New Climate Economics: Methodological choices and recommendations

Additional guidance supporting UNEP's MCA4climate initiative:
A practical framework for planning pro-development climate policies

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Projections of future impacts, benefits and costs of climate mitigation and adaptation policies are based on both detailed empirical research, and modelling choices and assumptions that frame the analysis. For instance, assumptions about the expected growth of population and incomes drive the projections of greenhouse gas emissions. Assumptions about the pace and nature of innovation, the economy-environment-society interactions and the relative value of future versus current resources affect the estimates of the long-run benefits or costs of climate policies. Assumptions about future population health in the business-as-usual scenario affect the estimates of the health benefits or harms of climate change mitigation and adaptation policies. Further, estimates and assumptions regarding climate variability affect the benefits of adaptation measures to tackle potential increases in climate-related extreme events. Also, methodological choices about the treatment of disparate, incommensurable impacts are often decisive for policy decisions.

This document presents a series of what we refer to as critical issues for climate mitigation and adaptation policy analysis, involving overarching choices that affect multiple areas of expert analysis, and in particular the socio-economic assessments of climate policies. The following pages identify key issues for a comprehensive and realistic economic analysis of climate policies, present a few major options for answering those issues, and recommend a preferred course of action or option for analysts to consider (akin to what some refer to as "new economic thinking"). The issue of risk and uncertainty has been addressed in a separate supporting guidance document, due to its overriding importance and specific inter-disciplinary profile (available on the website of the MCA4climate initiative: www.mca4climate.info). In addition, some practical implementation aspects of the issues discussed below have been provided in Annex 1 at the end of this document.

Some of the topics addressed here may be more amenable to qualitative than to quantitative analysis; potential examples include the valuation of non-market "goods" such as human health and environmental protection, and the goal of intergenerational equity. It is nonetheless important to understand the implications of both quantitative and qualitative approaches to these issues, since both approaches are often raised in the discussion of climate policy. The guiding principles underpinning the overall MCA4climate approach.

The MCA4climate approach to climate economics

Critics of traditional economic approaches argue that these are ill-suited to underpin climate change policy making because monetising human preferences, ecological properties and technological possibilities is difficult and can be misleading, and because the associated techniques neglect important ethical questions. A new thinking on the economics of climate change is emerging which seeks to take these shortcomings into consideration.

This new thinking claims that: (i) any underpinning of climate change policy-making needs to consider, in addition to economic aspects, health, equity, environmental, institutional and ethical perspectives, as well as the interactions amongst them; (ii) due consideration needs to be given to the evolution over time of changes in technologies which may occur as a response to climate policy, which are themselves influenced by institutional factors and past experiences; (iii) by avoiding the exclusive use of monetary valuations, important inter- and intra-generational equity and environmental concerns can be included in the analysis; and (iv) uncertainty and risk, which are central to climate change impact assessment, should play a major role in public policy. Multi-criteria analysis (MCA) is consistent with this approach, which is one of the main reasons for having structured our work on the MCA4climate initiative around it.

1. Future macro-level assumptions driving the analysis

<u>Rationale</u>

Most greenhouse gas emissions are direct results of economic activity. Thus the anticipated growth of population and per capita production and consumption represent major influences on future emissions. Faster-growing populations and economies will tend to have faster-growing emissions as well. Consistency of assumptions on these points is essential within any single national assessment; consistency between different national studies is desirable as well. The levels of economic, population and emissions growth in a business-as-usual scenario will also influence the costs and impact of climate policy action (e.g. higher baseline growth rates typically imply greater costs for switching to low-carbon economies, as well as greater potential for benefits – i.e. avoided costs – from emission reduction).

Other macro-level assumptions will also affect emissions. One of the most important influences on emissions intensity is the price of oil (and other fossil fuels). Higher oil prices increase the economic benefit of energy conservation measures, thereby inducing more energy saving technology. Higher oil prices can also have other socio-economic effects e.g. they can increase food prices because of increased transportation costs, and this in turn can affect the health and well-being of poor populations. Major studies of climate impacts and policy costs have differed widely on the impact of climate policies on the price of oil, with climate policy "optimists" often assuming higher oil prices than "pessimists."

