problem of minimising total costs of climate change presented in Chapter 1 (see Equation (1)). In this case, the problem is simplified because of the following reasons:

- mitigation costs are not accounted for, in accordance with Fankhauser (1995)- see Chapter 1. In particular, we assume that, even if mitigation measures are undertaken in the next years, they are not capable to change the foreseen effects on sea level rise before 2100, that is the chosen time horizon.
- If adaptation measures are implemented, the residual damage is set equal to zero. This is coherent with the assumption that protecting coasts with suitable defensive works completely avoids land loosing its economic value.

Given these assumptions, adaptation is justified, according to a cost efficiency approach, if the following condition is fulfilled:

ADAPTATION COSTS < EXPECTED DAMAGES WITHOUT ADAPTATION

The expected damages without adaptation correspond to the value of land which is at risk of being permanently flooded. It has been indeed assumed that all the land which is foreseen to reach an altitude below 0 within the considered time horizon will be lost forever, if appropriate defences are not set up. The ultimate purpose of the analysis is therefore to establish whether defensive measures are more or less costly, compared to a non-intervention scenario.

4.2.2 Hypotheses on adaptation behaviours

Three hypotheses on possible adaptation behaviours have been analysed:

Hypothesis 1: no adaptation and consequent inland loss;
Hypothesis 2: land protection by strengthening of the present system for land reclamation (water-scooping machines);
Hypothesis 3: land protection by reconstruction of the pre-existing dune as a first barrier to sea-level rise.

When dealing with adaptation studies, it is always recommendable, when possible, to take into account more than one adaptation options. This is particularly important in the case of a high degree of social conflict between stakeholders, with respect to the consequences implied by the choice of one or another adaptation options. Considering more than one alternatives lets the evaluation study be more equitable, by avoiding to limit *a priori* the decision set to a sub-set of possible solutions, therefore implying to favour this or that group of stakeholders. Besides, when decision processes are particularly complex, due to many different attributes to be considered in valuing alternatives, a broader methodology, like multiple criteria analysis, can be more suitable than cost benefit analysis to tackle the decision aiding problem.

4.2.3 Geographical and economic features of the Fondi plane

The plane has a total surface around 6,000 ha, of which 1,150 are already at an altitude below zero. Its territory includes most of the Fondi Municipality, besides little areas owing to the Municipalities of Monte San Biagio and Sperlonga. The total population is some 30,000 inhabitants, and the average GDP per capita in 2002 was around EUR 13,000 per year.
The area is characterised by:

- a vast reclaimed land devoted to agriculture (60% intensive greenhouse cultivation);
- a 14 km long coastal area, with a high potential for tourism;
- the Fondi lake, a brackish waters lake endowed with rare species, with a high potential for naturalistic tourism;
- an economy based on the agricultural sector, mostly characterised by small family enterprises.

With respect of the property rights of the land, a big share of the total surface, almost entirely destined to agricultural use but also characterised by a high number of illegal houses, is State ownership. Part of this area is authorised to a property and land use change, probably meaning that the area will become private or 'legitimated' land and suitable for building, namely houses and infrastructure for tourism.

4.2.4 Methodology

The analysis was developed with the purpose of calculating the economic value of areas at risk of permanent flooding, so as to compare it with the costs of the two alternative land protection measures. The starting point was the quantification of the total area at risk, diversified by land use, obtained by applying GIS techniques to the sea level rise scenario for the next century (Antonioli, 2002; Caiaffa and Leoni, 2002). Time milestones for quantifying the progressive extension of the area at risk were set at years 2002, 2050 and 2100. The considered land uses are agricultural land, forest and residential areas.
Then, the estimation of the area at risk was refined by considering:

- the soil nature (peat and non peat soil) and the type of cultivation (reclaimed and non reclaimed land), thanks to the analysis of an aerial picture of the area under investigation;
- the property regime (private land, State property, Municipal property), by analysing a map representing the civic uses of the land.

Once the area at risk was quantified as described above, an economic value was assigned to the land, differentiating by land use, soil nature and property regime. When existing, the commercial value was attributed. Such a value was based on interviews with local actors (i.e. real estate and land sale agencies), and verified by comparison with national statistics[5].
The income flow generated in the areas at risk was added to the total monetary value of the stock (i.e. the commercial value of the land). The income flow was derived by normalising the total income of the Municipality of Fondi with respect to the estimated population living in the area at risk at the three considered time milestones.

