

Several Gaps between IAMs and Developing Countries

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Epistemological gaps between Integrated Assessment Models [IAMs] and Developing Countries.

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Abstract

Integrated Assessment Models [IAMs] have been recognized as having great potential as an integrative analytical tool for assessment of climate change impacts and adaptation policies, linking the research and concerns of scientists, modellers and experts / policy-makers. However, for these tools to contribute to viable regional and international policies, it is crucial that one issue is addressed - the concern expressed by developing countries over theoretical and practical gaps relating to the applicability of existing IAM models.

This paper introduces a framework for discussion of these gaps, examining specific sub-topics under five general headings: the extent existing IAMs reflect socioeconomic structures in developing countries; whether it is possible to design IAMs to assess the same policy instruments to developing countries; whether regional characteristics are well represented within IAMs; how realistically IAMs estimate climate change impacts on developing countries; and the extent existing IAMs produce acceptable policy options for both developed and developing nations. These gaps, and their respective sub-headings, are illustrated in Table 1.

Consideration of the issues relating to the gaps leads to three main conclusions: firstly, that there is an urgent need for frank discussions between modellers and policy makers from developing and developed countries; secondly, that more collaborative studies, between developed and developing nations, are vital to meet the objective of ensuring IAMs are adapted and transferred to developing nations as a representative common analytical tool; and finally that there is a need to establish an integrated forum between modelling experts, scientists, and policy-makers, to ensure the coordination and dissemination of future research objectives and results from IAM studies.

Introduction

In order to further consensus on the need to address the potential impacts of climate change, and achieve the best potential and politically viable mitigation measures which could be utilised, it is vital that there is greater dialogue and understanding between the aims and priorities of modellers, scientists, and policy-makers in developing and developed nations.

This is of particular importance when one considers the history and parameters used in contemporary Integrated Assessment Models [IAMs]. These have been recognised by the IPCC as having great potential in becoming an effective communication tool between scientists and decision-makers, and between north and south, on the implications of international and domestic policies related to climate change. However, the IPCC advised against prematurely applying IAMs to actual policy proposals because of limitations in the models' scientific underpinnings and, most crucially, the omission of consideration of the socioeconomic dynamics of developing countries.

Table 1: GAPS RELATING TO USE AND THEORETICAL STRUCTURE OF INTEGRATED ASSESSMENT MODELS [IAMs].

Extent IAMs adequately reflect socio-economic structures in developing nations		
Business-as-usual [BAU] scenarios versus Asian autonomous structural changes	Market-based, efficiency oriented, neoclassical equilibrium models versus developing countries actual socioeconomic structures	Developed countries' technological assumptions versus developing countries' assumptions
Design of IAMs to assess the same policy instruments for developed and developing nations		
Developed countries' policy instruments versus developing countries' instruments	Climate policy in developed nations versus developing countries' policy linkages	
Extent regional characteristics are represented within IAMs		
Developed countries' damage functions versus developing countries' value systems	Assessment of Western life-styles versus utilisation of Asian social parameters	
Accuracy IAMs estimate climate change impacts on developing countries		
Assessment in developed countries versus policy responses in developing countries	Very ambitious models versus limited data in developing countries	
Extent existing IAMs produce policy options acceptable for both developing and developed countries		
Dynamic optimization versus South-North equity	Uncertainty versus developing countries' benefit/cost	Developed countries' optimal paths versus developing countries' incentives to be in the game

These concerns have been reflected in the experiences of researchers from developing countries in Asia and elsewhere, who have argued that IAM studies are deficient with respect to:

- representation of developing countries' socioeconomic realities.
- the validity of assumptions made about future conditions.
- the acceptability and validity of some crucial data.
- and the acceptability and implementability of recommended policies.

There is therefore now an urgent need to discuss the aims and development of IAMs. As a basis for further discourse, and increasing understanding between researchers from different nations and from different backgrounds, this paper introduces several epistemological gaps in the knowledge base and analytical priorities of the contemporary modelling and policy process. The gaps are cented around five macro-level headings, each sub-divided into several specific points. This structure is designed to stimulate discussion and, it is hoped, lead to conclusions and recommendations.