Unfortunately, there is no single, standard source of projections on these and other macro data inputs. Moreover, a complete model of climate policy costs and impacts should, in theory, make some of these data endogenous: climate damages can affect the rate of (business-as-usual) growth

of per capita incomes; climate policies can change the price of oil. In addition, future macro-level (baseline) assumptions need to be differentiated between the international/global level and the nation level. Ideally, the macro-level assumptions at the national level are endogenised and integrated into a global system of energy-environment-economy-health interactions.

Option 1

Use a very complete model of climate economics, to make as many variables as possible endogenous. This is theoretically appealing, but expensive and difficult in practice; even the best models may not produce adequate endogenous dynamics of output, emissions, prices, and incomes.

Option 2

Select a range of available studies that provide the needed projections (ensuring as much consistency as possible) and calculate the corresponding averages. This method is being used by some forecast providers on the basis that the average of a group of studies typically outperforms any particular model or team of experts. Note that some studies may be commonly accepted as the main authoritative source of projections, such as UN's Population Division on population projections, the World Health Organization (WHO) on population health projections, the World Bank on socio-economic projections, in which case such sources take priority.

Option 3

Select macro data for consistency with other planning studies in the same country. For instance, some countries have statistical offices which offer preferred projections of socio-economic growth. This promotes compatibility with the broader policy discourse within the country. National-level studies also tend to include more detailed country-level information and empirical research.

Recommendation

The MCA framework is targeting the national strategic policy level. However, assumptions on future growth rates of key global socio-economic variables need to be made since any domestic market interacts to some extent with international markets. Thus, for the macro-level assumptions at the international level, the recommendation would be to apply option 2 to existing sets of projections for exogenous global variables, such as GDP, population, population health and oil prices, unless a global endogenous model sufficiently disaggregated is being made available (for which option 1 would apply). For macro-level assumptions at the national level, the recommendation would be option 3. If nationally-sourced projections are not available or limited to the short-term horizon, using other relevant outside studies (option 2 may be applied if these are many) or using other countries' projections as proxies may be necessary.

Similar considerations apply to both adaptation and mitigation, although macro-level assumptions play somewhat different roles in these two areas. Mitigation typically involves decisions about emissions, which are directly tied to production and consumption; its connection to macro-level assumptions is immediate and inescapable. Adaptation requires the expenditure of economic resources, and is frequently designed, in part, to protect economic activity; thus it is also connected to macro-level assumptions. For both adaptation and mitigation, sensitivity analysis should be

carried out to determine the extent to which (i) the climate change impact estimates across the multiple criteria and (ii) the comparative evaluation of alternative climate policy options using the MCA decision analytical framework, are affected by the macro-level assumptions.

For additional discussion of macro-level assumptions, highlighting the role of government budgets, foreign trade, and other important macroeconomic issues, see the companion document, "Developing Baselines for Climate Policy Analysis", representing also supporting guidance under the MCA4climate initiative (www.mca4climate.info).

2. Technological innovation, learning, dynamics and feedbacks

<u>Rationale</u>

In long-run climate scenarios, assumptions about the flexibility of technology and the pace of technological change can be crucial to the ultimate outcomes. Will technology improve automatically, independent of policy (as in the "autonomous energy efficiency improvement" assumed in some models)? Or is it an endogenous process shaped by public policy, investments in research and development, and past experience (as in "learning curve" or "learning by doing" analyses)? Endogenous (or induced) technology models generally project much lower costs of climate policy, since the policy stimulates a virtuous circle of cost-reducing innovation and emission reduction.

There is a trade-off between aggregate or top-down approaches to technology, spanning the society as a whole (or major branches of the economy), versus bottom-up studies that allow a more detailed representation of specific technology options in a narrower domain. The bottom-up approach provides better technology detail, while the top-down approach provides a broader perspective on social goals and major policy options.

