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"Economic Valuation of Climate Change Impacts on Biodiversity and Human Well-Being"

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Abstract

Economics has played an important role in the analysis of policy alternatives for several hundred years. Presently, project analysts are often interested in comparing alternative policies on the basis of the society's welfare. Economic valuation is a process through which societal welfare is translated into economic terms. The societal-welfare element of various policies in economic terms can then be compared. It is not the sole determining factor in policy choice but is often important in the ultimate decision. This paper reviews the literature on the economics of climate change adaptation in developing countries, and identifies three key points for consideration in future studies. One key point is that all development policy should be formulated using forecasts from climate science as a baseline. When this is not done, there is risk that a false status quo without climate change is seen as an implicit baseline. Another important aspect is that the allocation of rights is crucial for the results; if households have a right to maintain their current livelihoods, the costs of climate change in developing countries are considerably greater than traditional willingness-to-pay studies would indicate. Thirdly to promote and discuss the incorporation of the valuation results into the support of policy making, including ecosystem- based climate change mitigation policies as well as ecosystem-based welfare re-distributional policies. Thus, costs and benefits of climate change adaptation cannot be analyzed using economic aspects only; climate science, behavioral science, and legal and moral aspects have crucial implications for the outcome of the analysis.

Keywords: climate change; climate change adaptation; developing countries, WTP/WTA

Introduction

The publication of The Economics of Climate Change: the Stern Review in 2006 (Stern, 2006)[1] has inspired an unprecedented outpouring of high quality economics articles on climate change ever since (Heal, 2008)[2] . Neoclassical economic theories have been extensively applied in the estimation of the costs of climate change to our economy and have led to a stably growing number of Integrated Assessment Models (IAMs), which integrate the economic aspects of climate change with the science and dynamics of the climate. system. However, the current literature has shown by far, very little effort in the economic valuation of climate change impacts on natural capital and ecosystem services [2,3] .

Understanding climate change impacts on biodiversity, ecosystem services and human wellbeing The impact of climate change is multidimensional and involves interactions among three systems: the climate system, the ecological system and the socioeconomic system. Figure 1 below shows how these systems interact with each other through four key components: biodiversity, ecosystem services, GHG emissions and human wellbeing. Among all others, biodiversity plays a fundamental role in conjoining the three systems together. For this reason, we shall start our illustration from the ecological system that biodiversity underpins.

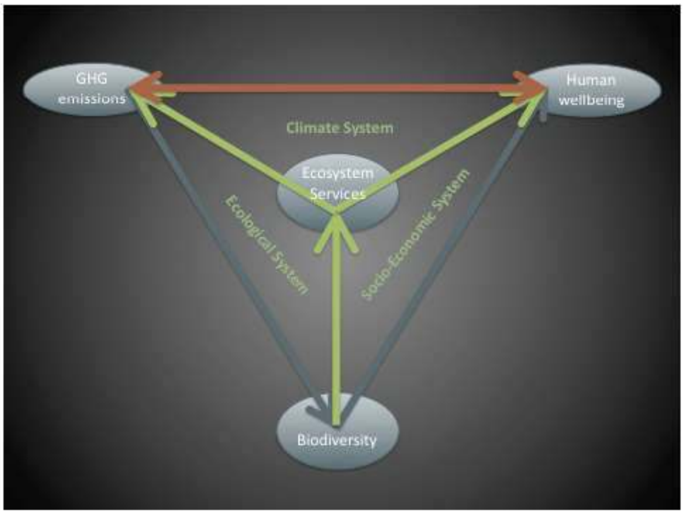

Figure 1. Graphic illustration of interactions between climate change, biodiversity, ecosystem services and human wellbeing

The ecological system biodiversity by definition encompasses the variety of life on earth from genes to species, through to the broad scale of ecosystems across time and space. It is important in terms of determining the health of ecosystem, ensuring the stability and productivity of ecosystems, as well as underpinning the supply of an array of ecosystem services that contribute directly and indirectly to human wellbeing.

The climate system The global climate system is connected with both the human socio-economic system and the biological system through the change of chemical composition of the atmosphere. There is new and stronger evidence that most of the warming over the last 50 years is attributable to human activities, such as coal and oil based energy generation, cultivation, deforestation and other land use changes that have greatly induced increases in atmospheric concentrations of carbon dioxide, methane, and nitrous oxide (IPCC, 2007) [4].

The socio economic system Mounting population, changing diets, urbanization, land-use changes and climate change are the major social-economic pressures on biodiversity, causing species to vanish at an alarming rate all over the world. This in turn can significantly affect the stability of ecosystem functioning and their capacity to retain the provision of ecosystem services to humans.