Epistemological gaps between IAMs and Developing Countries

The paper now considers five general questions, each representing a specific set of gaps between IAMs and developing countries, with the aim of illustrating where various modelling approaches have led to expression of reservation or concern amongst researchers from developing nations.

1. How adequately do IAMs reflect the existing socio-economic structure in Developing Countries?

(i) Market-based, efficiency oriented, neoclassical equilibrium models versus Developing Countries' actual socioeconomic structures.

Developing countries have pointed out that many long-term equilibrium models have been constructed within developed nations, utilising optimum criteria. The actual economic structure found in developing (and some developed) nations is often much more complicated, incorporating informal economic activities, weak markets, inadequate institutional arrangements, as well as disequilibriums in the energy, labour, infrastructure and financial markets, and between developed and developing countries.

For example, India has both a formal market, as analysed in the IAMs, and an underground market. Whilst the size of informal markets varies across countries, it is undeniable that, especially in nations where rural agriculture predominates economic activity, a failure to include some representation of informal markets may result in a gross misrepresentation of a nation's economic activity. The applicability of models to countries that were previously within the USSR is also debatable. Moreover, some developing nations have no desire to create the optimum economic parameters that are used in IAM models, believing that a level playing field is simply creating economic conditions which will enable developed nations to maintain their competitive edge in key sectors, and with respect to key technologies.

Whilst these disparities and omissions are not unique to IAMs¹, it has been argued that these omissions act as a constraint on the ability of IAMs to produce viable and relevant results.

Integrated Assessment (IA) Modellers have an opportunity to address this complex problem, and their efforts can make a major contribution to moving forward the frontiers of research.

(ii) Business-as-usual [BAU] scenarios versus Asian autonomous structural changes.

IAMs must also address the assumption that other countries will respond to climate change in the same fashion as that predicted to be applicable in the case of developed nations. For example, consider the assumption that sulphur dioxide emissions will continue to increase in a linear fashion under the Business as Usual scenario. Such an assumption ignores some historical lessons from countries such as Japan, and the possible sociopolitical constraints which may act on developing nations. In the 1960s, local concern over health-related threats from pollution exerted a political pressure which forced the Japanese polity to compromise its search for unlimited GDP increases, and introduce economic measures which considered environmental factors (Cameron 1996). Whilst Japan was able to relocate much industrial activity, developing countries may not have this option. For example, as Chinese GDP increases, there may come a point where the populace's desire for increased material affluence starts to be challenged by their desire for a healthy environment (their 'hierarchy of needs' may undergo value shifts)². The desire for decreased local pollution may outweigh the desire for unchanged rates of GDP increase. When models base their findings on the BAU scenario, as considered for developed nations, they fail to consider the rate of dynamic social change in developing nations. Thus the conclusion that unchallenged rates of SO₂ emission increase, under the BAU scenario, shall lead to extensive cooling and perhaps pollution-related deaths, in areas of China, fails in its relevance, as it does not include the likely social reaction to the emergence of *any* deaths. Most of the existing IAM models only consider economic criteria alone, and thus do not acknowledge the importance of the value of non-market impacts (stability, environmental quality, quality of life, health-related concern, and aspirations for future generations). Strong cultural traditions, such as those represented by forest preservation movements in India, can also have an important role on policy.

(iii) Developed Countries' technological assumptions versus Developing Countries' assumptions.

IAMs often work on the basis that developed nations will utilise 'frontier technology', adding new or more appropriate technologies to their existing strategies in a 'one step forward approach', leaving less appropriate technologies behind. In essence, technology is assumed to evolve in a linear pattern. However, both the pattern of technological utilisation inherent in this assumption, and the applicability of the terms 'old' and 'new' technology, can be questioned in the case of developing nations. In developing countries, existing indigenous/old technologies often interact with introduced/new technologies to produce a hybrid situation with distinct economic and social suitability to the situation in the developing nation. For example, in India many existing small cars have had IC technology added. Moreover, in other cases introduced/new and indigenous/old technologies coexist in dual economies: a small modern sector overlaps with a vast, traditional sector, each sector having vastly different production costs for an identical commodity. Existing IAMs cannot fully incorporate such hybrid and duality scenarios. Ownership of energy-intensive manufacturing industry is also relevant to the adoption of new technology (Sathaye 1997). In some developing countries, government control and ownership can mean that the technology adoption process is not always driven by profit maximisation principles³.

