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The Carbon conundrum

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Abstract:

This paper problematizes the basis for international policies and regulations towards adaptation, mitigation and adjustment for 'climate change'. Specific aspects of Fourth Assessment Report of IPCC have been evaluated on the basis of theory and methods of ecological science. In particular, requirements of legal certainty have been found to be at odds with the uncertainty in the supposed basis. The paper calls for adopting ethical rationality along with scientific rationality towards addressing problems of the society that are ecological in nature.

Key Words: Ecological Theories, Methods in Ecological Science, IPCC, Fourth Assessment Report, Legal Certainty, Methodological Value Judgments, NIPCC

A duck once met a porcupine; they formed a corporation
Which called itself a Porcuduck (a beastly configuration)!
A stork to a turtle said, "Let's put my head upon your torso,
We who are so pretty now, as Storile would be more so!
[..]
The giraffe with the grasshopper's limbs reflected:
Why should I go for walks in grassy fields, now that I can fly?

[Sukumar Ray, 'Stew Much' (*Khichudi*), *Aboltabol* (Utter Nonsense), English Translation by Satyajit Ray]

Introduction

The purpose of this paper[1] is to explore the link between law and science. In particular, it is to problematize the policies and regulations at the supranational level addressing 'climate change', which are claimed to have been based on various sub-disciplines of ecological science.[2]

Specifically, the paper focuses on the reports by the Intergovernmental Panel on Climate Change [IPCC, hereinafter] that have engaged its protagonists and the 'sceptics' in an interesting debate on various dimensions of the reports. [3] Questions had been raised on virtually everything: from stated objectives to principles followed, from the theoretical basis to methods of analysis, from models used to modelling software employed, from evidence collected to its partial analysis, from 'unsupported' findings to 'misplaced' conclusions, and also from being exclusive to making unspecified value judgements.

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[2] To the understanding of the author, the correct phrase would be climate variability, if not, weather variability. Change is an attractive word, but its inappropriate use leads to unwarranted semantic confusion with substantial external effects!

[3] Such kind of debates had been witnessed in the past on many issues, which are similar in nature. Consider the one between technological optimists and ecological pessimists or between 'anthropocentric' and 'ecocentric' positions on management of human society-ecosystem interactions.

From the purely academic standpoint, these questions are *valid*; indeed, such doubts gain strength from the many events that have been witnessed in the last twenty years. They range from (1) declarations signed by professionally competitive scientists with an expertise and experience to offer comments in this area, (2) publication of meticulously compiled reports, and (3) denial of information by the researchers on the nature of evidence used and specificity of software employed in modelling, engaged in climate research for IPCC in at least one prominent institution, to those who wanted to access it. These, at the very least, put a rather large question mark over the claim of 'scientific truth' by IPCC reports for their alleged nonconformity with the universally accepted principles of observability, repeatability and verifiability. This *certainty/truth* assumes more importance, for being the supposed basis for laws/policies in order to regulate, control, and manage perhaps all the ecosystems that inhabit the earth, in order to address the changes being witnessed within them.

Part I of the paper narrates the background of the type and nature of questions that have been asked over the claims made by IPCC. Part II provides an account of the theoretical aspects of the link between law and science, albeit the ecological 'science'. Final section examines two of the many aspects of the debate, triggered by the Fourth Assessment Report of IPCC [AR4 hereinafter]. First, contribution of anthropogenic and natural factors in atmospheric carbon dioxide enrichment and second, the biological impacts of such an increase in the level. Former was chosen for it apparent Malthusian pedigree, and the latter for being largely neglected by IPCC as per the claim made by its critics.[4]

The roadmap of this paper is as follows: after introducing the connection between law, policy and science through the requirements of certainty, in general terms, it addresses the specific: the link

[4] This selection had been done from the point of view of importance to a populous country like India where most derive their livelihood from agricultural and allied activities that has clear and established linkages with changes in climatic variables. While agricultural operations and production of many of its fossil fuel intensive inputs are a source of emission of many gases including nitrous oxide and methane, this sector also sequesters carbon and thus acts as a sink for CO_2.

between ecological science and environmental regulation and policy. The ‘scientific’ basis will be evaluated, next, in theoretical terms, followed by an analysis of selected evidence from AR4. Notwithstanding the alleged failure of the ecological science to provide a basis for the environmental policies and regulations, the final section argues for adopting an alternate principle for evaluating polices under uncertainty, of ethical rationality rather than scientific rationality.

I. Questioning the 'Obvious', Grilling the Goliath

> We urge the United States government to reject the global warming agreement that was written in Kyoto, Japan in December, 1997, and any other similar proposals. The proposed limits on greenhouse gases would harm the environment, hinder the advance of science and technology, and damage the health and welfare of mankind.
>
> There is no convincing scientific evidence that human release of carbon dioxide, methane, or other greenhouse gases is causing or will, in the foreseeable future, cause catastrophic heating of the Earth's atmosphere and disruption of the Earth's climate. Moreover, there is substantial scientific evidence that increases in atmospheric carbon dioxide produce many beneficial effects upon the natural plant and animal environments of the Earth.[5]

There had been 9,029 PhDs among the 31,478 American scientists[6] who had signed the above statement, as a part of the campaign initiated in 1998 by a group of scientists, through the 'Petition Project'.[7] The questions that were raised deal with the alleged anthropogenic contribution in the enrichment of carbon dioxide and the projected negative effects of such increase and neglect of the beneficial effects of the increase.

In 2007, the project had received a shot in the arm with an appeal from Frederick Seitz, past President of the National Academy of Sciences, USA and President Emeritus of Rockefeller University, USA which was circulated along with the petition.[8] In August 2007, Seitz had also approved an article by three scientists that had "reviewed the research literature concerning the environmental consequences of increased levels of atmospheric carbon dioxide".[9] These authors had claimed to have reached a conclusion which was diametrically opposite of the result that IPCC

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[5] Text of the Petition. [Global Warming Petition, http://www.petitionproject.org/ retrieved on 22 January 2011]

[6] "[A] group of physicists and physical chemists who conduct scientific research at several American scientific institutions". [Global Warming Petition, 'Frequently Asked Questions', http://www.petitionproject.org/frequently_asked_questions.php retrieved on 22 January 2011]

[7] Or 'The Oregon Petition', see, Oregon Institute of Science and Medicine, Petition Project, at http://www.oism.org/pproject/ retrieved on 22 January 2011. See, History Commons, 'Global Warming: Presentation of science', an open-content project, at http://www.historycommons.org/timeline.jsp?timeline=global_warming_tmln&global_warming_tmln_general_top.ic_areas=global_warming_tmln_presentation_of_science; also see, 'Oregon Petition' entry in Wikipedia, another open source web-content for an overview of the controversy on Oregon Petition at http://en.wikipedia.org/wiki/Oregon_Petition retrieved on 22 January 2011

[8] Text of the Letter from Frederick Seitz is available at http://www.oism.org/pproject/s33p41.htm retrieved on 22 January 2011

[9] Arthur B Robinson, Noah E Robinson, Andwillie Soon, *2007*, 'Environmental Effects of Increased Atmospheric Carbon Dioxide', *Journal of American Physicians and Surgeons*, 12 (3), pp. 79-90, available online at http://www.petitionproject.org/gw_article/GWReview_OISM150.pdf and also from the journal website, http://www.jpands.org/vol12no3/robinson.pdf , retrieved on 22 January 2011

had produced so far, relating to a number of dimensions of atmospheric carbon di-oxide. The claim made in the paper was that

> increases during the 20th and early 21st centuries have produced no deleterious effects upon Earth's weather and climate. Increased carbon dioxide has, however, markedly increased plant growth. Predictions of harmful climatic effects due to future increases in hydrocarbon use and minor greenhouse gases like CO_2 do not conform to current experimental knowledge.[10]

This time questions had been raised over neglect of positive biological effects and whether the 'experimental knowledge' could be regarded as the substitute for certainty/truth. International Symposium on the Greenhouse Controversy, held in Leipzig, Germany on November 9-10, 1995, under the sponsorship of the Prime Minister of the State of Saxony, had issued a similar statement titled 'The Leipzig Declaration', in 1996, with 100 climate scientists as signatories:

> [W]e consider the scientific basis of the 1992 Global Climate Treaty to be flawed and its goal to be unrealistic. The policies to implement the Treaty are, as of now, based solely on unproven scientific theories, imperfect computer models -- and unsupported assumptions that catastrophic global warming follows from the burning of fossil fuels and requires immediate action. ***We do not agree***. […]
>
> As the debate unfolds, it has become increasingly clear that -- contrary to the conventional wisdom -- ***there does not exist today a general scientific consensus about the importance of greenhouse warming*** from rising levels of carbon dioxide. In fact, many climate specialists now agree that actual observations from weather satellites show no global warming whatsoever -- in direct contradiction to computer model results.
>
> Historically, climate has always been a factor in human affairs -- with warmer periods, such as the medieval "climate optimum," playing an important role in economic expansion and in the welfare of nations that depend primarily on agriculture. Colder periods have caused crop failures, and led to famines, disease, and other documented human misery. We must, therefore, remain sensitive to any and all human activities that could affect future climate. […][11]

Thus, more questions were raised on the supposed theoretical basis, appropriability of the computer models used, findings of anthropogenic causes and even the very evidence of rise in the levels of carbon di-oxide. The declaration also had pointed out to the alleged neglect of the historically important evidence of a warmer period during the Middle Ages, when the level of atmospheric CO_2 was higher than the present.[12] Physiologically, rise in the temperature and the level of atmospheric

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[10] Robinson et al, op. cit., p. 79

[11] Science and Environmental Policy Project, 'Leipzig Declaration-The Updated Declaration', available online at http://www.his.com/~sepp/policy%20declarations/LDrevised.html; emphasis as in original

[12] See, figure 3(B) in Ulf Büntgen et al, 2011, '2500 Years of European Climate Variability and Human Susceptibility', *Science*, available online at http://www.sciencemag.org/content/331/6017/578.full, retrieved on January 14, 2011.

CO_2 results in higher accumulation of biomass that leads to higher carbon sequestration in absolute terms. Clearly, the net social effect depends on relative strength and intensity of all the contributing factors and only a holistic account can lead to a reasonably accepted conclusion. Narrower is the range of account, more difficult is to find its acceptance.

'Scepticism' was also offered, in the form of 'The Heidelberg Appeal',[13] and 'Statement by Atmospheric Scientists on Greenhouse Warming',[14] both in 1992. The appeals had centred on the 'balance of nature' argument, contested even among ecologists. Interestingly, on the one hand, while questions were raised on models, software, method and predictive limitation of 'scientific knowledge', on the other hand, rather than blaming the ecological science for the disputed conclusions, predictions and policy advices, calls were made to make the basis for policy even more 'scientific'.

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[13] The Heidelberg Appeal was publicly released at the 1992 Earth Summit in Rio de Janeiro. By the end of the 1992 summit, 425 scientists and other intellectual leaders had signed the appeal. Since then, many more scientists apparently had lent their support. [http://www.his.com/~sepp/policy%20declarations/heidelberg_appeal.html]. It reads:

> […] We contend that a Natural State, sometimes idealized by movements with a tendency to look toward the past, does not exist and has probably never existed since man's first appearance in the biosphere, insofar as humanity has always progressed by increasingly harnessing Nature to its needs and not the reverse. We full subscribe to the objectives of a scientific ecology for a universe whose resources must be taken stock of, monitored and preserved. […]
>
> We intend to assert science's responsibility and duties toward society as a whole.
>
> We do, however, forewarn the authorities in charge of our planet's destiny against decisions which are supported by pseudoscientific arguments or false and nonrelevant data. […]

[14] On February 27, 1992, 47 scientists had issued a letter on the eve of Rio Summit, that according to them "aims to impose a system of global environmental regulations, including onerous taxes on energy fuels, on the population of the United States and other industrialized nations". They argued that, "[s]uch policy initiatives derive from highly uncertain scientific theories. They are based on the unsupported assumption that catastrophic global warming follows from the burning of fossil fuels and requires immediate action", on which "[they] do not agree". Further the declaration had stated:

> A survey of U.S. atmospheric scientists, conducted in the summer of 1991, confirms that there is no consensus about the cause of the slight warming observed during the past century. A recently published research paper even suggests that sunspot variability, rather than a rise in greenhouse gases, is responsible for the global temperature increases and decreases recorded since about 1880.
>
> Furthermore, the majority of scientific participants in the survey agreed that the theoretical climate models used to predict a future warming cannot be relied upon and are not validated by the existing climate record. Yet all predictions are based on such theoretical models.
>
> Finally, agriculturalists generally agree that any increase in carbon dioxide levels from fossil fuel burning has beneficial effects on most crops and on world food supply.
>
> [http://www.his.com/~sepp/policy%20declarations/statment.html]

The latest organised effort had resulted in the publication of *Climate Change Reconsidered: 2009 Report of the Nongovernmental Panel on Climate Change* (NIPCC, hereinafter).[15] It contends that the many claims made in the AR4 titled *Climate Change 2007*[16] are of questionable basis; more importantly, in contrast to the IPCC's claim that "most of the observed increase in global average temperatures since the mid-twentieth century is *very likely* due to the observed increase in anthropogenic greenhouse gas concentrations", NIPCC had reached the opposite conclusion, "namely, that natural causes are very likely to be the dominant cause".[17] NIPCC, however, acknowledges the positive relationship between anthropogenic greenhouse gases (GHG) and warming, and argued that the present role of such gases in warming is not *substantial*.