Closely related to this is the question of modelling economic, health, political and environmental dynamics in general, through tools such as systems dynamics modelling. Dynamic models with multiple feedback loops and relying on extensive (time series and cross-sectional) datasets are undoubtedly more realistic, but also more complex, more difficult to estimate, and more sensitive to small fluctuations.

Learning and dynamics also play an important role in adaptation analyses, as they affect vulnerability and adaptive capacity. Often, due to a lack of data, current conditions are assumed for future vulnerability and adaptive capacity; this may not be a good approximation, as many societies have been shown to reduce vulnerabilities over time.

Option 1

Assume a fixed pace of technical change; minimise use of data and uncertain feedback loops. This option leads to simplicity and ease of calculation of results. On the other hand, it misses crucial dimensions of change over time, which may be essential to the desired results.

Option 2

Adopt a limited form of endogenous technological change, and a small number of crucial feedback and dynamic effects of policy choices. This incorporates some of the recent advances in modelling of system dynamics, while stopping short of the full complexity of real-world social processes.

Option 3

Attempt a completely data-intensive dynamic model with numerous causal pathways and feedbacks, as in some systems dynamics approaches. This pushes toward state-of-the-art modelling of a messy, complex reality, which should be the goal.

Recommendation

Option 2 represents the appropriate level of complexity for most studies. In cases of limited resources for analysis, Option 1 may be a cost-saving and time-saving alternative, though the likely costs and impacts of climate policies may be mis-represented.

Similar considerations again apply to both mitigation and adaptation, for slightly different reasons. For analysis of mitigation, there is naturally a trade-off between model complexity on the one hand and the ease of carrying out and interpreting the climate policy MCA assessments on the other hand. This requires selection and specification of a particular model of endogenous technical change and reliance on econometrics where data is available. For adaptation, the emphasis is less on long-term technological change, but on shorter-term feedbacks and dynamics; the ongoing process of learning about hazards and adaptation options makes an essential contribution to the reduction of vulnerability.

3. "No-regrets" options for mitigation and adaptation

Rationale

This issue has been debated most extensively in terms of mitigation costs, although it applies to adaptation as well. Many bottom-up analyses, such as the McKinsey cost curves, have identified substantial opportunities for mitigation at zero or negative net cost. Some economists have argued that this is impossible in a market economy (since "someone would have picked up any $20 bills found lying on the sidewalk"), and have therefore deduced that there must be hidden costs and barriers to the apparently no-cost opportunities. Many aggregated or simplified climate economics models cannot, by design, incorporate no-regrets options, i.e. opportunities for adaptation or mitigation at zero or negative net cost. Decisions on this issue, which involves philosophical as well as empirical questions, have a large effect on estimated costs of climate policy.

No-regrets options are more common in analyses that include the "co-benefits" of climate policy across different sectors. Co-benefits include for example the health benefits of reducing fossil fuel combustion (due to the reduction in non-GHG air pollution), and the increased resilience and reduced vulnerability to non-climate shocks that can result from successful adaptation measures. Both mitigation and adaptation policies may bring benefits of economic diversification and increased employment in new industries or protective investments. Unfortunately, it is not always easy to measure co-benefits such as the crosscutting effects of adaptation.

Option 1

Use the best available, disaggregated information on no-regrets or "win-win" options. These options will normally be the first priorities in any climate policy proposal; they will reduce the overall costs of a comprehensive climate policy.

Option 2

Reject the possibility of no-regrets options, and endorse the presumption from economic theory that there must be hidden costs large enough that all policy options have positive net costs.

Recommendation

For both adaptation and mitigation, option 1 should be accepted, as it makes better use of the available information about real-world costs. Wherever the available empirical information points to zero or negative net costs for policy measures, this information should be accepted; markets are imperfect and information is incomplete in reality, so the "no free lunch" deduction from economic theory does not always apply. In response to the economic theory critique, it is important to examine any potential no-regrets or win-win options carefully and identify and transaction or program costs needed to achieve the projected savings. This may reduce, but is unlikely to eliminate, the projected savings.