Given the crucial importance of the discount rate for the assessment of future damages, a sensitivity analysis was carried out with respect to two different discount rates, namely 1% and 3%, which are generally considered to be suitable for using in impact assessment studies by the international scientific community. Since sometimes the degree of uncertainty implied was high and the researcher's choice could greatly influence the final results, it was chosen to analyse two scenarios with different underlying hypotheses. Namely:

Low scenario	High scenario
• null value of illegal houses • low housing value in areas authorised to property changes • high % of peat land, low % of greenhouse land	• 0 < value of illegal houses < value of legal houses • higher housing value in areas authorised to property changes • low % of peat land, high % of greenhouse land

Hence, for each of the above scenarios and discount rates the present value of the area at risk was calculated. The main variables which the total value depends on are:

- the commercial value of agricultural areas, differentiated by the soil nature and the property regime;
- the commercial value of houses, differentiated according to the degree of legality of the buildings;
- the income produced.

Equation (3) synthesises what illustrated above. The three adding terms are referred to the different time points which were chosen as milestones for the calculation of the area at risk.

[5] A database of regional market values of agricultural land is available on INEA (Istituto Nazionale di Economia Agraria) website: www.inea.it.

$$PV = \sum_{lc,p}\left(S_{2002,lc,p} * V_{lc,p} + I_{2002}\right) + \sum_{lc,p}\frac{iS_{2050,lc,p} * V_{lc,p} + iI_{2050}}{(1+r)^{(2050-2002)}} + \sum_{lc,p}\frac{iS_{2100,lc,p} * V_{lc,p} + iI_{2100}}{(1+r)^{(2100-2002)}} \quad (3)$$

Where:
PV = present value
lc = land cover
p = property regime
S = surface at risk
V = economic value
I = income produced in the area at risk
iS = incremental surface
iI = income produced in the incremental area at risk
r = discount rate

The formula's result provides a measure of the damage relative to the sea level rise in the Fondi plane without adaptation.

Land protection measures were analysed by using a simplified expert based valuation method. In both cases experts were interviewed in order to come up with a rough estimate of costs implied by the two alternative defences. Of course, economic valuation of adaptation measures can be done at rising degrees of complexity, depending on the purpose of the analysis and on the level of the decision making process (policy level, planning level, project level).

4.2.5 Results

Hypothesis 1: no adaptation and consequent inland loss

The present value of the area at risk of permanent flooding within the time horizon 2002-2100 varies in a range between 130 and 270 million Euro, depending on the considered scenario (low, high), the discount rate (3%, 1%) and the upper and lower bounds assigned to some variables (see Table 1).

DISCOUNT RATE	LOW SCENARIO		HIGH SCENARIO	
	Lower bound	Upper bound	Lower bound	Upper bound
3%	130,860	199,238	186,518	260,127
1%	145,785	203,775	202,732	267,642

Table 1 – Present Value of the area at risk of permanent flooding in the Fondi plane (million Euro 2002)

It is interesting to note how the relative importance of the main classes of value varies by shifting from the low to the high scenario. Figure 3 shows that the most worthy class of value in the low scenario is the income produced, while in the high scenario the real estate has the highest relative importance, the discount rate being constant at 3%. This is due to the changing hypothesis about

the economic value of the great number of illegal houses in the area, passing from null in the low scenario to a positive value in the high scenario.