On the question of effects of the present and future warming on human health and the natural environment also, NIPCC had reached the opposite conclusion to the IPCC. While for IPCC, global warming will "increase the number of people suffering from death, disease and injury from heatwaves, floods, storms, fires and droughts', NIPCC argued that "[a] warmer world will be a safer and healthier world for humans and wildlife alike".[18]

Interestingly, NIPCC had claimed to reach such diametrically opposite conclusions while reviewing the identical material presented in the first two volumes of the AR4, *Climate Change 2007: The Physical Science Basis* and *Climate Change 2007: Impacts, Adaptation and Vulnerability*.[19] Its

[15] Craig Idso and S. Fred Singer, 2009, *Climate Change Reconsidered: 2009 Report of the Nongovernmental Panel on Climate Change (NIPCC)*, The Heartland Institute, Chicago, Indian Reprint, Liberty Institute, Dwarka, New Delhi [NIPCC, hereinafter]

[16] IPCC-AR4 2007, *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, Cambridge University Press.

[17] NIPCC, op. cit., iii; emphasis as in the original.

[18] NIPCC, op. cit., iii; NIPCC's qualifier here is the following: it does not deny the possibility of negative effects on human health and wildlife, but argued that the *net* effect (both positive and negative) will be beneficial to humans, plants, and wildlife.

[19] IPCC, 2007, *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (Eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, available online at

other claim is to have reviewed "thousands of peer-reviewed scientific journal articles that document scientific or historical facts that contradict the IPCC's central claims, that global warming is man-made and that its effects will be catastrophic".[20]

NIPCC alleges that AR4 is not based on the best available science, contrary to the claim made by IPCC. It had also found that latter's conclusions to be seriously exaggerated, relevant facts being distorted, and key scientific studies being omitted or ignored.[21] NIPCC had also claimed that, as the role of the IPCC was "to assess on a comprehensive, objective, open and transparent basis the latest scientific, technical and socio-economic literature produced worldwide relevant to the understanding of *the risk of human-induced climate change*, its observed and projected impacts and options for adaptation and mitigation", it had considered *only* those scientific reports that have focused solely on evidence that might point toward human-induced climate change.[22]

Arguably, such presumption of a particular type of risk presupposes a value judgement. Interestingly, the entire phrase of 'risk of human-induced' had been quoted as description of IPCC mandate in a number of websites.[23] However, in the mandate of IPCC on 26 January 2011, this phrase is conspicuously absent:

> […]
>
> The IPCC is a scientific body. It reviews and assesses the most recent scientific, technical and socio-economic information produced worldwide relevant to the understanding of climate change. It does not conduct any research nor does it monitor climate related data or parameters.

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http://www.ipcc.ch/publications_and_data/publications_ipcc_fourth_assessment_report_wg1_report_the_physical_science_basis.htm and IPCC, 2007: *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, [M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson (Eds.)], Cambridge University Press, Cambridge, UK, available online at http://www.ipcc.ch/publications_and_data/publications_ipcc_fourth_assessment_report_wg2_report_impacts_adaptation_and_vulnerability.htm

[20] Some of the material, however, had been published post May 2006, the deadline imposed by IPCC-AR4 [NIPCC, op. cit., p. iii]

[21] NIPCC, op. cit., p. iii

[22] NIPCC, op. cit., p. iv; emphasis as in the original

[23] See, Climate Change—Debate for Engineers-Scientific Information and Debate Portal, 'The IPCC and the Scientific Community', available online at http://ccd4e.org/ipcc_scientific_community/ and Copenhagen Climate Council, 'What is IPCC', available online at http://www.cop.enhagenclimatecouncil.com/get-informed/climate-negotiations-updates/what-is-the-ipcc.html; information from both the sites were retrieved on 26 January 2011.

> Thousands of scientists from all over the world contribute to the work of the IPCC on a voluntary basis. Review is an essential part of the IPCC process, to ensure an objective and complete assessment of current information. IPCC aims to reflect a range of views and expertise.
>
> […] [24]

There are various other phrases in IPCC's mandate like 'scientific *view* on the current state of knowledge', 'most recent scientific, technical and socio-economic *information'*, 'rigorous and balanced scientific *information* to decision makers' while it does not mention either 'assess on a comprehensive, objective, open and transparent basis the latest scientific, technical and socio-economic *literature'* or 'the risk of human-induced climate change' as it was earlier.[25]

Consider, in contrast the 'Role' of IPCC, as stated in 'Principles Governing IPCC Work', which states that all types of information are to be judged to understand the 'scientific basis of risk of human-induced climate change' for its role in policies towards mitigation, adaptation and adjustment.[26] This position is entirely different from the one that presupposes the 'risk of human induced climate change'. Clearly, such a value judgement and the following advice cannot be policy neutral, to say the least.[27]

Importance of the phrase 'human-induced' is more visible in the text of UN Framework Convention on Climate Change, whose preamble states: "*Concerned* that human activities have been substantially increasing the atmospheric concentrations of greenhouse gases, that these

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[24] IPCC, 'Organisation', available online at http://www.ipcc.ch/organization/organization.shtml, information retrieved on 26 January 2011

[25] Emphasis added throughout.

[26]
> [T]o assess on a comprehensive, objective, open and transparent basis the scientific, technical and socio-economic information relevant to understanding the scientific basis of risk of human-induced climate change, its potential impacts and options for adaptation and mitigation. IPCC reports should be neutral with respect to policy, although they may need to deal objectively with scientific, technical and socio-economic factors relevant to the application of particular policies.

IPCC, 'Principles Governing IPCC Work', approved at the Fourteenth Session (Vienna, 1-3 October 1998) on 1 October 1998, amended at the 21st Session (Vienna, 3 and 6-7 November 2003) and at the 25th Session (Mauritius, 26-28 April 2006), available online at http://www.ipcc.ch/pdf/ipcc-principles/ipcc-principles.pdf retrieved on 26 January 2011

[27] Consider, in contrast, the self-proclamation, by IPCC: "The work of the organization is therefore policy-relevant and yet policy-neutral, never policy-prescriptive". IPCC, 'Organisation', available online at http://www.ipcc.ch/organization/organization.shtml, information retrieved on 26 January 2011

increases enhance the natural greenhouse effect, and that this will result on average in an additional warming of the Earth's surface and atmosphere and may adversely affect natural ecosystems and humankind".[28] Similarly, objective of UNFCCC contained in Article 2 states: "The ultimate objective of this Convention and any related legal instruments […] is to achieve, […] stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent *dangerous anthropogenic interference* with the climate system".[29] Such position on is clearly evident in the text of Kyoto Protocol also.[30]

One of the plausible reasons in this ambivalence over the institutional position over the human contribution could be the release of emails and other documents on 20 November 2009, over the Worldwide Web, originating from the Climate Research Unit (CRU) at the University of East Anglia (UEA), UK.[31] The University had initiated two independent inquiries to inquire into the allegations that researchers at the CRU had attempted to manipulate data and subvert the peer review process to support their claims about global warming.[32] Further, a House of Commons' Science and Technology Committee was set up on 1 October 2009.[33] One of the three key issues in

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28 Text of UNFCCC, available online at http://unfccc.int/resource/docs/convkp/conveng.pdf; emphasis as in original

29 Emphasis added.

30 Consider, Article 3.1 that states, "The Parties included in Annex I shall, individually or jointly, ensure that their aggregate anthropogenic carbon dioxide equivalent emissions of the greenhouse gases […]".

31
> This institution has played a central role in the "climate change" debate. Its scientists, together with their international colleagues, quite literally put the "warming" into Global Warming: they were responsible for analysing and collating the various measurements of temperature from around the globe and that, going back for many years, collectively underpinned the central scientific argument that mankind's liberation of "greenhouse" gases—particularly carbon dioxide—was leading to a relentless, unprecedented and ultimately catastrophic warming of the entire planet.

[John Costella, 2010, *The Climategate Emails*, The Lavoisier Group Inc., Melbourne, p. 1, available online at http://www.lavoisier.com.au/articles/greenhouse-science/climate-change/climategate-emails.pdf]

32 First was the 'Independent Climate Change Email Review' (ICCER) [Sir Muir Russell, former civil servant as its head, to look for evidence of malpractice within CRU, review its procedures for acquiring and processing data, examine practice on responding to Freedom of Information requests and make recommendations for management reform] set up on 3 December 2009, and then the 'Scientific Appraisal Panel' (SAP) [Lord Oxburgh former geologist and Shell chairman as its head, to assess the integrity of research at CRU] set up on 22 March 2010.

33 Chair: Mr Phil Willis, report published on 31 March 2010

its inquiry was, "[w]hat were the implications of the disclosures for the integrity of scientific research?"[34] In its conclusion (no. 3) it had stated that,

> A great responsibility rests on the shoulders of climate science: to provide the planet's decision makers with the knowledge they need to secure our future. The challenge that this poses is extensive and some of these decisions risk our standard of living. When the prices to pay are so large, the *knowledge* on which these kinds of decisions are taken had better be right. The science must be irreproachable.[35]

The committee thus had made clear the necessity of knowledge so as to arrive at a situation conducive for making an informed choice.[36] Here also the call was made to the science, the impeccable science or the scientific truth.

Due to the approaching general election at UK, the Committee had to complete its work before the report of the UEA inquiries could be published.[37] Thus, once the reports were published, the newly formed Science and Technology Committee in the present UK government was asked to assess how both the committees had responded to the former Committee's recommendations and the concerns that it raised. The Committee published its 'follow-up report' on the disclosure of climate data from the CRU at UEA on 25 January 2011.

The key findings of the review, relevant to this paper, are the following:[38]

1. On 'Disclosure of data and methodologies'—

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[34] Eighth Report from the Science and Technology Committee, Session 2009–10, *The disclosure of climate data from the Climatic Research Unit at the University of East Anglia*, HC 387–I, available online at http://www.publications.parliament.uk/pa/cm200910/cmselect/cmsctech/387/387i.pdf, p. 8

[35] Eighth Report, op. cit., p. 46; emphasis added

[36] One may note the DIKW (Data, Information, Knowledge, Wisdom) hierarchy in Knowledge Management and Information Science domains. It was brought to prominence by Russell Ackoff in his address accepting the presidency of the International Society for General Systems Research in 1989. However, it was T S Eliot who had written, "Where is the Life we have lost in living? Where is the wisdom we have lost in knowledge? Where is the knowledge we have lost in information?" in 'The Rock', [Faber & Faber 1934]. Others had added understanding and intelligence before attaining wisdom. See, Jonathan Hey, 2004, 'The Data, Information, Knowledge, Wisdom Chain: The Metaphorical link', available online at http://best.berkeley.edu/~jhey03/files/reports/IS290_Finalpaper_HEY.pdf retrieved on 26 January, 2011.

[37] First Report from the Science and Technology Committee, Session 2010–11, *The Reviews into the University of East Anglia's Climatic Research Unit's E-mails*, HC 444, two volumes, available online at http://www.publications.parliament.uk/pa/cm201011/cmselect/cmsctech/444/444.pdf and http://www.publications.parliament.uk/pa/cm201011/cmselect/cmsctech/444/444vw.pdf; volume I, p. 5
ICCER report was published on 7 July 2010 and SAP was on 14 April 2010; First Report, vol. 1, op. cit., p. 5 fn

[38] First report, vol. I, pp. 20-31; emphasis added throughout.

A. *Raw data:*

> The disclosure of raw data and sufficient details of the computer programmes is paramount in encouraging people to *question science in the conventional way*, *challenging existing work, enabling validation of it* and coming forward with new hypotheses. […]

B. *The allegation of scientific fraud:*[39]

> We consider that data disclosed in publications should be accompanied by *sufficient detail of computer programmes*, *specific methodology* or *techniques* used to analyse the data, such that another expert could *repeat* the work. Providing the means for others to *question science* in this way will help guard against not only *scientific fraud* but also the spread of *misinformation* and unsustainable allegations.

2. Freedom of Information:[40]

A. *Application of Freedom of Information to scientific research:*

> The broader confusion about how FoI [Freedom of Information] legislation should be applied to *scientific research* must be resolved. […]

In its conclusion, the committee had stated that,

> The disclosure of data from the Climatic Research Unit has been a traumatic and challenging experience for all involved and to the wider world of science. Much rests on the accuracy and integrity of climate science. This is an area where strong and opposing views are held. […][41]

To sum up, the 'scientific' basis of International Law to address supposed alterations in the behaviour of the key climate variables had been questioned, to the extent of calling it 'unscientific'. Even without evaluating the claims of both the sides, one can safely conclude that there is a prima facie case to question the veracity of the claims by proponents of 'Climate Change Thesis'. The question is the following: how does the particular scientific knowledge pass the tests to provide the basis for a law, and that too an International Law having enormous ramifications across the world?