For a full life-cycle analysis of climate impacts and policy costs, co-benefits should be included whenever data are available. The inclusion of co-benefits frequently has a very important effect on the outcome of policy analyses. Central to the decision analytical framework proposed in this work is the ability to take into account the impacts of climate policy options across several criteria in order to select the most appropriate policy option.

4. Monetary valuation and non-marketed impacts

Rationale

Monetisation of the environment, health and other social issues has become a common practice, but it reduces transparency of the results, and raises a range of ethical and analytical dilemmas. Is it necessary to monetise every significant benefit? Are standard values available for non-market benefits? If the values are based on willingness to pay, do they vary with income? Economic logic suggests that they must vary; but are health and the environment worth more in a rich country? Alternatively, can the most important damages or benefits be reported in natural (physical or health) units as well as in monetary equivalents?

For health, there are three options for reporting data: individual outcome categories such as numbers of cases of bronchitis; total Disability Adjusted Life Years (DALYs) or similar measures; and monetary valuation of DALYs. Do DALY calculations adequately represent health outcomes? Does a single monetary measure adequately represent the value of a DALY? Does the value of a DALY depend on income?

Option 1

Apply the best available estimates of monetary valuations of all health and environmental impacts. This has the advantage of internal consistency, and creates a bottom-line numerical estimate for any scenario. It is required for cost-benefit analysis.

Option 2

Apply only the most established, least controversial valuations of non-market benefits, such as the externality prices for common air pollutants used in energy sector analyses. In addition, report all major health and environmental impacts in their natural units. Report health impacts both in DALYs and in specific health outcomes. Qualitative assessments may also be pursued in parallel for impacts that do not easily lend themselves to quantification.

Option 3

Avoid all use of monetary valuations of non-market benefits. Report all market costs and benefits in monetary terms; report all health and environmental impacts in natural units. Avoid DALYs, as well as surrogate prices, for health outcomes. This has the advantage of avoiding the ethical and logical paradoxes of pricing the priceless values of life, health, and nature, and leaves the issue of valuation of different criteria on the same metric to policy-makers.

Recommendation

For both mitigation and adaptation analysis, Option 2 is preferable to Option 3, since it allows comparison to other studies using now-standard monetary values for some externalities, and DALYs for health impacts. It preserves and presents, however, the essential information about impacts in natural units, which is required for transparency and communication with non-specialist readers. Both Options 2 and 3 are preferable to Option 1; any attempt at complete monetisation threatens to obscure the underlying information on climate consequences and policy action, while inevitably omitting or misrepresenting some important categories, particularly in the areas of health and environmental impacts.

For a comparative evaluation and prioritization of climate policy options based on multiple criteria, relative weights may have to be assigned to each of the criteria, based on stakeholder consultation and employing MCA techniques (such as the Multi-Attribute Value Analysis). This valuation of the criteria is done, however, at the policy scoring and ranking stage, rather than embedded in the impact estimates or assessment of likely effects.

5. Discounting

Over the long spans of time in climate analyses, the discount rate (if any), applied to future costs and benefits of any climate policy action is of great importance. Discounting plays a major role in any economic analysis of costs and benefits extending over a period of years; for conventional project analysis or investment decisions, it is appropriate to use an economic discount rate, based on the opportunity cost of investments in capital markets. For public policy decisions, however, especially for those with very long-term consequences, it is appropriate to use a social discount rate, reflecting society's evaluation of present vs. future costs and benefits. A host of questions have been raised

regarding the choice of a social discount rate for climate policy analysis, which can be outlined as follows (with recommendations following each question).

5A. Should future costs and benefits be discounted?

Some moral philosophical and ethical arguments have been raised against discounting; critics have suggested alternatives such as summing undiscounted future quantities up to a fixed time horizon of, say, N years, and then ignoring later years (which, for a constant, unending data series, is mathematically equivalent to discounting at an annual rate of 1/N). Our recommendation would be not to discount quantities that cannot be adequately expressed in monetary terms, such as many health and ecological impacts. However, since the practice of discounting is widely accepted, and even expected in climate analyses, our further recommended choice would be to use discount rates for future quantities that lend themselves to monetary valuation.