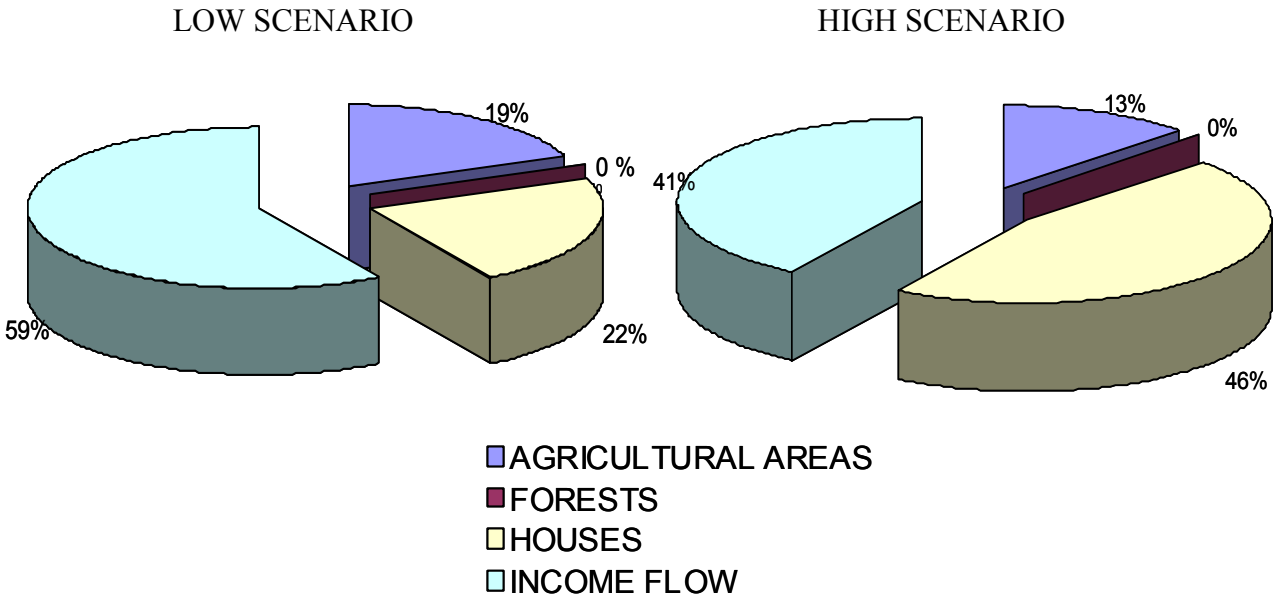

Figure 3 – Percentage distribution of the present value of the area at risk of permanent flooding in the Fondi plane per class of value (discount rate = 3%)

It is important to underline that the resulting values are very much dependent on possible options of modification of the actual territorial structure. For example, options like a property and/or land use change in the area south of the state road Flacca (i.e. from State ownership and agricultural use to private property for the development of infrastructures for tourism), as well as the creation of a natural park in the area south of the Fondi lake, which are currently under examination by the Municipality, would signify a great increase in the value of the area. Consequently, the potential economic damage due to the sea level rise in the next century would increase as well.
With reference to the two considered adaptation options, a rough estimate of costs relative to the necessary works is as follows:

Hypothesis 2: land protection by strengthening of the present system for land reclamation

DESCRIPTION OF NECESSARY WORKS	TOTAL COST
Increase of power of water scooping machines Increase of carrying capacity of canals and elevation of banks (km 356)	Around 250– 300 million euros, of which: - 200 million has already been assigned independently on forecasts about sea level rise (no – regret expenses) - 50 – 100 million euros need to be added to face sea level rise threats
Widening of the irrigation system Improvement of the sewerage system in the town of Fondi	

Hypothesis 3: land protection by reconstruction of the pre-existing dune as a first barrier to sea-level rise

DESCRIPTION OF THE COST ELEMENTS	INDIVIDUAL COSTS
Rebuilding of 12 Km of the pre-existing dune and waterproofing	12 – 15 million euros
Value of houses to be demolished	30 - 50 million euros
Elevation of banks in the lakes behind the dune	Not available
Closing of 2 existing canals with direct discharge into the sea and building of new scooping machines for the streaming out of water	Not available

The partiality of these results is due to the lack of a technical feasibility study of the two adaptation options. In general, a feasibility study is requested only once a sufficient certainty about the social acceptability of the options is reached. This is more likely to be obtained if a participatory process involving the interested parties is undertaken from the beginning of the decision process.

The results show that, due to an already developed and well working drainage system, the incremental costs linked to the expected sea level rise are much lower compared to the potential damage implied by a 'do nothing' strategy. In fact, the potential damage, according to our estimates, ranges between 130 and 270 million euros, while an amount between 50 and 100 million euros is considered sufficient by the interviewed experts to accommodate the existing drainage system to the projected sea levels. Such figures indicate that in other planes, with different characteristics with respect to the functionality of the drainage system and/or the land use of areas at risk, the economic analysis could suggest the inefficiency of this kind of protection measures.

The results concerning the second adaptation option do not allow to reach any conclusions about its economic efficiency, due to the limited information available. Nevertheless, the major social changes implied by such a strategy (i.e. abatement of many illegal houses), suggest that a deep social and political analysis, followed by a technical feasibility study, should precede any economic valuation.