[39] There has been another section titled CRY methodologies, which is outside the scope of this paper.
[40] There is another section titled 'Peer Review' with sub-sections as Confidentiality of peer review, and Subversion of peer review. Being out of scope of the paper, we do not mention them in the text.
[41] First report, vol. 1, op. cit., p. 33

II. Science, Ecology, and Law: the Tumultuous Relationship(s)

A. Science and Law

Science's relationship with law is as nuanced as any other relationship. Role of science can be observed from the policymaking to the enactment of the legislation to the issue of notification/order to dispute resolution or even in the appellate review.[42] Even without considering the area of 'hard' scientific research, say, gene or patents, a cursory look at the 15 year old short history of World Trade Organisation shows enough evidence of this relationship.[43]

Susan Haack[44] had argued that scientific experts were often relied upon to arrive at 'factually correct verdicts', in order to reach the goals of 'substantial justice'.[45] Robin Feldman,[46] author of

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[42] Similarly, in the evolution of customs: consider management of tanks for indigenous irrigation practices in South India (*erie*) and Bihar (*ahar*) in nineteenth century or fisher's right in sea fishing, notwithstanding the 'inferior' status of the scientific knowledge incorporated in these practices. See, Nirmal Sengupta, 2004, 'Property Rights, Incentives, and Efficiency: Natural Resources in Indian Legal System', retrieved from http://www.igidr.ac.in/~babu/law2004/slides/SENGUPTA_paper.pdf on 2 January 2011

[43] See, for example, Kathleen A Ambrose, 1999-2000, 'Science and the WTO', *Law & Pol'y Int'l Bus*, 31, 861-8. Also see, Robert I Howse and Henrik Horn [2009, 'European Communities-Measures Affecting the Approval and Marketing of Biotech Products' in Henrik Horn and Petros C Mavroidis, eds., *The WTO Case Law of 2006-2007: Legal and Economic Analysis*, Cambridge University Press, Cambridge, pp. 49-83]. The authors of the second paper had argued that in *EC-Biotech*, the WTO Dispute Settlement Panel had to "take a stand on the limits of science, or technocratic regulatory controls, to protect against objective risk. [...] [The] complexities perhaps even require rethinking of the wisdom of using, in the text of SPS, 'science' as an arbiter in trade disputes concerning food safety." In particular, the authors had stated the following:

> [A] second difficulty with the controversy underlying the *EC-Biotech* WTO dispute relates to the place of the SPS agreement in judging food regulations that respond to public feelings that combine, somehow, concerns with health risks in the narrow sense with more ethical, religious, or spiritual misgivings. [...] The modern scientific, or more precisely secularist, worldview that arguably underpins the SPS agreement, and perhaps the entire WTO structure, implies a clear divide between the regulation of 'objective' risks, to health, the environment, etc., which can be tested by science, and strictures that are faith-based, purely 'subjective', nonmaterial, or 'irrational', as would be understood to be the case with the dietary laws of particular religious communities. [...] It appears as if people increasingly regard food choices as a matter of 'right living'--body and soul together--and they may see those choices not merely as individual lifestyle choices but ones with a collective or societal dimension. Obviously, to judge such choices by the standard meaning of 'science', would be to miss the point. In *EC-Hormones I*, the Appellate Body seemed to glimpse something of this difficulty and sought to alleviate it within the parameters of interpretation of the SPS text, by referring for instance to the possibility of a WTO Member relying on nonmainstream 'science' or by alluding to risk as not just risk to be tested in the laboratory but risks as seen in the real world where people live and die.

[44] Distinguished Professor in the Humanities, Coop.er Senior Scholar in Arts and Sciences, Professor of Philosophy, and Professor of Law, Department of Philosophy, University of Miami, USA [http://www.as.miami.edu/phi/peop.le/faculty.html]

[45]
> [T]ruth is surely *relevant* to legal proceedings, for we want, not simply resolutions, but *just* resolutions; and substantial justice requires factual truth. In its efforts to arrive at factually correct verdicts, the legal system has come to rely a good deal on scientific experts, who by now testify on just about every scientific, and quasiscientific, subject imaginable: experts on blood, bullets, bite-marks, battered

The Role of Science in Law[47] had found a much clear 'allure of science' in the legal history of United States of America. The reason being what science supposedly promises: "a tune of perfection, of elegance, of solid dependability and the promise of endowing law and legal actors with the respect and deference from society that we crave. […] [W]e look to science to rescue us from the experience of uncertainty and the discomfort of difficult legal decisions". Further, Feldman states even if the notion of what constitutes science and what it would take to make law more scientific varies across time, return to the science to provide answers to law's dilemmas has continued and more importantly, the associated disappointment.

> We internalize science by borrowing *science rules* for *legal rules* or we externalize our problems by giving scientists and other experts the power to make legal decisions. Our deference to these pillars of neutral rationality is supposed to bring clarity, certainty, and a resolution that all can respect. The strategy continually fails, however, leaving as much chaos, confusion, and disagreement as before.[48]

The controversy over the role of science in law can be summed up as a "debate between a world of inviolable, deterministic science and an overly cynical one in which science cannot be trusted unless it is purified of all corrupting influences".[49] In the muddle, what has been forgotten is that the "[s]cience is […] inherently pluralistic, as the different scientific disciplines attest, and [in particular] a unitary conception of environmental science is neither a desirable end nor a viable goal. It follows from this pluralistic view that a general standard for judging scientific results does not exist".[50]

> wives; experts on PCBs, paternity, poisons, post-traumatic stress; experts on radon, recovered memories, rape trauma syndrome, random-match probabilities; experts on psychosis, asbestosis, silicosis (and for all I know, on psittacosis!).

[2008, 'Of Truth, in Science and in Law', *Brooklyn Law Review*, 73 (2), University of Miami School of Law Legal Studies Research Paper No. 2008-15, available at SSRN: http://ssrn.com/abstract=1099422; emphasis as in original.]

[46] Presently, Professor of Law and Director, Law & Bioscience Project, University of California Hastings College of the Law [http://www.uchastings.edu/faculty-administration/faculty/feldman/index.html]

[47] 2009, Oxford University Press, USA

[48] Robin Coop.er Feldman, 2009, 'Law's Misguided Love Affair with Science', *Minnesota Journal of Law, Science & Technology*, available at SSRN: http://ssrn.com/abstract=1127569 last retrieved on 22 January 2011; emphasis added.

[49] David E Adelman, 2007, 'The Art of the Unsolvable: Locating the Vital Center of Science for Environmental Law & Policy, Environmental Law, Arizona Legal Studies Discussion Paper No. 07-17, available at SSRN: http://ssrn.com/abstract=991427, p. 938

[50] Adelman, op. cit., p. 939

B. Certainty, Law and Policy

Law, by definition, demands certainty: it is, in fact, of fundamental importance. Such certainty is required on the object of interest, its nature, its impact and so on. Its absence leads to all kind of confusions, ambiguities and complexities.[51] A policy, in contrast, does not require such specificity.[52] Even otherwise, the in-built flexibility in a policy permits abstraction to some extent. However, the legislation, that is to follow, must be bereft of such suppleness, and the black letters are to ensure the hard/stiffness.[53] The orders/notifications by the implementing agencies are bound to be more specific, than the legislation itself. After all, the requirement is to have an 'objective'

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[51] "But law is at last, adjudication. At first level, it represents the conversion of political power and value choices into a set of authoritative precepts for action. It is a framework for state action. It is a codification of a programme of development. The law, in this role, outlines structures of authority, control, hierarchy and communication for political and administrative action. It this shapes and reshapes structures of bureaucracy or administration". [Upendra Baxi, 1987, 'Environmental Law: Limitations and Potential for Liberation', in J Bandopadhyay et al., eds., *India's Environment: Crises and Responses*, Natraj Publications, Dehra Dun, pp. 291-309: 293]

[52]

> 10. A "policy" is very much like a decision or a set of decisions, and we "make", "implement" or "carry out" a policy just as we do with decisions. Like a decision a policy is not itself a statement, nor is it only a set of actions, although, as with decisions, we can infer what a person's or organisation's policy is either from the statement he makes about it, or, if he makes no statement or we don't believe his statement from the way he acts. But, equally, we can claim that a statement or set of actions is misleading and does not faithfully reflect the "true" policy.
>
> 11. In some other ways a policy is not like a decision. The term policy usually implies some long-term purpose in a broad subject field (e.g. land tenure), not a series of ad-hoc judgements in unrelated fields. Sometimes, however, we conceive of policy not so much as actively purpose oriented but rather as a fairly cohesive set of responses to a problem that has arisen. In the sphere of government development activities, governments have policies, plans, programmes and projects, each of these in succession being a little more short-term, more specific in place and timing than the previous and each successively more executive rather than legislative.

[Stephen Sandford, 1985, 'Better livestock policies for Africa', Network paper No. 1, Alpan - African Livestock Policy Analysis Network, International Livestock Centre for Africa (ILCA), Addis Ababa, Ethiopia, Food and Agriculture Organisation (FAO), retrieved from http://www.fao.org/wairdocs/ILRI/x5499E/x5499e03.htm]

[53] However, it is often mentioned that, drafters of the legislations do not understand the intent of the policymakers, ending in poorly framed regulations. Perhaps, one reason is the incompetence of the drafter herself: this occupation is yet to attract good talent even amidst the euphoria witnessed in the recent times, due to the role played by the justice delivery mechanism in addressing the shortcomings of the other two pillars of democracy and also the emergence of 'Law Schools' imparting professional legal education . In the latter, policy studies has become 'in', but drafting remains in one corner of one of the many clinic courses; the ones that are to be 'done' and not studied. One may also compare the glamour associated with 'policy-makers' with that of a lowly drafter. In the words of Upendra Baxi [op. cit., 294]:

> When the law deals with highly technical matters, the colonial method of lawmaking ensures its failure from the moment of its birth. […] This attitude signifies, and it is still widely prevalent, a total incomprehension of the fact that drafting of the text of legislation depends on a close understanding of the how and why of a particular policy package. The draftsperson or legislative adviser may through incomprehension subvert the policy and programme packaged by the technocrats. If the lawperson is merely regarded as a technician rather than a co-architect of the programme of the law, the understanding and formulation of the policy into the law will depend on intuition or inertia. Intuition is a bad guide when complex human behaviors and attitudes to be regulated. And inertia entails copycat drafting […].

standard, for the clear understanding of the administrators. A rule of 'Zero Tolerance' is applicable to uncertainty within this long chain. Further, at the level of disputes, its redressal and the subsequent appeal, any uncertainty is expected to contribute in more confusion, adding to the complexity of the subject under litigation and may as well end up in creating conflicting precedence and thus, a jurisprudence of questionable value.[54] This requirement of certainty is one of the key issues in the regulatory aspects of climatic change thesis, on which there are several crucial but unanswered questions on theory and method, which are discussed in the paper.

C. *Law's Relationship with Ecology*

There are several juridical reasons that explain a rather short history of regulations for management of complex ecosystems. Consider the following: (1) any such regulation requires drawing clear boundaries, for the rights and obligations, while ecosystems hardly follow any human made borders,[55] (2) following (1), such "unified ecosystem, management effort in the face of a legal structure which separates branches (legislative, executive, judicial) and levels (federal, state and local) of government" faces the problem of pitting against each other,[56] (3) while traditionally a single resource had been managed by regulations, for the ecosystems it involves multiple and diverse ones in an integrated manner,[57] (4) the resources that had faced historical neglect, possibly for having no 'value', (inherent or instrumental) are now being valued, while the valuation itself is a contested domain,[58] (5) a successful management effort do require handling resources located in both private and public lands and at a very large spatial and considerably large temporal scales for

[54] Admittedly, differences exists within the codified civil law and common law: while in the former judges traditionally justify their decisions in reference to precedent and social norms, or on the 'rationality' presupposed by public policy, in the latter justification is sought through the interpretation of a code directly by reference to its meaning. See, Robert Cooter and Thomas Ulen, , 2000, 'Chapter 3: An Introduction to Law and Legal Institutions', in *Law and Economics*, Third Edition, Addison Wesley Longman, pp. 57-70

[55] Richard O Brookes, Ross Jones and Ross A Virginia, 2002, *Law and Ecology: The rise of the ecosystem regime*, (Ecology and Law in Modern Society), Ashgate, Hants, p. 374. At another level, there are calls for conferring rights to different elements in the ecosystem, if not the earth itself (as the 'Gaia hypothesis' of James Lovelock); for their intrinsic value rather than the instrumental value for providing various ecosystem services.

[56] Brookes et al, op. cit., p. 374

[57] Robert B Keiter, 1998, 'Ecosystems and the Law: Toward an Integrated Approach', *Ecological Applications*, Vol. 8, No. 2, pp. 332-341: 332

[58] Keiter, op. cit., p. 374

which the level of coordination may not even be in the possession of countries with distinct track record of governance. Keiter (1998: 332) observes further:

> [t]he very concept of legal ownership right implies certainty and stability, but the nature of ecosystems is instability and disequilibrium, […] requiring a management strategy based on adaptive experimentation. […] Moreover, the existing legal order is generally designed to ensure prompt and tangible financial returns, while ecological management often requires lengthy periods and management forbearance. […] As a result, only a fragmentary and incomplete ecosystem management obligation can be derived from existing law.