5B. Should the discount rate be constant or declining over time?

Constant discount rates have long been the norm. They simplify calculations and theories; they follow the logic of financial markets, and prevent arbitrage and paradoxes of preference reversal. The arguments for constant discount rates are certainly valid for short or medium-term financial calculations.

For intergenerational public policy choices, however, there is less need for consistency with markets. Discount rates that decline over time have been proposed on the grounds of psychological research on individuals' time preferences, and separately on the basis of uncertainty about future interest rates and growth rates. Declining discount rates are starting to appear in climate policy analyses, e.g. in recent UK government guidance on such analyses.

The recommended choice is to explore, through sensitivity analysis, the effects of declining discount rates, in addition to or in place of constant rates; UK guidance provides one model. Note that a study can easily explore multiple approaches to discount rates, in effect by making a simple change in its final spreadsheets. In view of the sensitivity of long-term calculations to the discount rate, it may be desirable to contrast the implications of more than one discount rate scenario. It is even possible to back-calculate the discount rate at which a policy proposal "breaks even."

5C. If the discount rate is based on financial markets, what rate of return should be used?

Economic theory offers two major approaches to discount rates, sometimes called "descriptive" and "prescriptive." The descriptive approach assumes that financial markets already reveal the value of future versus current assets, so the discount rate should be set equal to a market rate of return. For investments with returns that vary with the broader market (i.e. positive correlation with stock market index or other indicator of profitability), the rate of return on risky assets such as stocks should be used; this is often taken to be 5% - 7% in real terms, as a long-run average. For investments with returns that are not correlated, or negatively correlated, with the broader market, the appropriate rate is the rate of return on risk-free assets such as long-term government bonds from developed countries, often taken to average 1% or less in real terms.

Efforts at climate mitigation and adaptation have a more valuable "return" in scenarios where climate damages are severe; they are better understood as social insurance against disaster, rather than ordinary profit-seeking investment. As is typical for insurance, their returns are uncorrelated or negatively correlated with the broader market. Thus the risk-free rate of return is the recommended choice under the descriptive approach to discount rates.

5D. If the discount rate is based on the "Ramsey equation," what rate should be used?

The alternative, "prescriptive" approach of economic theory derives the intergenerational discount rate from general principles, using a framework and an equation that date back to the early twentieth-century economist Frank Ramsey. There are three components to the discount rate under this approach.

5D.1. The rate of pure time preference is the discount rate that would apply if all generations were known, with certainty, to have identical incomes and resources. Some economists have argued for a significantly positive rate of pure time preference, on grounds of the observed impatience of consumers. Other analysts, including many non-economists, have argued for a zero or near-zero rate of pure time preference, to reflect the ethical principle that all generations are equally important. The Stern Review provides an excellent summary of the arguments for a near-zero rate of pure time preference, which is the recommended choice.

5D.2. The income-based component of the discount rate is a multiple of the rate of growth of per capita consumption. This reflects the principle that the marginal benefit of another dollar of income is lower for richer people – and therefore, benefits to richer, future generations can be "discounted." (If future generations turn out to be poorer, this can yield a negative discount rate.) Economic theory does not have a simple recommendation for what multiple of the rate of growth of per capita consumption should be included; many studies have used values in the range of 1 - 2. This is the recommended choice; a single value should be selected at the outset of a study.

5D.3. The uncertainty-based component of the discount rate is often overlooked, but the full analysis of the Ramsey equation in the financial literature includes a third term which is a negative multiple of the variance in future growth rates. The more uncertain the future will be, the lower the discount rate should be; this reflects the greater need for precautionary savings in a more uncertain world. Some estimate of the uncertainty-based component should be included in the discount rate; the common use of the Ramsey equation with only the first two terms amounts to assuming that the future is known with certainty.