Moreover, the assumption that technology evolves in a linear fashion ignores the influence of the international political economy on developing nations ability to capture, and incorporate,

new technologies into their economic structure. They may often lack an infrastructure which would enable them to utilise technologies that emerge from developed nations, assuming that the developed nations are willing to transfer such technologies. Models need to address the question of the *technology differential* between developed and developing nations. In the case of Japan, the technological gap between Japan and the Western nations, at the commencement of Japan's industrialisation in the 1950s, was arguably much smaller than the technological gap currently faced by developing nations. It may not be possible for developing countries to utilise technology assumed to be available in models.

2. Is it possible to design IAMs to assess the same policy instruments for developing and developed nations?

(i) Developed Countries' policy-instruments versus Developing Countries' instruments.

IAMs have tended to focus on mitigation policy instruments, such as carbon taxes and tradable emission permits, that are of direct relevance and interest to developed nations. Such measures are very effective in terms of their applicability to developed nations. However, countries are not equal in their capacity to implement adequate measures to address climate change impacts. It is therefore necessary for modellers to consider the applicability of policy instruments to developing countries, and incorporate such considerations into the integrated assessment structure. Some policy instruments are very difficult to apply, and require a degree of administrative infrastructure, and economic development, which is not always present and/or constant in developing countries (where great regional and national variation exists). Developing countries may not be able to adapt due to institutional weakness, practical geographical limitations on the actual measures which can be introduced, and a lack of funds to introduce such measures. Most models also presume no global transaction costs when evaluating different policy alternatives. However, policies which require social and institutional change in the developed countries shall impose additional transaction costs. Moreover, the exact character of the policy instrument chosen can have serious implications for developing nations. For example, it has been calculated that the impact of a tradable emissions regime on India can be positive or negative depending on whether the initial allocation is made on the basis of population or 'grandfathered' emission.

(ii) Climate-policy versus Developing Countries' policy linkages.

Developing countries have very few incentives to introduce climate change policies. To encourage developing countries, it is vital to give a clear picture of the costs and benefits associated with climate change, as they relate to the developing nations. Moreover, the costs and benefits should be defined across a wide frame of reference, linking SO₂ emissions, CO₂ emissions, Ozone policies, and plantation policies, to the vital areas of food and water resources. These are the areas which are a great priority to many developing nations, and IAMs should be able to explain the impacts of climate change with respect to these resources.

However, establishing these costs and benefits appears to be a very low priority in developed countries, where climate change is considered across a narrow frame of reference, and mitigation measures are not designed to link/integrate policies to address the wider conception of climate change. The focus of political will in developed nations is on increasing GDP, maintaining job security, examining indicators that operate on a narrow time-frame, and within a well defined political arena. The longer-term and wider-impact implications of climate change are lower down the political scale.

IAMs must attempt to narrow this gap, and allow developing nations to discuss the costs and benefits of climate change in terms which are of direct relevance to their perceptions.

3. Are regional characteristics well represented within IAMs?

(i) Developed Countries' damage functions versus Developing Countries' value systems.

Researchers have also queried the applicability of models which draw up their conclusions for developing nations, using data derived solely from developed nations. For example, one area of particular concern is that damage functions, calculated on the basis of criteria found in developed countries, should not be extended uncritically to developing countries. Some developing country researchers have argued such an approach can lead to simplistic, even offensive, conclusions. Using damage functions for developed countries and applying them for developing nations overstates the *economic* damage, and understates the *social* damage, that climate change may cause in a developing nation. Another problem is the scale of applicability of data (Sathaye 1997). In some models, the coefficients for one country have been used to represent an entire continent, without reference to vastly differing geographical, socioeconomic, and developmental parameters.