Thus, nature fails a number of tests for qualifying as being the subject of law for being "neither predictable nor inert; rather it is evolutionary and self-modifying".[59]

D. Questions over Ecological 'Science' as the basis for Environmental Policy: Theory and Method

Instances of emphasising on science and scientific knowledge and the underlying principles are many, for addressing and solving the societal problems as well as its development.[60] In fact, scientists' skills in practical problemsolving are often seen as a barometer for the methodological sophistication of the theories that they employ.[61] A method is considered good, if it leads to successful problemsolving, and vice versa. In the instant case, the connected theory is based on the discipline of ecology and the 'problem' is supposedly the changes in atmospheric variables.[62]

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[59] Peterson, G., S. Pope, G. A. De Leo, M.A. Janssen, J.R. Malcolm, J.M. Parody, G. Hood, and M. North, 1997, 'Ecology, ethics, and advocacy', *Conservation Ecology* [online], 1(1), 17, available online at http://www.consecol.org/vol1/iss1/art17/ retrieved on 29 January 2011

[60] "If politics is the art of the possible, [scientific] research is surely the art of the soluble" [P B Medawar, 1967, 'The Act of Creation', *The Art of the Soluble*, Heinemann Young Books, quoted in Adelman, op. cit. p 936

Varieties in science range from being 'top-down' to being hierarchical or representing only a particular kind of science, often away from the 'people'. The difference between knowledge and 'science' is often blurred also. An example towards this difference follows: In 1985, the National Research Council of United States of America had brought together nine of the leading ecologists of the country to form the Committee on the Applications of Ecological theory to Environmental Problems. In its very first meeting, the committee had a discussion on the question of successful application of ecological theory to environmental problem vis-à-vis the empirical contribution. The members concluded that it is the successful application of specific ecological knowledge, rather than, the general ecological theory, that is known about. As a result, they had changed the word 'theory' to 'knowledge' in defining its task. In the introduction to the report, [National Research Council, 1986, *Ecological Knowledge and Environmental Problem-Solving*, pp. 1-2] the committee had stated, "'Ecological theory,' as described in standard textbooks on ecology, is seldom applied directly to environmental problems. But ecological 'knowledge' … has been extremely important in developing approaches to a wide range of environmental problems". [Mark Sagoff, 1986, Ethics, Ecology, and the Environment: Integrating Science And Law, *Tennessee Law Review*, 56, pp. 77-229]

[61] Shrader-Frechette and McCoy, op. cit., p. 1

[62] To be more precise, they are the sub-disciplines, like behavioural ecology, population ecology, community ecology, ecosystem ecology, landscape ecology, global ecology and the like, differentiated on the basis of the scale and type of interaction of organism/species and the scale of such interaction with the environment. [Brookes, op. cit., p 10]

Philosophers, scientists, and policymakers have argued for "the privileged position of ecology and ecologists in shaping the goals of environmental decisionmaking and in providing strategies for realizing these policy goals".[63] Consider Aldo Leopold,[64] for whom "[a] thing is right […], when it tends to preserve the integrity, stability, and beauty of the biotic community. It is wrong when it tends otherwise".[65] It is a different debate altogether as to the veracity of this thesis on equilibrium of nature and its stability, which is beyond the scope of the paper. But the moot point is important to note: that of the perceived notion of a 'balance of nature' notwithstanding the contesting claims on both theoretical and empirical grounds. For Shrader-Frechette and McCoy (1993: 2) "scientists themselves have not resisted the temptation to use ecology as a metaphysics, a world view, or an ethics—the foundation for environmental policy". Consider Arthur Cooper, the then President of Ecological Society of America, who had said in 1982 that "ecological "facts" provide at least part of the basis for inferring what ethical, political, and practical "values" ought to characterize environmental decisionmaking".[66] In the process, connections between facts and values had been made, unacknowledged more often than not. Stronger the connections, more widespread are the beliefs, to the extent of latter replacing the former. The question, therefore, is whether ecological science is geared for being such a guiding force for environmental policy making, leave alone the regulations which require even more specificity and certainty.

Shrader-Frechette and McCoy (1993: 3) had argued that "general ecological theory has, so far, been able to provide neither the largely descriptive, scientific conclusions often necessary for

[63] Shrader-Frechette and McCoy, op. cit., p. 2
[64] Being learnt about scientific conservation, Leopold had developed a philosophy of 'game management' modelled closely on the principles of scientific forestry, so as to harvest wildlife on a 'sustained yield' basis. In 1935, he had established Wilderness Society, an autonomous pressure group which had, as one of the objectives, setting aside of wild areas yet to be touched by mining, industry, logging, roads etc. for posterity. [Ramachandra Guha, 2000, *Environmentalism: A global history*, OUP]. Leopold, along with John Muir, "appear to be far more congenial to the mind and heart of the American environmentalist", and like Lewis Mumford had valued primeval nature and biological diversity. [Ramachandra Guha and Juan Martinez-Alier, 1997, *Varieties of Environmentalism: Essays North and South*, OUP, pp. 199-200]
[65] Aldo Leopold, 1949, *A Sand Country Almanac*, pp. 224-5, as quoted in Shrader-Frechette and McCoy, op. cit., p. 2
[66] Shrader-Frechette and McCoy, op. cit., pp. 2-3

conservation decisions, nor the normative basis for policy, both of which environmentalists have sought".[67] In the remainder of this section, the paper explores the appropriateness of ecology or ecological science as a guiding tool for environmental policy, on the grounds of theory and method.

(1) Ecological Science as a 'Scientific' Theory

The area under consideration in this paper, as stated earlier, is one of the many supposed bases for the recent policies and regulations for adaptation, mitigation and adjustment associated with alleged changes in key atmospheric variables at the global level: the reports of IPCC, and in particular AR4. Arguably, ecological science, the discipline that has apparently provided the theoretical basis for IPCC reports, does not hold the scrutiny of a 'pure' science. Consider Karl Popper's famous demarcation between science and non-science, where he had argued that, "every genuine scientific theory [...] is prohibitive, in the sense that it forbids, by implication, particular events or occurrences. As such it can be tested and falsified, but never logically verified".[68] In the words of Thornton (2009), what Popper had stressed was that,

> it should not be inferred from the fact that a theory has withstood the most rigorous testing, for however long a period of time, that it has been verified; rather we should recognise that such a theory has received a high measure of corroboration, and may be provisionally retained as the best available theory until it is finally falsified (if indeed it is ever falsified), and/or is superseded by a better theory".[69]

Such demarcation insures that any theory which explains a phenomenon can also predict it. The difference between explanation and prediction is crucial for the distinction between historical and non-historical sciences: a 'historical' one, like geology or ecology, in contrast to molecular biology or chemistry, make more references to the history of the system under study. [70] While all sciences

[67] Authors had provided examples from community ecology as well as ecosystems ecology.
[68] Stephen Thornton, 2009, 'Karl Popper', in Edward N. Zalta (ed.), The Stanford Encyclopaedia of Philosophy (Summer 2009 Edition), available online at http://plato.stanford.edu/archives/sum2009/entries/pop.per/, retrieved on 22 January 2011
[69] Thornton, op. cit.
[70]
> An explanation explains an observation by showing that the observation could have been predicted by an existing theory or law. Thus an explanation consists of showing that a phenomenon in a particular case of a known regularity. Explanation differs from prediction only by the order in which the theory and the observation are invoked. In prediction, the theory is used to identify the probable observation

use the temporal dimension of the history of phenomena, for effective prediction and explanation, some of the branches use it more, to constitute a sufficient basis for prediction and scientific explanation. However, it is also possible to have both scientific and historical explanations with the latter attempting replace predictive knowledge. But, both the constructs that predict and those which cannot be simultaneously called scientific theories, as this may result in confusing the scientific theories themselves.[71] Peters (1991: 147) finds contemporary ecology to be a case in point.

Scientific explanation to both the phenomenon as well its predictive ability together is termed as 'covering law explanations' since they explain in reference to widely accepted theories or laws.[72] They invoke 'general laws' which are defined as universal statements, unbounded by space or time. Peters (1991: 149) argues further that, in ecology, explanations to these laws are offered by the historical sciences, but these sciences also rely on several types of 'historical laws'.[73] Three types of such 'laws' are found—'empirical rules'[74], 'developmental laws'[75] and 'a type [that] employs entities that invoke temporal concepts, like ancestor or relic'. The former, quiet obviously is unacceptable as universal laws for its building block, the samples, being restricted in space and time; such rules, thus are 'laws of limited generality'.[76] Developmental laws, on the other hand, attempt to explain by reference to a pattern or sequence, so as to predict the future observations and

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> and subsequently this prediction may be compared with the actual observation. In explanation, the observation is already in hand and we seek to show that this observation could have been expected by referring to the appropriate scientific theory. This reference simultaneously explains why some other logically possible but theoretically improbable observation did not occur. Thus scientific explanations explain both the observation of the probable event and the non-observation of possible but improbable events as instances of known theories.

[Robert Henry Peters, 1991, *A Critique for Ecology*, Cambridge University Press, p. 148]

[71] However, Peters (1991: 147) maintains that there is no logical problem in the continued coexistence of both: 'a science of ecology' and 'an art of natural history'.

[72] Peters, op. cit., p. 148. Also see, Laird Addis, 1974, 'On Defending the Covering-Law "Model"', *Proceedings of the Biennial Meeting of the Philosophy of Science Association*, 1974, pp. 361-368

[73] Peters, op. cit. p 149; consider Second Law of Thermodynamics, or other Laws of Physics and Chemistry.

[74] "Patterns observed in the past that allow both prediction, on the assumption that the patterns persist, and explanation, by showing that a particular case is consistent with known regularities". Peters, op. cit., p. 150

[75] "Which holds that certain temporal sequences recur, as early successional stages lead to later ones and that both explanation and prediction can be made by reference to this recurrent sequence". Peters, op. cit., p. 150

[76] Peters, op. cit. p. 151

explaining the past ones. Due to many reasons,[77] "[t]he predictions have either proven to be wrong or the theories have been distorted to make them tautologically true: the patterns hold, except where they do not".[78]

Clearly each of these explanations are non-scientific, in the sense of the distinction that had been made with the scientific ones.[79] Ecological theories/laws, in other words, do not enjoy the status of a universal law, and thus using them as the basis for any policy must be done in a very cautious manner. It is more so, when the object under consideration for such policy is virtually the entire population of this planet. The problem can be summed up as the following:

> Perhaps more than other disciplines, ecology is beset with the difficulty of developing laws and theories about different cases, no two of which are similar in all relevant respects. Hence, compared to other scientists, ecologists face a particularly problematic task when they attempt either to move from singular to theoretical explanation (bottom-up) or to apply a general law to a specific case (top-down). They must clarify how and why the case is relevantly similar to others allegedly covered by the same law, and they must know the precise constraints on idealization in science. Of course, all scientific laws are idealized, and all particular applications of them raise questions about the required closeness of empirical fit in a given situation. Because of the difficulty of finding situations/cases in community ecology that are precisely and relevantly similar, the ecologist faces the problem of scientific idealization in an acute way.[80]

(a) Evaluation of an Ecological Theory: Diversity-Stability Hypothesis

Consider the case for diversity-stability (D-S) hypothesis, one of the many 'theories' that had enjoyed near universal acceptance until very recent times. It simply states that, more diverse the community of species, it is more stable. A natural corollary is that, "some 'balance of nature' is maintained by promoting diverse communities of species"[81] which has prompted many ecologists to argue for "complex trophic systems and diverse communities" as being more stable than less diverse, simpler ones.[82] Shrader-Frechette and McCoy (1993: 4) had found that, "[m]erely on the

[77] See, Peters, op. cit. pp. 153-4
[78] Peters, op. cit. p. 154
[79] There exist many other non-predictive, historical explanations in ecology, however. See, Peters, op. cit. pp. 155-170 for details of each type as well as dangers of such explanations in ecology.
[80] Kristin S Shrader-Frechette and Earl D McCoy, 1993, *Method in Ecology: Strategies for Conservation*, Cambridge, p. 9
[81] Shrader-Frechette and McCoy, op. cit. 3
[82] Shrader-Frechette and McCoy, op. cit. 3-4

grounds of its repetition over several decades, by the late 1960s the diversity-stability hypothesis achieved the status of a proposed truth, an ecological theory or paradigm". However, research in the decade of the 1970s and 1980s had refuted the supposed 'truth' on both mathematical and empirical grounds.[83] Even then, the D-S theory remained as the "most persuasive of the utilitarian arguments for environmental protection, perhaps because it is *something that people like and want to believe*".[84] In the United States, the Endangered Species Act (1973),[85] is supposedly based on the D-S hypothesis and the very fact that it has not been challenged had prompted Shrader-Frechette and McCoy (1993: 5) to conclude that, "environmental legislation might not need to rely primarily on ecological findings, but could be supported instead by purely human (aesthetic, cultural, utilitarian, for example) preferences for preservation and conservation". We shall return to this value question shortly.

2. Methods in Ecology and its Scientific Basis: Hypothetico-deductive method

One more source for failure of the 'ecological science' to prove itself as a 'pure' science lies in the methods for such testing; one of them is Hypothetico-deductive method (H-D method or H-D). [86] It

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[83] The examples are salt marshes and rocky intertidal: "Salt marshes are simple in species composition, but they are stable in the sense that species composition rarely changes over time. On the other hand, the rocky intertidal is a relatively diverse natural system, yet it is highly unstable, since it may be perturbed by a single change in its species composition". [Shrader-Frechette and McCoy, op.. cit. 4]

[84] Shrader-Frechette and McCoy, op. cit. 4; emphasis added.

[85] In the introduction to the Act in the chapter titled 'The Courtship of Law and Ecology', Brookes et al, op. cit., p. 194, states:

> Environmental law has evolved from concern for policies to protect species threatened with extinction to policies designed to protect their niches and habitat. […] The threat of extinction became a kind of symbol for the degradation of nature. Hence the public culture of species protection was wrapped up in the environmental myths and a growing biocentrism that swept America in the early 1970s.

[86] This method involves all the traditional steps of observing the subject, in consideration to an area of study. The first step for the researcher is to generate a *testable* and realistic hypothesis. Such hypothesis must not be falsifiable by recognized scientific methods but may never be fully confirmed, because refined research methods may disprove it at a later date. Next, the researcher must generate some initial predictions from the hypothesis, which can be proved, or disproved, by the experimental process. For the hypothetico-deductive method to be a valid process, these predictions must be inherently testable, a crucial requirement. Experiment is performed then, for obtaining statistically testable results, which can be used to analyze the results and determine the validity of the hypothesis. The experiment may involve some manoeuvring of the variables to allow the generation of data open to analysis. Finally, statistical tests are required to confirm whether the predictions were correct or not. The rigor of this method is such that it is rare for a hypothesis to be completely proved. However, some of the initial predictions may be correct which may lead to new areas of research and refinements of the hypothesis. It is important to note that, proving and confirming a hypothesis has never been a clear-cut and definitive process: however strong the results are generated, there is always a chance of experimental error. In addition, there may be other unknown reason(s) that explains the results.

was introduced by English scholar William Whewell (1794-1866) and was developed by Karl Popper. It is a "procedure for the construction of a scientific theory that will account for results obtained through direct *observation* and experimentation and that will, through *inference*, predict further effects that can then be *verified* or disproved by empirical evidence derived from other experiments".[87] Observation assumes importance from the fact that, "the acceptability of theoretical claims depends upon whether they are true (approximately true, probable, or significantly more probable than their competitors) or whether they 'save' observable phenomena".[88] For arriving at such 'truth', "[i]t's natural to think that computability, range of application, and other things being equal, true theories are better than false ones, good approximations are better than bad ones, and highly probable theoretical claims deserve to take precedence over less probable ones".[89]

Ecological science had been perceived by many to develop along the lines of H-D; so as to provide a precise foundation for environmental policy.[90] However, "laws and theoretical generalization seldom if ever entail observational predictions unless they are conjoined with one or more auxiliary hypotheses taken from the theory they belong to. When the prediction turns to be false, H-D has trouble explaining which of the conjuncts is to blame."[91] In the context of applicability of H-D in ecological science, Shrader-Frechette and McCoy (1993: 81) had argued that,

> Using H-D in ecology is not alone sufficient to resolve the methodological problems in the science, in part because (1) the lawlike status of ecological hypotheses is often questionable; (2) it is difficult to construct uncontroversial null models to test hypotheses; and (3) cognitive or methodological value judgments in ecology often determine the relationship between evidence and theory.