Conclusions and policy implications

In this study we have explored the socio-economic dimension of climate change impacts and adaptation in Italy, first drawing a conceptual and theoretical framework for the economic assessment of climate change impacts, based on an in-depth review of the relevant literature, and then carrying out two case studies.

The WISE case study develops a simple methodology to estimate climate change impacts on the socio-economic systems and to assess the welfare change induced by those impacts. The estimated results suggest that Italy is highly vulnerable to climate change, consistently with the IPCC regional projections: outdoor fires are the most critical impact, followed by effects on tourism, energy consumption and agricultural production, which appears to be characterised by a high intra-annual and inter-regional variability. The case study analysis on the perception of climate change shows that in Italy individuals are fully aware of the effects of climate extremes on their daily habits and on their quality of life, being very concerned about future impacts, and that they tend to respond to climate extremes through some adaptive behaviour, which varies between the North and the South. Overall, the study adds to the existing literature on vulnerability by assessing climate change impacts by sector at the country level, and by providing, where possible, a monetary evaluation of the impacts. The variability of the impacts of climate change across Italian regions furthermore suggests the need for policy interventions which take into account the specificity of the geographical, economic, social and institutional context.

The Fondi Plane case study, focused on adaptation, identifies the most efficient option of adaptation to an expected sea-level rise in the coastal area of the Fondi plane, providing a sound methodological framework for the socio-economic evaluation of local interventions of adaptation through the application of cost-benefit analysis. The economic value of the areas at risk of flooding in the Fondi Plane is calculated, to represent the 'no intervention' option, and compared with the costs of two alternative measures of land protection, i.e. the improvement of the existing inland water drainage system and the reconstruction of a pre-existing dune along the coast. Case specific results suggest the efficiency of the improvement of the drainage system vs. other options. Results of course apply to the Fondi plane, and may be very different in another socio-economic and geographical context. The analysis of this case strongly suggests the need to complement the economic analysis not only with a technical feasibility study, but primarily with a social and political analysis of the local context. In particular, the study highlights how the social costs of local interventions can be very high and that the social acceptability of the adaptation options must be taken into account and become crucial to the process of evaluation.

Hence, the paper proposes simple and sound methodologies for both impact assessment and the economic evaluation of adaptation options. The economic dimension of climate change is one of the main points of view that policy makers, both at the national and local levels, should take into account when dealing with this issue. The methodologies proposed can either complement other types of analyses, or be extended in order to include other dimensions of the problem, such as the social and environmental aspects of climate change. The case studies analysed are a contribution in view of a pro-active behaviour towards the identification of the most severe impacts of climate change and the evaluation of adaptation options, that can help lessening the long period negative effects that local communities are likely to experience.

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(lix) This paper was presented at the ENGIME Workshop on “Mapping Diversity”, Leuven, May 16-17, 2002
(lx) This paper was presented at the EuroConference on “Auctions and Market Design: Theory, Evidence and Applications”, organised by the Fondazione Eni Enrico Mattei, Milan, September 26-28, 2002
(lxi) This paper was presented at the Eighth Meeting of the Coalition Theory Network organised by the GREQAM, Aix-en-Provence, France, January 24-25, 2003
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(lxv) This paper was presented at the EuroConference on “Auctions and Market Design: Theory, Evidence and Applications” organised by Fondazione Eni Enrico Mattei and sponsored by the EU, Milan, September 25-27, 2003
(lxvi) This paper has been presented at the 4th BioEcon Workshop on “Economic Analysis of Policies for Biodiversity Conservation” organised on behalf of the BIOECON Network by Fondazione Eni Enrico Mattei, Venice International University (VIU) and University College London (UCL) , Venice, August 28-29, 2003
(lxvii) This paper has been presented at the international conference on “Tourism and Sustainable Economic Development – Macro and Micro Economic Issues” jointly organised by CRENoS (Università di Cagliari e Sassari, Italy) and Fondazione Eni Enrico Mattei, and supported by the World Bank, Sardinia, September 19-20, 2003
(lxviii) This paper was presented at the ENGIME Workshop on “Governance and Policies in Multicultural Cities”, Rome, June 5-6, 2003
(lxix) This paper was presented at the Fourth EEP Plenary Workshop and EEP Conference “The Future of Climate Policy”, Cagliari, Italy, 27-28 March 2003
(lxx) This paper was presented at the 9th Coalition Theory Workshop on "Collective Decisions and Institutional Design" organised by the Universitat Autònoma de Barcelona and held in Barcelona, Spain, January 30-31, 2004

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