In general, most models have emphasised economic criteria, without fully incorporating the valuation of non-market impacts. Moreover, such economic criteria associate impact with income, giving additional weight to an impact in a developed nation over an identical impact in a developing nation. In the case of irreversible and extreme vulnerability events, the situation is exacerbated: lower incomes, and a lower willingness/*ability* to pay, leads to estimates of damage much lower than those for lesser impacting events in the developed nations. Furthermore, the impacts of extreme events are usually non-linear, and highly uncertain, but such events are poorly represented in many existing models. Again, this is especially relevant for the developing countries: the degree of uncertainty associated with extreme events can combine synergistically with the uncertainty inherent in economic valuation of key areas, such as agriculture, which are affected by such events.

IAM researchers have argued they lack data from developing countries to include in their models. Whilst this lack of data is a valid point, it is also vital to address ethical concerns surrounding the valuation of impacts. As opposed to simply extending models, it is crucial that ways to supplement and improve existing approaches are considered. Researchers from developed and developing countries can further this end via discourse and mutual collaboration. Having more opinions influencing the design and valuation intrinsic to models can lead to mutually acceptable parameters, making models more universally applicable and policy recommendations more acceptable.

(ii) Assessment of Western life-styles versus utilisation of Asian social parameters.

Another area worthy of discussion relates to some of the social parameters used to calculate elements within IAMs. Some models assume that all nations follow the social parameters evident in Western developed nations (and, indeed, that the Western developed nations all have homogeneous consumption patterns). As a result, models often fail to incorporate important elements of traditional sectors in developing countries, such as the use of biomass fuels to meet energy needs in rural households. Many Asian nations represent a heterogeneous mix of household characteristics. For example, in many cities, higher income households are very similar to those in developed nations, in terms of their lifestyles, fuel

consumption and appliance ownership. However the rural sector often remains distinct, and even in the case of urban districts, differences are often pronounced⁴. Population migration, the breakdown of traditional structures in the face of industrialisation and internationalisation, and attitudinal shifts accompanying changes in income, all result in a complex and dynamic situation, one which is very hard for models to fully represent, when such efforts are even attempted.

The exact units of reference used are another area of useful theoretical discussion. For example, energy-service estimates are based on units of energy consumption per capita. For the USA, there is a high calorie per capita value. When a model assumes that China's predicted increase in GDP per capita will be accompanied by an increased energy consumption per capita, and the actual value of the increase is based on the US energy consumption value, it can lead to the conclusion that China will have serious problems relating to food supply. However, such an assumption is too simple, as it is very hard in Asian (and other) countries, to reproduce the unit of food consumption at the level of the individual (as is used in Western models). In fact, the family may be a better unit for estimation, and this may lead to a different pattern of social response to increased food demand and energy demand. Markets in developing countries are often governed within the family or community, and, especially in rural regions, are highly localised.

The input from developing country researchers, as to how such social parameters should be utilised in IAMs examining their countries, is of vital importance. The input from developed nations researchers as to how their models can be adapted is of equal importance.

4. How accurately do IAMs estimate climate change impacts on developing countries?

(i) Assessment in Developed Countries versus policy responses in Developing Countries.

All Integrated Assessment Models, *especially in the impact analysis field*, have been constructed by researchers in developed countries. Researchers in developed nations are using these models to outline suitable policy responses in both developed *and* developing nations. As matters currently stand, researchers in the developing nations have little access to use, and help the definition of parameters within, IAM models. Models in developed countries are being used to predict that climate change impacts will be much more serious in developing countries. However such assessments need to be replicated and verified by models constructed in developing nations. To illustrate this point another way, currently no models in developing nations are assessing the impacts of climate change on developed countries.

Moreover, data and information may be asked to fit around the requirements of a model, as opposed to the other way around. The obvious conclusion is that the models may produce skewed and unreliable results. It has been argued that simplistic assumptions about the south and a lack of understanding about the southern perspective are inherently imbedded in present IAM models, reflecting what has been described as a lack of procedural equity.