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87 Encyclopædia Britannica, 2011, "Hypothetico-deductive method", Encyclopædia Britannica. Encyclopædia Britannica Online Web, http://www.britannica.com/EBchecked/top.ic/280110/hypothetico-deductive-method Retrieved on 20 January 2011; emphasis added.

88 Bogen, Jim, 2010, 'Theory and Observation in Science', in Edward N. Zalta, ed., *The Stanford Encyclopaedia of Philosophy*, Spring, http://plato.stanford.edu/archives/spr2010/entries/science-theory-observation/ Retrieved on 20 January 2011

89 Bogen, op. cit. Also see, Karl Popper, 1959, *The logic of scientific discovery*, Basic Books, New York for a discussion on Science—Non-science, falsified claims, testable hypothesis, etc. In Popper's view, any hypothesis that does not make testable predictions is simply not science. Such a hypothesis may be useful or valuable, but it cannot be said to be science

90 Shrader-Frechette and McCoy, op. cit., p. 80

91 Bogen, op. cit.

An ecological law is difficult, if not impossible, to find, as stated earlier. Such 'laws', in reality, are "frequently not generalizable and are indistinguishable from mere principles".[92] Further, ecologists seldom agree on what the basic principles or laws are; at times, such 'laws' are trivial, tautological, or not testable.[93] Quite clearly, a test of a hypothesis that is tautological or definitionally true cannot help in an H-D account of the predictive power or the general theory of ecology. As a result, testing of H-D is restricted by the nature of the hypotheses and regularities in ecology.[94] For any move to the 'general theory' methodological value judgments are required, which at times are controversial. They often weaken the significance of null models, even, as mentioned earlier. Arguably, such value judgements are essential in every discipline; in social sciences, they are more explicit, while in natural sciences and law, they often remain unacknowledged.

> [T]he aura of objectivity associated with science is often accepted uncritically and that when this occurs, science loses both its primary compass, namely, a critical mode of inquiry, and becomes vulnerable to the prevailing biases of the day. Uncertain science, or science for which little empirical or theoretical support exists, therefore requires a particularly high level of vigilance to protect it against overreaching.
>
> Much of the criticism of environmental science is driven by a concern that science, particularly when subject to large uncertainties, is being leveraged beyond what it can reasonably support or co-opted for political ends.[95]

The last argument is identical to the one offered by NIPCC, referred earlier in this paper. In other words, there may not be any objection, per se, in taking a political position. But the problem occurs with the 'hidden agenda' being projected as a 'policy neutral' endeavour. "The blind attempt to produce value-neutral science only produces biases in research and political repercussions in the real world that typically favour the haves against the have-nots".[96]

3. *Methodological Value Judgment in Science*

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[92] Shrader-Frechette and McCoy, op. cit., p. 81; a principle, by definition, is a rule that has to be done in a specific way and thus is different from a law.
[93] Shrader-Frechette and McCoy, op. cit., p. 81
[94] Shrader-Frechette and McCoy, op. cit., p. 81
[95] Adelman, op. cit. pp. 957-8
[96] Lélé, Sharachchadra and Richard B Norgaard, 2003, 'Sustainability and the Scientist's Burden', in Vasant Saberwal and Mahesh Rangarajan, eds., *Battles over Nature: Science and the Politics of Conservation*, Permanent Black, New Delhi, p. 161

Helen E Longino (born 13 July 1944), an American philosopher of science,[97] in *Science as social knowledge: values and objectivity in scientific inquiry* had stated:

> It is, of course, nonsense to assert the value-freedom of natural science. Scientific practice is governed by norms and values generated from an understanding of the goals of scientific inquiry. If we take the goal of scientific activity to be the production of explanations of the natural world, then these governing values and constraints are generated from an understanding of what counts as good explanation, for example, the satisfaction of such criteria as truth, accuracy, simplicity, predictability, and breadth. […]
>
> Independence from these sorts of values, of course, is not what is meant by those debating the value freedom of science. The question is, rather, the extent to which science is free of personal, social, and cultural values, that is, independent of group or individual subjective preferences regarding what ought to be (or regarding what, among the things that are, is best). [98]

She termed those from "an understanding of the goals of science" as "*constitutive values* to indicate that they are the source of the rules determining what constitutes acceptable scientific practice or scientific method"[99]. On the other hand, "the personal social and cultural values, those group or individual preferences about what ought to be", was terms as *contextual values* "to indicate that they belong to the social and cultural environment in which science is done".[100] The third type is termed bias value, though admittedly this classification is neither mutually exclusive nor exhaustive.[101] Among the three, constitutive or methodological values are the most difficult to avoid. [102]

Charles Babbage (26 December 1791 – 18 October 1871), the English mathematician, philosopher, inventor, and mechanical engineer who originated the concept of a programmable computer, in

[97] Currently she is Clarence Irving Lewis Professor of Philosophy and holds the Department Chair, Department of Philosophy, Stanford University, USA.
[98] (1990: 4), Cambridge University Press, also referred extensively by Shrader-Frechette and McCoy, op. cit.
[99] Longino, op. cit., 4; Shrader-Frechette and McCoy uses methodological value interchangeably with constitutive.
[100] Longino, op. cit., 4; contextual values are also influenced by cultural, metaphysical, ethical, and financial considerations[Shrader-Frechette and McCoy, op. cit. 83]
[101] It occurs whenever researchers deliberately misinterpret or omit data in order to serve their own purposes. [Shrader-Frechette and McCoy, op. cit. 82]
[102] They originate from particular research design or even the software for analysis when it was created by someone else. Collection of data also "requires use of methodological value judgments because one must make evaluative assumptions about what data to collect and what to ignore, how to interpret the data, and how to avoid erroneous interpretations". [Shrader-Frechette and McCoy, op. cit. 82] Shrader-Frechette and McCoy (1993: 7) found also that "all empirical results […] are value laden", epistemic, cognitive and at times, ethical.

Reflections on the Decline of Science in England,[103] had identified four such methodological value judgements, namely hoaxing, forging, trimming and cooking.[104] *Hoaxing* deals with descriptions of imagination, placed as truth; the deceit is intended to last for a time and then be discovered. [105] *Forging* on the other hand is recording of observations the claimant had never made, in order to acquire reputation. *Trimming* "consists of clipping off little bits here and there from those observations which differ most in excess of mean, and in sticking them on to those which are too small".[106] Objective of *cooking* "is to give to ordinary observations the appearance and character of those of the highest degree of accuracy".[107]

(a) Methodological Value Judgments in Ecology

Shrader-Frechette and McCoy, had separated methodological value judgments into *instrumental* and *categorical* ones. The former assists in finding "the extent to which a particular thing possesses a characteristic value […] [say, of the] explanatory or predictive power […] of an ecological theory about community structure […] or about the extent to which a community is stable through time".[108] Categorical judgments are largely subjective that deals with the fact that "whether an alleged property, […] is really a value for a particular scientific theory, […] [say] about whether a characteristic, such as stability, is really a value/goal for communities or ecosystems".[109] In sum, "[i]nstrumental value judgments posit that, if a specified value or goal (e.g. community stability) is

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[103] 1830, *Reflections on the Decline of Science in England and on some of its causes*, volume 1, B Fellowes and J Booth, London, pp. 174-5

[104]
> Scientific inquiries are more exposed than most others to the inroads of pretenders; and I feel than I shall deserve the thanks to all those who really value truth, by stating some of the methods of deceiving practiced by unworthy claimants for its honours, […]
> There are several species of impositions that have been practiced in science, which are but little known, except to the initiated, and which it may perhaps be possible to render quite intelligible to ordinary understandings. These may be classified under the heads of hoaxing, forging, trimming and cooking.

[105] Babbage warned: "It should be remembered, that the productions of nature are so various, mere strangeness is very far from sufficient to render doubtful the existence of any creature for which there is evidence; and that, unless, the memoir itself involves principles so contradictory, as to outweigh the evidence of a single witness, it can only be regarded as a deception, without the accompaniment of wit. [Babbage, op. cit., pp. 176-77]

[106] Babbage, op. cit., p. 178; emphasis as in original

[107] Babbage, op. cit., p. 178

[108] Op. cit., p. 96

[109] Op. cit., p. 96

to be obtained, then a certain action (e.g. promoting species diversity) is good because it is a means to the value or goal. Categorical value judgments state that a certain goal, for example, community stability, is prima-facie good".[110] At the same time, these "[m]ethodological value judgements are unavoidable even in 'pure' science" for their ability to connect hypotheses and evidence.

> Perception does not provide us with pure facts. Knowledge, beliefs, values, and theories we already hold play a key part in determining what and how we perceive, and some beliefs and values are more reliable determinants of perception than others. Different background assumptions (methodological value judgements) enable us to assess the evidence differently.[111]

Only way to make an assessment of these methodological value judgements is to treat them as we do to the theories: "on the basis of their heuristic power, explanatory fertility, simplicity, and so on".[112] The hypothetico-deductivists, who believe that categorical value judgements have no place in science, therefore appear to commit a mistake,

> because they demand assurance inappropriate to much investigation […] because their requirement of empirical confirmability would not allow those who do pure science (if there is such a thing) to decide on criteria for theory choice, gathering and interpreting data, or rejecting hypotheses, because such judgments could not be empirically confirmed. (And they could not be empirically confirmed because each of them relies on at least one categorical judgment about methodological values, that is, each relies on an assumption about the prima-facie importance of some criterion - e.g., testability, explanatory power, simplicity - for theory/hypothesis choice).[113]

Such categorical value judgements however are necessary and have other roles to perform. For example, "ecology cannot typically tell us, in a non-question-begging way, how to preserve the health of the biosphere".[114] Its inability arises from the simple fact that this discipline "alone cannot provide conclusive grounds for making categorical judgments of value, […] [as] like all sciences, its focus is descriptive/empirical, and value judgments must be justified via logical and conceptual analyses, not on descriptive/ empirical grounds alone".[115] In other words, while ecological sciences cannot provide uncontroversial, categorical judgments of value, on the other, "such judgments are

[110] Op. cit. p. 96
[111] Shrader-Frechette and McCoy, op. cit. 85
[112] Shrader-Frechette and McCoy, op. cit. 85
[113] Shrader-Frechette and McCoy, op. cit. 97
[114] Shrader-Frechette and McCoy, op. cit. 98
[115] Shrader-Frechette and McCoy, op. cit. 98

essential to practical, environmental applications of ecology", as a result of which "ecologists themselves are forced to make value judgments about the interpretation and adequacy of their scientific goals, methods, hypotheses, and conclusions".[116] Precisely for these methodological value judgments, ecologists' scientific findings do not always stand up under epistemological and ethical scrutiny.[117] Thus any attempt to use ecologists' value-laden scientific conclusions as a basis for environmental policy is bound to be controversial; it will be pity if the surrounding criticism results in undermining of the ecological science itself.

To sum up, due to many such "conceptual, theoretical, and evaluative problems associated with developing a precise, quantitative, and explanatory ecological science"[118] some experts had argued against any role of ecology for grounding environmental policy; neither for providing the goal or the values. Its role is often restricted to be a guide on the means to attain the ends or goals.[119] It had been argued that while it is possible for ecology to provide a basis for environmental policy, such a policy need to be necessarily "a function of […] methodological value judgments" the particular ecologists had made. [120] For example, in case, we make a categorical value judgement that increase in the level of CO_2 is bad, it is possible for ecology to help us in such policymaking so as to achieve this end; but, *per se*, this end is not to be set by ecology. If ecology has to support policy, it must be applied in an extremely complex and probabilistic manner.[121]

On the question of "precision, explanatory power, and empirical adequacy of the methods of community ecology", Shrader-Frechette and McCoy [1993: 1] had argued that "when we wish to

[116] Shrader-Frechette and McCoy, op. cit. 99
[117] Shrader-Frechette and McCoy, op. cit. 99
[118] Shrader-Frechette and McCoy, op. cit., p. 8
[119] Contrast medicine with ecology, where the former does have a well-defined goal, that of the health of the individual patient. The accepted clinical norms that are set to evaluate the human health has no corresponding indicator for a community to be 'normal' or healthy. Second, the fact that ecological practice has heterogeneous impact on different persons depending on one's interest, location, priorities, etc. "Thus, even if ecology could unambiguously define a goal for ecological activity, it would still face the problem of which species' and which individuals' welfares to aim at optimizing". [Shrader-Frechette and McCoy, op. cit. 102]
[120] Shrader-Frechette and McCoy, op. cit. 102
[121] Shrader-Frechette and McCoy, op. cit. 114

apply ecology in order to promote conservation or preservation, our knowledge of particular taxa is more important than our knowledge of general theory". Indeed, once, naïve positivism of hypothetico-deductive methods in science and the belief that the value judgements are avoidable in science are rejected, 'top-down' theories give way to 'bottom-up' approaches.[122] Then, randomness and uniqueness to ecological phenomena that challenges the untestable 'grand' theories, no longer remains a 'problem'. Indeed, as Shrader-Frechette and McCoy argues, it is the application of ecology in practical problem solving through case-studies and rough generalisations that makes a strong case for the discipline to serve as the basis for environmental policy.[123]

For such practical and applied science of case studies, however, scientific explanation and rationality in ecology need to be altered, they argue. In contrast to epistemic or scientific rationality[124] as in the case of pure science, say physics, for practical environmental problem solving, ecological science "ought to follow […] *ethical* rationality"[125], in addition to the scientific one. We shall return to this point in the final section.