6: Time horizon of the analysis

Rationale

The time dimension of the climate change problem is crucial. Climate science deals with long-time horizons of at least 100-200 years. Climate policy for both mitigation and adaptation would need to follow climate science in order to prepare for long-term planning and understand the long-term costs and benefits that may be associated with switching to low-carbon economies.   Thus in

addition to the short (and medium) term projections, the analysis of positive and negative climate policy impacts in the long term is essential for designing robust policy responses. Projecting far into the future would also help understanding potential links with fiscal sustainability. However it should be noted that the longer in the future is the time horizon of analysis, the larger the uncertainty in the estimates of the impacts.

Option 1

Focus on the short term, e.g. up to the year 2020. The advantage of this approach is that more information and modelling applications are available, particularly on the socio-economics side. Moreover, it minimizes the importance of the choice of discount rates and the treatment of uncertainty, avoiding those difficult questions. However, time spans of one or even two decades are too short to see any major impact of policy choices on climate outcomes; 10-20 years may also be too short to identify social impacts, induced technological change, and other long-term economic trends.

Option 2

Focus on a time horizon extending at least to 2050 and up to 2100. This would provide a better evaluation of meeting stabilisation targets, effectively adapting to longer-term climate impacts, identifying patterns in long-term economic cycles and technological innovation, and exploring the potential for co-benefits. However, as the time horizon increases, the greater the uncertainties inherent to the analysis are.

Option 3

Focus on a time horizon that takes the analysis up to 2200. Whilst this is desirable as it would extend the socio-economic analysis over the time spans relevant to climate science, the uncertainties may be too large to perform a stable analysis.

Recommendation

Option 2 would be preferable within the context of a project aiming at guiding the long-term planning process of mitigation policies. However, the short to medium term impacts of long-term plans also need to be explored. For adaptation, both options 1 and 2 are reasonable choices. Many policies have a short-term focus, yet there is need to consider longer term adaptation measures, which can have time horizons up to 2050.

Annex 1: Implementation aspects of the issues considered

A note by Zaid Chalabi and Sari Kovats

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The MCA4climate initiative sets out six critical points concerning a robust economic analysis of climate change policies. These conditions are based on the *new thinking* of climate economics[1-3]. The justification and rationale for establishing the standards are very well argued from the theoretical perspective. However these conditions are defined in general terms. It is necessary that they are translated into a more explicit set of rules or guidelines which can be taken on board by anyone wishing to apply these in practice. It is important to note however that these conditions are not independent of each other and there is need to ensure consistency across them.

1. *Future macro-level assumptions the analysis*. Ideally, all groups should develop MCA assessments under a specific set of scenarios for future conditions. Adherence to this condition is straight-forward in theory but requires some thought in practice. It is not expected that users of this guidance would necessarily generate their own future scenarios; they should instead take "off-the shelf" projections as appropriate from the UN, WHO, World Bank and other bodies. Given that most MCA assessments are to be done at the country level, then the country's own scenarios of population and economic growth should be used where possible.

It is important that analysts (i) agree on the future scenarios particularly in relation to climate and country-specific socio-economic projections (ii) establish the extent to which the assessments are affected by some detailed macro- (and country-level) socio-economic and governance assumptions (iii) offer scenarios analysis as a means to test the sensitivity of the assessments to departures from future projections.

2. *Technological innovation, learning, dynamics and feedbacks*. The rationale behind this is that economic, social, environmental and ecological systems are inherently dynamic. In other words, they change considerably with time over the time horizon of analysis. This is so because the (climate or non-climate induced) disturbances to any system, and the reaction of the system to the disturbances, are essentially time-varying. In addition, these systems have feedbacks loops which mean that their variables are coupled and that past changes in the variables would affect the future evolutions of the variables. The presence of feedback loops influences the stability of these systems. A system dynamics approach (which takes into account the time-varying nature of the system variables and their feedback interactions) would be more appropriate than a static approach for evaluating the impacts of climate shocks and climate policies on these systems. By their nature, social and environmental systems cannot be simply described by one-directional causal network between input and output variables. These systems are essentially governed by multiple feedback

loops which would have strong bearing on the stability of their responses to climate shocks and disturbances.