Developing nations have a crucial role to play in the international negotiation process. They need both a more open structure wherein they can modify the processes represented within each module of the modelling framework⁵; and access to integrated models to allow their respective nations to frame their *own* analysis of the impacts and solutions to global warming. This will permit greater transparency and a more accurate representation of country-specific processes; enable developing nations to contribute more to the international negotiation

process; and thus further the aim of obtaining some political consensus on the problems associated with global warming. There needs to be greater dialogue and collaboration between researchers from developing and developed nations.

(ii) Very ambitious models versus limited data in Developing Countries.

IAMs have a very ambitious structure, analysing many distinct factors across varying scales in space and time. This is especially true in the case of impact models. For example, impact models may attempt to analyse all soil types or crops in a specific geographical location, or may require detailed energy consumption data for each individual process that they are considering. Even in the developed nations, acquiring, and verifying, such data can be highly problematic, and costly. Results can be affected by the degrees of uncertainty associated with the sampling and accuracy of data.

In the case of developing countries, the extensive data requirements of the IAMs becomes a serious constraint. It is very difficult to generate enough income to allow a viable data set to be collected, due to:

- Structural constraints on one's ability to collect data.
- The availability of enough data of the character required by IAMs.
- The rapid rate of social and economic change in many developing nations causing the data that is collected to rapidly lose relevance.

Moreover, the *character* of the data used is often contentious, most notably with respect to:

- Assessment of non-market impacts.
- Irreversible and extreme vulnerability events.
- Uncertainties and discount rates.

In the case of standardised topics, such as population and demography, economic and financial statistics, agencies do exist for data collection. However, additional data⁶ is required for climate change investigation, and as the agencies to collect this data are often lacking, data collection and collation is sporadic at best (Sathaye 1997).

5. To what extent do existing IAMs produce acceptable policy options for both developing and developed countries?

(i) Dynamic optimization versus South-North equity.

Some recent IAM studies have recommended that the optimal policy for climate change mitigation is to shift mitigation measures to a future date, and to developing nations. Conclusions on the optimal timing have been based on a relative assessment of the cost of mitigation measures at the present, as opposed to the cost in the future (when potential technological improvement, and discounting factors, can be incorporated). In essence, it is argued that the cost of mitigation measures will be felt *now*, whereas the actual damage caused will not be felt until much *later*. This conclusion has been debated on a number of practical and theoretical points. Firstly, researchers have contested the assumption that relevant technological improvement is both linear and possible. Secondly, both the importance of the discount rate as a model parameter, and the use by some models of the market rate of interest as the discount criteria, have been challenged.

In the case of the latter recommendation, the costs of mitigation measures in developed nations are given a high value due to higher currency exchange values and economic activity levels. Converse economic criteria lead to a lower valuation of the benefits associated with mitigation of impacts in developing nations. The end result doubly supports the conclusions that mitigation actions should be shifted to developing nations. However researchers from developing nations have argued that this two-pronged conclusion only reflects a double-bias in relative valuation.

It has been contended that this debate illustrates how contemporary IAMs theoretical frameworks result in conclusions based on the priorities and socioeconomic parameters of developed countries. Vital issues relating the South-North equity are not addressed. By moving the costs of climate change mitigation to the future, and, in many cases, primarily to developing nations, such models reach conclusions which have profound implications for intragenerational equity between developing and developed nations. Many developing country researchers have argued these conclusions are worthy of greater discussion, and that no policy initiatives which fail to incorporate such discussion can be deemed suitable by their governments.

Moreover, the relationship between the timing of mitigation measures and endogenous technological change, has been poorly considered by most models. Technological advances can be facilitated by research and development. It is therefore important to acknowledge the influence of the relationship between policies to encourage research and development, and the cost/availability of new/future technologies. Such issues are addressed by two other papers in these proceedings.

(ii) Uncertainty versus Developing countries' benefit/cost.

In IAMs, the uncertainties considered are primarily those derived from the science of climate change. Uncertainties associated with socioeconomic and political factors, such as those affecting implementation of mitigation measures, have not always been well represented. In both cases, the uncertainties are often more pronounced in the developing nations, where socioeconomic and political flux is frequently of a greater magnitude and the impact of natural change can have a dramatic impact (as in the case of flooding, or changes to agricultural patterns).