[122] Top.-down approaches tend to use an account of theoretical explanation to underwrite talk about fundamental mechanisms and identification of causes in particular cases. Bottom-up approaches tend to focus on specific phenomena; they emphasize our ability to see causal relations in such phenomena and then to pull together results about individual cases or events into some sort of theoretical explanation. We shall argue that, insofar as ecology is required for solving practical environmental problems, it is more a science of case studies and statistical regularities, than a science of exceptionless, general laws. Insofar as ecology is an applied endeavor, it is more a science that moves from singular to theoretical explanation, than one that proceeds from theoretical to singular explanation. [Shrader-Frechette and McCoy (1993: 1)]

[123] Shrader-Frechette and McCoy, op. cit. 149

[124] It is based primarily on using scientific theory to assess the probability associated with various competing hypothesis and their consequence. It is a rationality of beliefs. Shrader-Frechette and McCoy, op. cit. 149

[125] Shrader-Frechette and McCoy, op. cit. 149; emphasis as in original. "Ethical rationality is based on using ethical theory and norms (about rights, duties, and ideals) to assess the *moral goodness or badness* associated with alternative *actions* and their consequences. Ethical rationality is rationality of actions". Shrader-Frechette and McCoy, op. cit. 149; emphasis as in original.

B. Level of Atmospheric CO_2: its Sources and its Biological Effects

A. 'Climate Change': Meaning, Detection, Attribution

Article 1 of UNFCCC defines 'Climate Change' as "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods". On the other hand, for IPCC, it "refers to any change in climate over time, whether due to natural variability or as a result of human activity".[126] Notwithstanding the stated position of considering both anthropogenic and natural causes, a cursory reading of selected portions of AR4 does indicate to the absence of any difference between IPCC and UNFCCC on the question of sources of alleged climate change.

In AR4, Chapter 9 of Report of Working Group I supposedly assesses "scientific understanding about the extent to which the observed climate changes […] are expressions of natural internal climate variability and/or externally forced climate change" and its 'detection' and 'attrition'.[127]

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[126] IPCC, 2007a, 'Summary for Policymakers', in *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M.Tignor and H.L. Miller (eds.)], Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, p. 2, fn 1.
Glossary provides a more specific definition:

> Climate change refers to a change in the state of the *climate* that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or *external forcings*, or to persistent *anthropogenic* changes in the composition of the *atmosphere* or in *land use*.

[127] 'Detection' is the process of demonstrating that climate has changed in some defined statistical sense, without providing a reason for that change. An identified change is stated to be 'detected' in observations, if its likelihood of occurrence by chance due to internal variability alone is determined to be small. A failure to detect a particular response might occur for a number of reasons, say, (1) the response is weak relative to internal variability, or (2) that the metric used to measure change is insensitive to the expected change. [IPCC, 2007a, p. 667]. Interestingly, the definition of 'change' rules out internal variability. Without noting these finer points, it is reasonable to expect a confusion between changes due to internal variability and external forcings.
Detection does not imply attribution of the detected change to the assumed cause. 'Attribution' of causes of climate change is the process of establishing the most likely causes for the detected change with some defined level of confidence. [IPCC, 2007a, p. 668] In plain language attrition is nothing but causality and the method is an accepted one.

Among the two sources, internal variability takes place at all time scales; from instantaneous (condensation of vapour into clouds) to many years (large ice sheets). Each of the components of the climate system produce internal variability on their own while at the same time integrates variability from the rapidly varying atmosphere. In addition, internal variability is produced by coupled interactions between components. Thus there are interdependent variables changing at varying time scales. We shall return to this issue shortly.

AR4 had stated that "most of the observed increase in global average temperatures since the mid-20th century is *very likely* due to the observed increase in anthropogenic greenhouse gas concentrations",[128] while attributing the 'remaining uncertainty' to the 'current methodologies'.[129] It had also found 'discernible human influences' in ocean warming, continental-average temperatures, temperature extremes and wind patterns. The following table describes the hypotheses on the causality of the various aspects of changes in the climate.

No	**Hypothesis**	**Nature of Certainty and Degree**
1	Increases in greenhouse gas concentrations alone could have caused more warming than observed because volcanic and *anthropogenic* aerosols have offset some warming that would otherwise have taken place	*Likely*
2	Global climate change of the past 50 years can be explained without external forcing[130]	*Extremely unlikely*
3	Global climate change of the past 50 years is not due to known natural causes alone	*Very likely*
4	The observed pattern of tropospheric warming and stratospheric cooling is due to the combined influences of greenhouse gas increases and stratospheric ozone depletion	*Very likely*
5	There has been significant *anthropogenic* warming over the past 50 years averaged over each continent except Antarctica	*Likely*
6	*Anthropogenic* forcing to have contributed to changes in wind patterns, affecting extratropical storm tracks and temperature patterns in both	*Likely*

[128] IPCC, 2007a, op. cit. 10
[129] IPCC, 2007a, op. cit. 10, fn 12
[130] External forcing refers to a forcing agent outside the *climate system* causing a change in the climate system. Volcanic eruptions, solar variations and *anthropogenic* changes in the composition of the *atmosphere* and *land use change* are external forcings. [IPCC, 2007a, 'Glossary']

	hemispheres	
7	Temperatures of the most extreme hot nights, cold nights and cold days are to have increased due to anthropogenic forcing.	*Likely*
8	*Anthropogenic* forcing has increased the risk of heat waves	*More Likely than Not*
9	The equilibrium climate sensitivity, a measure of the climate system response to sustained radiative forcing, which is defined as the global average surface warming following a doubling of carbon dioxide concentrations to be (a) in the range 2°C to 4.5°C with a best estimate of about 3°C, and (b) to be less than 1.5°C. [131]	 *Likely* *Very unlikely*
10	Climate changes of at least the seven centuries prior to 1950 were due to variability generated within the climate system alone	*Very unlikely*
11	*Anthropogenic* forcing contributed to the early 20thcentury warming evident in reconstructed Northern Hemisphere inter-decadal temperature variability over seven centuries prior to 1950	*Likely*
Source: IPCC, 2007a, op cit., pp. 10, 12; also see, table 9.4.a. pp. 729-30		

Making the statements as in the above table, certainly involves separating out the impact of each variable, which requires a very careful analysis. IPCC (2007a: 666) itself had stated on its proposed causalities and the level(s) of confidence that each of them enjoy:

> Better understanding of instrumental and proxy climate records, and climate model improvements, have increased confidence in climate model-simulated internal variability. However, uncertainties remain. For example, there are apparent discrepancies between estimates of ocean heat content variability from models and observations. While reduced relative to the situation at the time of the TAR [Third Assessment Report], uncertainties in the radiosonde and satellite records still affect confidence in estimates of the anthropogenic contribution to tropospheric temperature change. Incomplete global data sets and remaining model uncertainties still restrict understanding of changes in extremes and attribution of changes to causes, although understanding of changes in the intensity, frequency and risk of extremes has improved.

In terms of mathematics, it involves taking a partial differentiation of each of the dependent variables with respect to the independent variables under ceteris paribus condition, which is certainly impossible. IPCC (2007a: 668) itself admitted the impossibility: to have unequivocal attribution as that would require controlled experimentation with the climate system.

Alternately, one may begin with the physical understanding of the climate system, which in turn is based on physical principles. The conceptual model can then be converted into a quantified climate

[131] Cloud feedbacks remain the largest source of uncertainty, admittedly

model based on forcing history or histories.[132] Predictions from models are then compared with the observed evidence. One then had to conclude on detection and attribution through 'objective statistical tests' for assessing "whether observations contain evidence of the expected responses to external forcing that is distinct from variation generated within the climate system (internal variability)".[133] Such causality is extremely difficult to establish, admittedly. What essentially follows is the usual hypothesis testing drawn on the amplitude of the pattern of change. As a result

> attribution of anthropogenic climate change is understood to mean demonstration that a detected change is 'consistent with the estimated responses to the given combination of anthropogenic and natural forcing' and 'not consistent with alternative, physically plausible explanations of recent climate change that exclude important elements of the given combination of forcings'.[134]

However, adoption of such a hypothetico-deductive method fails in ecological science for reasons elaborated earlier in the paper.

Further, varying time-scales pose uncertainty of a different nature. Arguably, both detection and attribution require knowledge of the internal climate variability on the time scales considered which are usually decades or even longer. For estimation of internal variability sometimes the residual variability that remains in instrumental observations after the estimated effects of external forcing is removed. IPCC (2007a: 668) acknowledges that, "these estimates are uncertain because the instrumental record is too short to give a well-constrained estimate of internal variability, and because of uncertainties in the forcings and the estimated responses". Thus, for estimation of internal climate variability long control simulations from coupled climate models are used. An assessment follows, of the consistency between this residual variability and the model-based estimates of internal variability; analyses that yield implausibly large residuals are not considered credible.

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[132] Such models range from simple energy balance models to models of intermediate complexity to comprehensive coupled climate models.
[133] IPCC, 2007a, p. 667
[134] IPCC, 2007a, p. 668

In such a scenario, studies where the estimated pattern amplitude is substantially different from that simulated by models can still provide some useful knowledge about the climate change but they are to be treated with caution. For variables where confidence in the climate models is limited, such a result may simply reflect weaknesses in models. Alternately, for variables where confidence in the models is higher, questions may be raised about the forcings, such as whether all important forcings have been included or whether they have the correct amplitude, or questions about uncertainty in the observations. This is precisely the point that NIPCC draws on Aerosols. Indeed, on the importance of model and forcing uncertainties in attribution research, IPCC admits this.

> Ideally, the assessment of model uncertainty should include uncertainties in model parameters (e.g., as explored by multi-model ensembles), and in the representation of physical processes in models (structural uncertainty). Such a complete assessment is not yet available, although model intercomparison studies […] improve the understanding of these uncertainties. The effects of forcing uncertainties, which can be considerable for some forcing agents such as solar and aerosol forcing […], also remain difficult to evaluate despite advances in research.[135]

We shall discuss this Aerosol issue below, but it is important to point out the conclusion of IPCC despite acknowledgment of the possible sources of error in judgment.

> Detection and attribution results based on several models or several forcing histories do provide information on the effects of model and forcing uncertainty. Such studies suggest that while model uncertainty is important, key results, such as attribution of a human influence on temperature change during the latter half of the 20th century, are robust.
>
> Detection of anthropogenic influence is not yet possible for all climate variables for a variety of reasons. Some variables respond less strongly to external forcing, or are less reliably modelled or observed. In these cases, research that describes observed changes and offers physical explanations, […] contributes substantially to the understanding of climate change […].
>
> The approaches used in detection and attribution research described above cannot fully account for all uncertainties, and thus ultimately expert judgement is required to give a calibrated assessment of whether a specific cause is responsible for a given climate change.

The concluding remark is remarkable, on the question of providing possible knowledge to the policymakers:

> While the approach used in most detection studies assessed in this chapter is to determine whether observations exhibit the expected response to external forcing, for many decision makers a question posed in a different way may be more relevant. For instance, they may ask, ‘Are the continuing drier-than-normal

[135] IPCC, 2007a, p. 669

> conditions in the Sahel due to human causes?' Such questions are difficult to respond to because of a statistical phenomenon known as 'selection bias'. The fact that the questions are 'self selected' from the observations (only large observed climate anomalies in a historical context would be likely to be the subject of such a question) makes it difficult to assess their statistical significance from the same observations.[136]

B. Radiative Forcing

Energy balance of the climate system[137] is affected by the changes in the atmospheric quantity of greenhouse gases and aerosols, in solar radiation and in land surface. 'Radiative forcing' represents such change, which can be both positive and negative.[138] IPCC had used radiative forcing values for 2005 relative to pre-industrial conditions defined at 1750. It had found that global atmospheric concentrations of carbon dioxide, methane and nitrous oxide had increased markedly as a result of human activities since the base-year and also had far exceeded corresponding values. It had also asserted that the global increases in carbon dioxide concentration are due primarily to fossil fuel use and land use change, while those of methane and nitrous oxide are primarily due to agriculture. Equipped with an 'improved' understanding since the publication of Third Assessment Report vis-à-vis 'anthropogenic warming and cooling influences on climate', IPCC had stated in AR4 with very high confidence[139] that the global average net effect of human activities since 1750 has been one of warming, with a radiative forcing of +1.6 [+0.6 to +2.4] watt per metre square ($W.m^{-2}$).[140] It had also found that the combined radiative forcing due to increases in carbon dioxide, methane, and nitrous oxide is +2.30 [+2.07 to +2.53] $W.m^{-2}$, and its rate of increase during the industrial era is very likely[141] to have been unprecedented in more than 10,000 years. In particular, the carbon

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[136] IPCC, 2007s, p. 669

[137] Climate system means the totality of the atmosphere, hydrosphere, biosphere and geosphere and their interactions. [UNFCCC convention]

[138] Radiative forcing is a measure of the influence that a factor has in altering the balance of incoming and outgoing energy in the Earth-atmosphere system and is an index of the importance of the factor as a potential climate change mechanism. Positive forcing tends to warm the surface while negative forcing tends to cool it. [IPCC, 2007a, op. cit., 2]

[139] As per IPCC's definition it means at least a 9 out of 10 chance of being correct.