The figure implies that climate is an integral part of ecosystems and organisms have adapted to their regional climate over time. Climate change is already having an impact on ecosystem and biodiversity in various world regions, in particular on the high-altitude and high-latitude ecosystems. Projections suggest if global mean temperatures exceed 2-3 °C within this century, climate change will become a progressively more significant threat to ecosystem through changing species distribution, population sizes, the timing of reproduction or migration events as well as through increasing the frequency of pest and disease outbreaks [5].

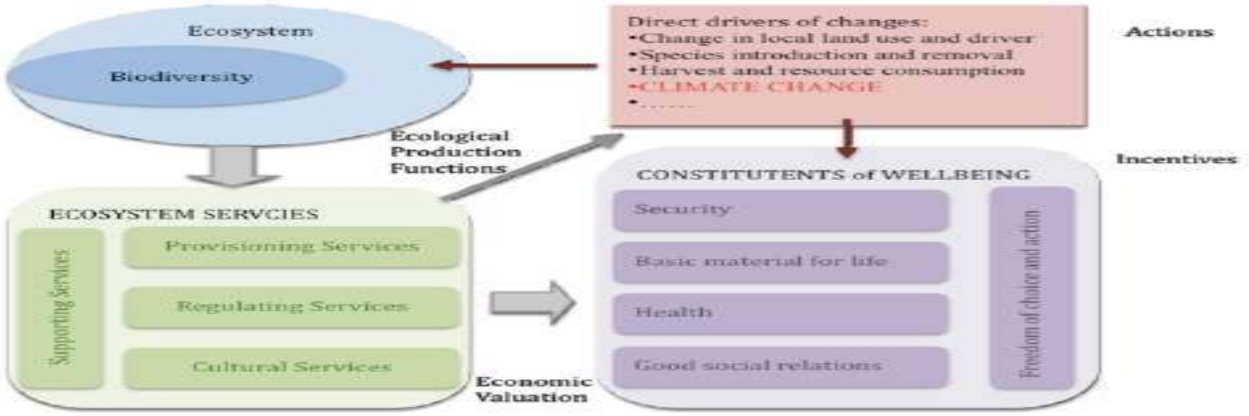

Figure 2. An analytical framework to link biodiversity, ecosystem services and human wellbeing (Source: MA (2005), adapted)

There is widespread recognition that climate change and biodiversity are linked. Most obviously, by changing the environmental conditions within which species exist, climate change induces an adaptive response on the part of species. An extensive literature over the last two decades has described this effect on both species and ecosystems [6,7,8]. Much of this is summarized in the international biodiversity and climate assessments at various scales [9,10,11].

Estimating the Value of Climate change and Biodiversity-Related Changes in Ecosystem Services

Evaluation of the impacts of climate change on biological resources and biodiversity requires estimation of the consequential changes in the production of ecosystem services. This includes changes induced by alteration of environmental conditions reflected, for example, in the changing costs of agriculture, forestry and fisheries. It also includes changes in a set of no marketed ecosystem services. The current assessment of the economics of ecosystems and biodiversity (TEEB) has addressed the problem of identifying the biodiversity-mediated impact of climate change by developing a database of valuation studies, and reporting the distribution of the estimated values associated with the ecosystem services affected by climate change. It is not the purpose of this paper to review this material. It is sufficient to note that the value estimates reported are marginal, instrumental, anthropocentric, individual-based and subjective, context and state-dependent [2,11]. Moreover, for the most part, ecosystem services are valued through their impact on the production of commodities or non-marketed effects that are directly valued by people [13,14,15], and the value of ecosystems as natural assets derives from the services they produce [16]. Its interim conclusions on this system indicate that two types of benefit are dominant: one being tourism, recreation and amenity, the other being coastal protection. The mean marginal value of ecosystem services in US$/ha/year generated using this method was $86,524 for tourism, recreation and amenity, and $25,200 for moderation of storm events. By contrast, the mean marginal value of food production (fisheries) was only $470 [17,18]. While this disparity is almost certainly an artefact of the approach adopted (it averages over studies rather than systems) it does illustrate an important feature of the value estimates attaching to all ecosystem services: that measures of people's marginal willingness to pay to acquire an ecosystem service reflect both their preferences for that service relative to others, and their income level. Willingness to pay is as much a measure of ability to pay as it is a measure of preference. The people who depend on coral reefs for fisheries are not the same as the people who access coral reefs for pleasure. They come from different countries, they have fewer assets and they have lower income. An additional qualification noted by TEEB is that there may be discontinuities (threshold effects) in the impact of climate on systems like coral reefs.