Analysts should define their system variables and their interactions and disclose any time-varying behaviour or feedback mechanisms which govern their relationships. It is recognised however that the overall system description should be a balance between complexity on one hand to ensure that all aspects of climate-system interactions are taken into account in the climate policy assessments and simplicity on the other to ease the assessment exercise.

3. *"No-regrets" options for mitigation and adaptation*. This condition is a reminder to analysts that climate change mitigation and adaptation measures can have negative costs, particularly depending on whether one considers co-benefits and co-harms, which should be taken into account in the overall assessments. For example, the health co-benefits of climate change mitigation have been demonstrated recently [4-6]. The co-benefits and co-harms should be considered under the proposed framework of the MCA assessments to include the effects of the policy option on health, social and environmental spheres. However, the consideration of co-benefits and co-harms may require a broader perspective. It is often argued however that there are also opportunity costs (particularly in the case of developing countries) to some of the climate change adaptation policies and that these opportunity costs should be considered in the overall assessment. Naturally if the funding of the climate-change adaptation policies is not in competition with other funding, then these issues do not necessarily arise. Nevertheless it is important to note that uncertainty should be considered when evaluating the co-benefits (and co-harms) of the climate polices. Careful analysis should also explore the "win-win" situations.

Analysts should consider if their climate change mitigation (and adaptation) policies can have co-benefits (and co-harms) in other spheres. Where appropriate their assessments should also take into account opportunity costs of the policies.

4. *Monetary valuation and non-marketed impacts*. The rationale behind this condition is that environmental, health and social impacts cannot all be given a monetary value due to ethical and other philosophical considerations[1-3]. Standard methods which transform all impacts across several dimensions into a single metric (currency) for cost-benefit analysis are therefore not appropriate. This is indeed the reason why MCA4climate advocates the use of multi-criteria analysis instead of the classical one-dimensional cost-benefit analysis.

Analysts should define all the impacts in their 'natural' (i.e. non-monetary) units. They need to say whether their non-cost impacts are quantitative, qualitative or fuzzy variables.

5. *Discounting*. Much attention has been paid recently to the rationale for setting discount rate for climate policies [1-3,7-8]. It has been shown that the cost-benefit analysis is very sensitive to the choice of the discount rate and that discount rate is indeed one of the most important variables in this analysis[5]. In the *new climate economics* paradigm, the selection of the discount rate should either be prescriptive or descriptive[3]. In the prescriptive approach, the discount rate is determined from basic economics principles. It is essentially decomposed into three components: the pure time preference component (zero rate), income-based component (1-2 multiples of the rate of growth per capita consumption), and uncertainty-based component (negative multiple of the variance of the future

growth rate). In the descriptive approach the discount rate is set exogenously, however instead of using the classical approach of return to investment to set the rate [9] an insurance-based ('risk-free' rate) approach is deemed to be more logical [3,8].

Analysts should ideally agree on the rate for discounting future costs and benefits. It may be difficult to get consensus because benefits accrued in one domain may take longer than another domain, but nevertheless there needs to be agreement on the rationale for choosing the discount rate. Experts should also be aware that some of the metrics (indicators) that they use for assessment may have in-built discount rates which if unaccounted risks double discounting.

6. *Time horizon for the analysis*. The issue of selecting the appropriate time horizon of the analysis is intertwined with uncertainty. The longer the analysis looks into the future the more there is uncertainty in the estimated impacts. The choice of the appropriate time horizons is a trade-off between the need to extend the time horizon of the analysis for the climate policies to take effect on the one hand, and the need to shorten the time horizon to reduce the uncertainty in the impacts on the other hand. Users and analysts should be aware that the time horizon for the analysis of policies (which is usually in the order of 20 years) need not be necessarily the same as the time horizon for the analysis of the impacts which can be much longer.

Analysts should explore different time horizons (short and mid-term, up to 2050-2100) for the analysis but should also take into consideration the progressively larger uncertainty with longer time horizons.

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