[140] IPCC, 2007a, p. 3

[141] To 'indicate the assessed likelihood, using expert judgement, of an outcome or a result' in 'Summary for policymakers', IPCC had used the following terms: *Virtually certain* > 99% probability of occurrence, *Extremely likely* >95%, *Very likely* > 90%, *Likely* > 66%, *More likely than not* > 50%, *Unlikely* < 33%, *Very unlikely* < 10%, *Extremely unlikely* < 5% [IPCC, 2007a, op. cit. p. 3, fn 6]

dioxide radiative forcing increased by 20% from 1995 to 2005, the largest change for any decade in at least the last 200 years, it had stated.

AR4 had separated the sources of radiative forcing into anthropogenic and natural. Former included (1) long lived greenhouse gases, (2) ozone, (3) stratospheric water vapour from CH_4, (4) surface albedo, (5) total aerosol ((a) direct effect, and (b) cloud albedo effect), and (6) linear contrails. Natural included only solar irradiance.[142]

Further, IPCC (2007a: 666) had stated that "estimates of some radiative forcings remain uncertain, including aerosol forcing and inter-decadal variations in solar forcing". At the same time, it had concluded that "[t]he net aerosol forcing over the 20th century from *inverse estimates* based on the observed warming likely ranges between –1.7 and –0.1 W m^{-2}".[143] NIPCC has challenged this on the ground of being too low, as radiative forcing of aerosols may be as large as, or larger than, the radiative forcing due to atmospheric CO_2.[144] This paper has chosen the issue of radiative forcing due to aerosol forcing as a case study of attributing a change to anthropogenic and natural factors.

1. *Aerosol Effect*

Consider a change of magnitude X that has occurred resulting from Y–Z or A–B, or for many other combinations involving two or more than two contributing factors. Y or A are not observed directly but are calculated as residuals, given X. Assuming correctness of X, it is possible to conclude on Y or A, if Z and B can be estimated correctly. Therefore it is extremely important to follow a method for estimating Z or B. Now, if the two happen to be the same variable, but differ only in the method, then we do have a case of methodological value judgement. There is nothing wrong in

[142] Fig SPM.2, in IPCC, 2007a, op. cit. 4
[143] Emphasis added.
[144] NIPCC, op. cit., p. 48

taking such a position per se, but it must be clearly stated and making any policy conclusion must be done with utmost care.

(a) Total Aerosol Effect

According to Anderson et al. (2003) there are two different ways by which the aerosol forcing of climate may be computed.[145] The first is the 'forward calculation' that utilizes known physical and chemical laws and assumes nothing about the outcome of the calculation. The other approach is the 'inverse calculation' which is based on matching residuals, where the aerosol forcing is computed from what is required to match the calculated change in temperature with the observed change over some period of time. Clearly, in the latter, there is a possibility of circular reasoning. Apparently, "virtually all climate model studies that have included anthropogenic aerosol forcing as a driver of climate change have used only aerosol forcing values that are consistent with the inverse approach."[146] However, negative forcing of anthropogenic aerosols derived by the first method is 'considerably greater' than that derived by latter one to the extent of results differing 'greatly' and 'even the sign of the total forcing is in question'.

IPCC itself had stated the following on the method of estimating Aerosol:

> [F]orward calculations of aerosol radiative forcing, which do not depend on knowledge of observed climate change or the ability of climate models to simulate the transient response to forcings, provide results (–2.2 to –0.5 $W.m^{-2}$; 5 to 95%) that are quite consistent with inverse estimates; the uncertainty ranges from inverse and forward calculations are different due to the use of different information. The large uncertainty in total aerosol forcing makes it more difficult to accurately infer the climate sensitivity from observations.[147]
> […]
> An important source of uncertainty arises from the incomplete knowledge of some external factors, such as humansourced aerosols. In addition, the climate models themselves are imperfect.[148]
> […]
> Despite continuing uncertainties in aerosol forcing and the climate response, it is likely that greenhouse gases alone would have caused more warming than observed

145 T L Anderson, R J Charlson, S E Schwartz, R Knutti, O Boucher, H Rodhe, and J Heintzenberg, 2003, 'Climate forcing by aerosols—a hazy picture', *Science*, 300, pp. 1103-1104, cited in NIPCC, op. cit.,
146 Anderson et al. quoted in NIPCC, op. cit.
147 IPCC, 2007a, op. cit., p. 678
148 IPCC, 2007a, op. cit., p. 702

> during the last 50 years, with some warming offset by cooling from aerosols and other natural and anthropogenic factors.[149]

(i) Primary Biological Atmospheric Particles

There are allegations by NIPCC over exclusion of the primary biological atmospheric particles or PBAPs by IPCC, which apparently has significant influence on cloud cover, climate forcing and feedback and global precipitation distribution.[150] NIPCC quotes a study by Jaenicke et al. (2007) that had argued that "by number and volume, the PBAP fraction is ~20 per cent of the total aerosol, and appears rather constant during the year", with the overall conclusion that "PBAPs are a major fraction of atmospheric aerosols, and are comparable to sea salt over the oceans and mineral particles over the continents". Based on these, NIPCC (2009: 49) had commented that

> [o]ver much of the planet's surface, the radiative cooling influence of atmospheric aerosols (many of which are produced by anthropogenic activities) must prevail, suggesting a probable net anthropogenic-induced climatic signal that must be very close to zero and incapable of producing what the IPCC refers to as the "unprecedented" warming of the twentieth century. Either the air temperature record they rely on is in error or the warming, if real, is due to something other than anthropogenic CO2 emissions.

Similar to alleged discrepancies in the 'total Aerosol effect', NIPCC had cited contradictory hypotheses on Biological (aquatic), Biological (Terrestrial), Non-Biological (Anthropogenic), and Non-Biological (Natural) effects. Due to paucity of space, only the first contention is mentioned below briefly.

(b) Aerosol Effect—Biological (aquatic)

Charlson et al. way back in 1987 had described a multi-stage negative feedback phenomenon,[151] several components of which have been verified by subsequent scientific studies, linking biology with climate change, NIPCC had stated. An initial impetus for warming begins a process that

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[149] IPCC, 2007a, op. cit., p. 704

[150] They include cultureforming units, including pollen, bacteria, mold and viruses, fragments of living and dead organisms and plant debris, human and animal epithelial cells, broken hair filaments, parts of insects, shed feather fractions, etc. [R Jaenicke, S Matthias-Maser, and S Gruber, 2007, 'Omnipresence of biological material in the atmosphere', *Environmental Chemistry*, 4, pp. 217-220, cited in NIPCC, op. cit.]

[151] R J Charlson, J E Lovelock, M O Andrea, and S G Warren, 1987, 'Oceanic phytoplankton, atmospheric sulfur, cloud albedo and climate' *Nature*, 326, pp. 655-661, cited in NIPCC op. cit. pp. 50-51

stimulates primary production in marine phytoplankton, which in turn leads to the production of more copious quantities of dimethylsulphoniopropionate, followed by the evolution of greater amounts of dimethyl sulphide, or DMS, in the surface waters of the world's oceans. Larger quantities of DMS gets diffused into the atmosphere, where the gas is oxidized, leading to the creation of greater amounts of acidic aerosols that function as cloud condensation nuclei. This phenomenon then leads to the creation of more and brighter clouds that reflect more incoming solar radiation back to space, resulting in a cooling influence that counters the initial impetus for warming. In sum, "[t]he normal hour-to hour, day-to-day, and season-to-season behaviors of the phytoplanktonic inhabitants of earth's marine ecosystems seem to be effectively combating extreme environmental temperature changes".[152]

C. Biological Effects of Carbon Dioxide Enrichment

IPCC (2007a) in the 'Chapter 2: Changes in Atmospheric Constituents and in Radiative Forcing', had stated the following on the biological effects of atmospheric CO_2 enrichment:

> Increased CO2 concentrations can also 'fertilize' plants by stimulating photosynthesis, which models suggest has contributed to increased vegetation cover and leaf area over the 20th century (Cramer et al., 2001). Increases in the Normalized Difference Vegetation Index, a remote sensing product indicative of leaf area, biomass and potential photosynthesis, have been observed (Zhou et al., 2001), although other causes including climate change itself are also likely to have contributed. Increased vegetation cover and leaf area would decrease surface albedo, which would act to oppose the increase in albedo due to deforestation. The RF [radiative forcing] due to this process has not been evaluated and there is a very low scientific understanding of these effects.[153]

In contrast to the 'low scientific understanding' on the issue of radiative forcing, in 'Chapter 5: Food, Fibre and Forest Products', that discusses food crops, pastures and livestock, industrial crops and biofuels, forestry (commercial forests), aquaculture and fisheries, and smallholder and subsistence agriculturalists and artisanal fishers, IPCC (2007b: 276) had claimed to be consistent on

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[152] NIPCC, op. cit. p. 51
[153] Full citation for references in the quote: W Cramer, et al., 2001, 'Global response of terrestrial ecosystem structure and function to CO_2 and climate change: Results from six dynamic global vegetation models' *Global Change Biol.*, 7, pp. 357–373 and L M Zhou, et al., 2001, 'Variations in northern vegetation activity inferred from satellite data of vegetation index during 1981 to 1999', *J. Geophys.Res*., 106(D17), pp. 20069–20083.

the 'treatment of uncertainty'. In particular, it had stated that, "[t]raceable accounts of final judgements of uncertainty in the findings and conclusions are, where possible, maintained. These accounts explicitly state sources of uncertainty in the methods used by the studies that comprise the assessment". Before discussing some of the key findings in the 'Section 5.4 Key future impacts, vulnerabilities and their spatial distribution',[154] the major hypotheses in this chapter are placed in the table below.

No	Hypotheses	Nature of Certainty
1	In mid- to high-latitude regions, moderate warming benefits crop and pasture yields, but even slight warming decreases yields in seasonally dry and low-latitude regions	Medium Confidence
2	The marginal increase in the number of people at risk of hunger due to climate change must be viewed within the overall large reductions due to socio-economic development	Medium Confidence
3	Projected changes in the frequency and severity of extreme climate events have significant consequences for food and forestry production, and food insecurity, in addition to impacts of projected mean climate	High Confidence
4	Simulations suggest rising relative benefits of adaptation with low to moderate warming, although adaptation stresses water and environmental resources as warming increases.	Medium Confidence Low Confidence
5	Smallholder and subsistence farmers, pastoralists and artisanal fisherfolk will suffer complex, localised impacts of climate change	High Confidence
6	Globally, commercial forestry productivity rises modestly with climate change in the short and medium term, with large regional variability around the global trend.	Medium Confidence
7	Local extinctions of particular fish species are expected at edges of ranges.	High Confidence
8	Food and forestry trade is projected to increase in response to climate change, with increased dependence on food imports for most developing countries	Medium to Low Confidence
9	Experimental research on crop response to elevated CO2 confirms Third Assessment Report (TAR) findings New Free-Air Carbon Dioxide Enrichment (FACE) results suggest lower responses for forests	Medium to High Confidence Medium Confidence
Source: IPCC, 2007b, op cit., pp. 275-6		

1. Limitations and Uncertainties on Plant Growth for IPCC

On 'Effects of elevated CO_2 on plant growth and yield', IPCC had acknowledged that

> plant physiologists and modellers alike recognise that the effects of elevated CO_2 measured in experimental settings and implemented in models may overestimate actual field- and farm-level responses, due to many limiting factors such as pests, weeds, competition for resources, soil, water and air quality, etc., which are neither well understood at large scales, nor well implemented in leading models

[154] IPCC, 2007b, op. cit., pp. 282-95

Similarly on ‘Interactions of elevated CO_2 with temperature and precipitation’, one can find the identical response

> In general, changes in precipitation and, especially, in evaporation-precipitation ratios modify ecosystem function, particularly in marginal areas. Higher water-use efficiency and greater root densities under elevated CO2 in field and forestry systems may, in some cases, alleviate drought pressures, yet their large-scale implications are not well understood.

More importantly in sub-section ‘5.4.2.3 Research tasks not yet undertaken–ongoing uncertainties’ IPCC had stated,

> Several uncertainties remain unresolved since the TAR. Better knowledge in several research areas is critical to improve our ability to predict the magnitude, and often even the direction, of future climate change impacts on crops, as well as to better define risk thresholds and the potential for surprises, at local, regional and global scales.
>
> In terms of experimentation, there is still a lack of knowledge of CO_2 and climate responses for many crops other than cereals, including many of importance to the rural poor, such as root crops, millet, brassica, etc., with few exceptions […]. Importantly, research on the combined effects of elevated CO_2 and climate change on pests, weeds and disease is still insufficient, though research networks have long been put into place and a few studies have been published […] Impacts of climate change alone on pest ranges and activity are also being increasingly analysed […] Finally, the true strength of the effect of elevated CO_2 on crop yields at field to regional scales, its interactions with higher temperatures and modified precipitation regimes, as well as the CO_2 levels beyond which saturation may occur, remain largely unknown.

This is a rather strange conclusion. One can well understand the focus on projecting ‘Impacts, Adaptation and Vulnerability’ being part of report of the Working Group II, but then one can expect IPCC to deal with the issue in more detail. Paucity of literature is certainly not the issue here, but the prioritisation of issues reflecting a value judgment.