Re-evaluating Biodiversity and Climate Change

To estimate the value of climate-related biodiversity change, we need to understand (a) the impact of land use change on climate and the other structural characteristics of the system that affect biodiversity, (b) the effect this has on the functional diversity of species, and (c) the consequences of change in the functional diversity of species for the ecosystem services that people care directly about—such as the supply of foods, fuels and fibers, pharmaceuticals, scientific information, genetic resources, recreation, tourism, amenity and spiritual satisfaction. The greater the diversity of species within functional groups, the greater will be the capacity of the system to continue to produce valuable services under climate change. One challenge in estimating the value of climate-related biodiversity change is that we do not have general models of interactions between the biosphere, the hydrosphere and the atmosphere, and the social system.

The models developed by environmental economist all focus on individual components of the general system, and include only a limited set of feedbacks. The models used to estimate the economic impacts of climate change are similarly highly simplified, but they do attempt to capture at least some of the biodiversity-mediated costs of climate change. (Mendelsohn ,1998) [19] estimated impacts for agriculture, forestry, energy, water and coastal zones. (Tol 2002)[3] extended this to include impacts on other ecosystems, as well as mortality from vector-borne disease, and (Nordhaus and Boyer 2000)[20] added, in addition, impacts of pollution and effects on recreation. Estimates of the long-term global damage cost associated with climate change vary significantly, lying anywhere between zero to 11 percent of global GDP. The damage estimates derive from the IPCC’s integrated assessment models, which are unable to incorporate activity changes induced by feedbacks within the socio-economic system. Stern argued that all models omitted potentially important impacts, and that taking these into account would likely increase cost estimates substantially. In particular, he estimated that inclusion of non-market impacts on the environment and human health would increase the total cost of business as usual climate change from 5 percent to 11 percent of GDP, excluding ‘socially contingent’ impacts such as social and political instability [1]. The Fourth Assessment Report of the IPCC reported significant improvements in the capacity to predict changes in land cover and species richness associated with climate change, appealing to results from climate envelope modelling (niche-based, or bioclimatic modeling) and dynamic global vegetation modelling [21]. However, the same limitations on the capacity to model interactions between the social and bio geophysical system apply. It is not yet possible to use the integrated assessment modeling approaches of the IPCC to project, with confidence, the magnitude of the global effects of biodiversity change as it impacts climate change, or of the effects of climate change on biodiversity. Current models of the global economic impacts of climate change are useful in identifying areas where impacts may be significant, but we are not able to use them to estimate the value of climate-related biodiversity change.

The general implication of their result is that in the poorest countries, income growth is strongly correlated with increasing levels of threat to biodiversity. This reflects the fact that the poorest countries are also strongly agrarian. In such countries, income growth depends both on the extensive growth of agriculture (the expansion of agricultural lands into more ‘marginal’ areas that are otherwise habitat for wild species) and on agricultural intensification (the progressive simplification of the agro ecosystem as pests, predators and competitors are ‘weeded out’ of the system). While there is the potential to design agro ecosystems in ways that reduce the biodiversity/ agricultural output trade-off, the empirical evidence is that in low-income countries increasing agricultural output has the highest priority, and that consequential impacts on wild species is regarded as a reasonable cost of that activity.

Discussion and Conclusion

The point was made in the introduction to this paper that climate change is both a cause and an effect of biodiversity change. It is one of the main drivers of change in the distribution of both beneficial and harmful species. It is also a consequence of the way that people use biological resources, and structure ecosystems. The production and use of biological resources for foods, fuels and fibers and the way in which the landscape is structured have direct impacts on carbon sources and sinks and, at the same time, indirect impacts on the capacity of ecosystems to adapt to changes in climate. We do not yet have good measures of the value of biodiversity as either a cause or an effect of climate change.

The point here is that however the economic losses of climate change are calculated, a very substantial part of those losses are biodiversity related. The point has also been made that biodiversity is much more than the macro fauna and macro flora that attract the attention of the conservation community. Every ecosystem service depends on some combination of species. The number and diversity of species associated with particular services varies widely, but in almost all cases greater species diversity means that the supply of ecosystem services may be maintained over a wider range of conditions. Hence, the value of functional diversity under climate change is the capacity it gives to adapt successfully.

Finally, it is worth underlining the fact that the climate and adaptive capacity externalities of biodiversity change are a very significant part of the climate change problem. Despite the growing attention to adaptation, this has not been fully appreciated. Although it may not currently be possible to put a reliable value on the impact of functional diversity for the adaptive capacity of the system, it is certainly large—several percentage points of global GDP

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