IAMs have set up uncertainty analytical frameworks to consider the range of possible climate sensitivity, and accompanying range of changes/damages, for developed countries. The possible costs and benefits of climate change are then assessed. However the analytical frameworks used apply to the uncertainty criteria for developed nations. Developing nations desire to know *their* uncertainty criteria, and not simply be provided with an extrapolation of the situation for developed nations. Again, discourse could help refine existing models, and develop new analytical tools.

(iii) Developed Countries' optimal paths versus Developing Countries' incentives to be in the game.

IA models assume a uniform global policy regime for both climate change, and mitigation measures, under ideal economic and political conditions. However, any climate change policies shall fail unless there is widespread acceptance for them. In turn, this necessitates a high level of participation, acceptance, and support, for predictive IAM models and their resultant policies, by all concerned stakeholders. As has been discussed in 5 (i), dynamic

optimisation models have lead to conclusions which emphasise the benefit to *developed countries* of postponing the introduction of mitigation policies. However, such a conclusion is obviously of little attraction to developing countries, and gives them no incentive to compromise on their increasing/predicted increases in emissions.

Models need to focus on the likely reaction of both developed and developing countries, and the interaction between the stances of the two. Models that consider how to 'keep the game going', and reach a coalition solution, would be of great benefit. Discourse could focus on the potential of such models, and the practical ability of collaborative work to developed them.

Conclusions and recommendations

It is apparent, from the consideration of the theoretical and practical gaps, that there is great need for frank discussions between policy makers and modellers from developed and developing countries. Such discussion will allow models to be more applicable for, and more acceptable to, developing countries. Such adaptation will enhance mutual understanding and communication, laying the basis of a framework for greater future engagement and cooperation.

To facilitate this process, there needs to be more collaborative scientific, modelling, and policy-related research, between developed and developing countries. Such collaborative research will facilitate the adaptation and transfer of IAMs to developing countries.

To facilitate the organisation of such collaborative research, and dissemination of subsequent conclusions, there is an urgent need to establish an integrated forum for communication between modelling experts, scientists, and policy makers. Regional research networks, and increased international cooperation and communication, can greatly facilitate this aim, allowing IAMs to meet their potential as an analytical tool for address the challenges posed by global greenhouse gas related change.

END NOTES

¹Indeed they are found in most macro-economic models of developing country economies, often as a result of a lack of data on informal markets, or a rigid approach amongst economic modellers.

²It can be argued that this is already being manifest in many countries throughout the region, either through protest, or government planning. Recent changes in the political ecology of Southeast Asia, representing a cumulative reaction to decades of environmental degradation (Cameron 1996), illustrate this point, as do similar protests in India and other Asian nations.

³Though this does not necessarily mean that the technology adoption process is inefficient. China has a high degree of government control, but has exhibited some very exact policy choices relating to its adoption of new and existing technologies.

⁴Some of the distinctive regional areas in Tokyo represent this well. Cultural patterns, transferred from the rural region, are still evident in strong neighbourhood associations.

⁵Individual processes could be adjusted and modelled outside the overall framework, after the optimal approach was selected from a range of developed options, and then included to facilitate complete analysis. This approach would have the additional benefit of allowing process represented within each country to be driven by the data available for that particular module (Sathaye 1997).

⁶Such as end-use energy data; mitigation and adaptation costs; soil, silvicultural and agricultural characteristics; and species diversity and abundance data.

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The ideas contended in these works were included a discussion paper, "Framework for discussion of theoretical and practical epistemological gaps, between developed and developing nations, in relation to climate change modeling and policy", circulated in 1996, in preparation for the IPCC Asia-Pacific Workshop on Integrated Assessment Models. This framework document acted as a template for this paper, and the authors would like to thank all the researchers who provided invaluable analysis of the original draft of this paper. In particular, Prof. Jayant Sathaye gave incisive and useful comments, which were most appreciated.

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