‘Chapter 7: Biological Effects of Carbon Dioxide Enrichment’, of NIPCC spans over 105 pages and in each of its sections (Plant Productivity Responses, Water Use Efficiency, Amelioration of Environmental Stresses, Acclimation, Competition, Respiration, Carbon Sequestration, Other Benefits, and Greening of the Earth), there is a crop specific discussion of the literature. For example, under sub-section ‘7.1 Plant Productivity Responses’, in ‘7.1.1 Herbaceous Plants’, 7.1.1.6 discusses Rice, a key crop for India and China, the more populous countries of the world at present.[155] In contrast to one Figure 5.2[156] and a few general statements in the IPCC (2007b),[157] the section on rice in NIPCC discusses variations in productivity with respect to changes in elevation, season, environmental stresses, and CO_2 concentration. In summary, the report concluded: "as the CO_2 concentration of the air continues to rise, rice plants will likely experience greater photosynthetic rates, produce more biomass, be less affected by root parasites, and better deal with environmental stresses, all of which effects should lead to greater grain yields".[158]

Plant Photosynthesis (Net CO_2 Exchange Rate) Responses to Atmospheric CO_2 Enrichment of 300-ppm for selected crops is provided in the table below:[159]

Plant Name	Number of Studies	Arithmetic Mean	Standard Error
Cotton [Gossypium hirsutum]	18	46.40%	5.50%
Soybean [Glycine max]	75	56.20%	9.40%
Sunflower [Helianthus annuus]	13	41.50%	6.10%
Barley [Hordeum vulagare]	13	55.20%	12.60%
Rice [Oryza sativa]	64	49.70%	5.70%
White Potato [Solanum tuberosum]	15	33.20%	5.50%
Common Wheat [Triticum aestivum]	83	64.90%	10.20%
Corn [Zea mays L.]	21	28.50%	11.50%
Source: Table 7.1.2 – Plant Photosynthesis (Net CO_2 Exchange Rate) Responses to Atmospheric CO_2 Enrichment, NIPCC, op. cit., pp. 727-39			

[155] For a complete list of each of the sub-Sections refer to Annexure 1, collated from NIPCC, op. cit.

[156] The set of 6 diagrams had been derived from the results of 69 published studies at multiple simulation sites, against mean local temperature change used as a proxy to indicate magnitude of climate change in each study. [IPCC, 2007b, op. cit. p. 286]

[157]

> The benefits of adaptation vary with crops and across regions and temperature changes; however, on average, they provide approximately a 10% yield benefit when compared with yields when no adaptation is used. Another way to view this is that these adaptations translate to damage avoidance in grain yields of rice, wheat and maize crops caused by a temperature increase of up to 1.5 to 3°C in tropical regions and 4.5 to 5°C in temperate regions. Further warming than these ranges in either region exceeds adaptive capacity. The benefits of autonomous adaptations tend to level off with increasing temperature changes […] while potential negative impacts increase. [IPCC, 2007b, op. cit., p. 295]
>
> According to […], rice production in Asia could decline by 3.8% during the current century. Similarly, a 2°C increase in mean air temperature could decrease rice yield by about 0.75 tonne/ha in India and rain-fed rice yield in China by 5-12% […] [ibid, p. 297]

[158] NIPCC, op. cit., p. 372

[159] Whenever the CO2 increase was not exactly 300 ppm, a linear adjustment was computed by NIPCC. The data in this table was tabulated from the Plant Growth database of Center for the Study of Carbon Dioxide and Global Change as it existed on 23 March 2009. For more recent additions, see CO2Science, 'Plant Photosynthesis (Net CO2 Exchange Rate) Responses to Atmospheric CO2 Enrichment' at http://www.co2science.org/data/plant_growth/photo/photo_subject.php

To sum up, there have been quite clear and distinct instances of applying value judgment by IPCC in its reports. Be it in theory, in method or even in prioritising issues to be studied for assessment. Such problems apart, generalised conclusions at the level of global ecosystem are certainly not a very certain basis for policy recommendations. Recall that it is the case-studies, albeit on a smaller scale, where ecological science can prescribe policies with more certainty, if it can at all. IPCC also admits that “[d]ifficulties remain[ed] in reliably simulating and attributing observed temperature changes at smaller scales. On these scales, natural climate variability is relatively larger, making it harder to distinguish changes expected due to external forcings. Uncertainties in local forcings and feedbacks also make it difficult to estimate the contribution of greenhouse gas increases to observed small-scale temperature changes”.[160]

[160] IPCC, 2007a, op. cit., p. 10

Concluding Remarks

This paper has argued against employment of inappropriate theories for addressing ecologically significant alterations, citing objections at both theoretical and empirical levels. At the same time, a plausible argument can be advanced in favour of regulating the use of hydrocarbons on the basis of moral or ethical rationality: for preservation of this exhaustible natural resource for the future generations:[161]

A. *Rationality in the time of Uncertainty*

Importance of ethical rationality originates from the fact that “scientific account of ecological rationality often given problematic advice in situations of factual or statistical uncertainty”.[162] The issue under consideration of this paper has utilised ecological science for policy making faced with uncertainty.

Imagine a situation, where the scientists cannot reduce both type I and type II error, and she must give priority to one over the other. [163] Is it better to risk Type-I or Type-II, under uncertainty? Scientists are divided over this, as well. Note that, justice system is supposed to follow the famous

[161]By exhaustible we mean within a reasonably long time horizon of say 100 years, within which these resources will be finished with given rates of extraction.

[162] Shrader-Frechette and McCoy, op. cit. 152

[163] Consider a situation where a person is accused of criminal charges framed by police. Here the justice system is to decide upon the claim by the police that the person is guilty, while following the standard of "beyond the reasonable doubt". Such claim, note that, need to be decided upon. The original claim is that "every person is innocent until proven guilty". This claim is denoted by H_0, or the null hypothesis, against an alternative hypothesis, H1 which is the claim made by the police. Note that, we can either "reject H_0 in favour of H_1" or "Do not reject H_0" but can never conclude "reject H_1" or even "accept H_1". Second, or "do not reject H_0" does not necessarily mean that null hypothesis is true; it simply means that there is not sufficient evidence against H_0 in favour of H1. Similarly, the first, or "reject H_0 in favour of H_1" means that the alternative hypothesis may be true. In hypothesis testing, a type I error is said to have occurred when the null hypothesis is rejected when it is in fact true; that is, H_0 is wrongly rejected. In contrast, a type II error occurs when the null hypothesis H_0, is not rejected when it is in fact false. The theory and the corresponding matrix in the justice system is as follows:

		Decision			Decision	
		Reject H_0	Don't reject H_0		Reject presumption of innocence (Guilty verdict)	Fail to Reject Presumption of innocence (Not Guilty verdict)
Truth	H_0=Defendant Innocent	Type I Error	Right decision		Type I Error	Right decision
	H_1=Defendant Guilty	Right decision	Type II Error		Right decision	Type II Error

‘Blackstone Ratio’: "Better that ten guilty persons escape than that one innocent suffer". Statistically speaking, false convictions are analogous to Type I errors[164], by way of rejecting a true null hypothesis. In contrast, false acquittals are analogous to Type II errors, the error of accepting a false null hypothesis. In other words, type-II error may happen, but we are not to risk type-I error. To be precise, probability of type-I error is to be minimised than type-II error. Does this priority apply to matters of environmental policy as well, based on ecological science? The choice is not to be considered in abstract form only, but faced in real life by scientists faced with additional constraints. They are in the form of undetermined probability of a low-probability, high-consequence accident and the uncertain nature of the impact of such an accident. In such a situation the scientist is forced to make a value judgement in giving priority to either of the two statistical errors.

There are no easy answers to this choice, however. More so, as either of the errors can never be zero. Consider the level of significance of 0.01, that states there is no more than a 1 in 100 chance of committing the error or rejecting a true hypothesis. C West Churchman in *Theory of Experimental Inference uses* the typology of ‘Producer Risk’ and ‘Consumer Risk’.[165] Shrader-Frechette and McCoy (1993: 155) had renamed them to be ‘Developer Risk’ and ‘Public Risk’. Arguably, those who produce the risk to a particular well-defined harm to a subset of the ecosystem[166] are most likely the ‘developers’ of some kind, while those who are most likely to be ‘consumers’ of the benefits of preservation of the same subset of the ecosystem are the members of the public.

One may also note that, “minimising developer risk would increase public risk, […] [and] minimising public risk would increase developer risk. […] Statistically, however, although

[164] See, the immediately preceding footnote.
[165] Minimisation of type-I error is akin to the error of rejecting a harmless development, the ‘Producer Risk’. Minimisation of type-II error minimizes the error of accepting a harmful development, the ‘Consumer Risk’. Shrader-Frechette and McCoy, op. cit. 155
[166] Recall the earlier discussion on the importance of this definiteness.

minimising the probability of type-I error would increase the probability of type-II error, minimising the probability of type-II error would not increase the probability of type-I error". The question posed earlier can be reformulated in the context of the paper: that of the average level of CO_2 and the biological impacts of increase in its level.

Given that there are only two sources of this gaseous substance, anthropogenic and natural, a possible null hypothesis can be: capping the CO_2 emission per country's population to x will make the sea level to fall by y cm. Another null hypothesis could be: increase in the average level of CO_2 by x will cause y harm (or damage, which is assumed to be countable) to the human well-being.

How does one decide whether to run the developer risk of rejecting a true null hypothesis, that of, increase of CO2 by x will not result in y harm? Or ought one to run the public risk of not rejecting an allegedly false null hypothesis? Reduction of the former may hurt the public[167], while reduction of public risk might hurt the developers[168]. Shrader-Frechette and McCoy (1993: 157-169) had discussed in detail, why ecologists have an obligation to give priority to minimization of public risk in situations of uncertainty, that involve potentially grave threats to welfare, contrary to the prevailing dominant position.[169]

In environmental impact assessment[170], the typical value judgement is to prefer type-II error (of not rejecting a harmful development) over type-I (of rejecting a harmless development). In other words,

[167] We are not making a distinction between public of m country and of n country, nor we are making any heterogeneous treatment to various components of the ecosystem from organism to the community Public includes every living organism, if not the abiotic resources.

[168] Unlike the case of public, developers are a subset of public, engaged in activities result in CO2 emission to the open access property, the atmosphere.

[169] Unless otherwise mentioned, reference in this section is Shrader-Frechette and McCoy, op. cit.

[170] Environmental Impact Assessment (EIA) is an effort to anticipate, measure, and weigh the socio-economic and biophysical changes that may result from a proposed project. It assists decision-makers in considering the proposed project's environmental costs and benefits. […] EIA, in brief, extrapolates from scientific knowledge to assess the problem consequences of some human interventions on nature. Although EIA uses the techniques of science, it differs from ordinary scientific inquiry, because it is dealing with events which have not yet occurred, may not occur, and whose chances of occurrence may be changed by the very statement that they may occur. [Environmental Information

such assessment prefers the risk of not rejecting the null. In contrast, "the public generally, however, tend to support an *ethical* concept of rationality under uncertainty. They tend to reject the null and to prefer type-I (over type-II) errors when both cannot be prevented".[171]

Such preference is in conformity with the scientific practice, that of being consistent with scientific rationality, in particular of limiting false positives. It is in line with the standard of criminal cases of being "beyond the reasonable doubt".[172] Finally, "[p]reference for minimising developer risk, in a situation of ecological uncertainty where both kinds of risk cannot be avoided, also likely to arise as a consequence of the fact that experts almost always use widely accepted Bayesian decision rules based on expected utility and subjective probabilities".[173] IPCC (2007a: 704) itself had acknowledged use of Bayesian inference theory, for making its claim of anthropogenic causes:

System Centre, 'EIA-Environmental Impact Assessment', ENVIS CENTRE, Madras School of Economics, available online at http://envis.mse.ac.in/Environmental%20Impact.asp retrieved on 20 January, 2011]

[171] Op. cit., p. 157

[172] See footnote 162 above

[173]

> "Bayesian inference differs from classical, frequentist inference in four ways:
> 1 Frequentist inference estimates the probability of the data having occurred given a particular hypothesis (P(Y|H)) whereas Bayesian inference provides a quantitative measure of the probability of a hypothesis being true in light of the available data (P(H|Y));
> 2 Their definitions of probability differ: frequentist inference defines probability in terms of long-run (infinite) relative frequencies of events, whereas Bayesian inference defines probability as an individual's degree of belief in the likelihood of an event.
> 3 Bayesian inference uses prior knowledge along with the sample data whereas frequentist inference uses only the sample data;
> 4 Bayesian inference treats model parameters as random variables whereas frequentist inference considers them to be estimates of fixed, 'true' quantities.
> The last three distinctions are epistemic, and one should consider them carefully in choosing whether to use Bayesian or frequentist methods".

The application of Bayesian inference to ecological questions has been found in Dynamics of single species, Dynamics of interacting species and Multispecies community ecology [Source: Table 1 Ecological studies using Bayesian inference published since 1996 in the major ecological journals (American Naturalist; Journal of Ecology; Ecology; Ecological Monographs; Journal of Animal Ecology; Oikos; Journal of Applied Ecology; Oecologia; Ecological Applications; Conservation Biology; Ecology Letters)]

Admittedly,

> [t]here is recognized uncertainty in the parameter estimates of both classical and Bayesian models. Less often appreciated is the uncertainty involved in selecting a particular model relative to other plausible models [...] Yet, the incorrect specification or choice of a statistical model can result in faulty inferences or predictions. [...] Recognizing uncertainty in parameter estimates and predictions of ecological models [...] and communicating the uncertainty in the range of ecological models considered [...] can lead to better understanding by ecologists of the power and limitations of statistical inference and prediction.

Author warns, "deciding whether to use Bayesian or frequentist inference demands an understanding of their differing epistemological assumptions. Strong statistical inference demands that ecologists not only confront models with data

> Many studies have detected a human influence on near-surface temperature changes, applying a variety of statistical techniques and using many different climate simulations. Comparison with observations shows that the models used in these studies appear to have an adequate representation of internal variability on the decadal to inter-decadal time scales important for detection. When evaluated in a Bayesian framework, very strong evidence is found for a human influence on global temperature change regardless of the choice of prior distribution.

Against these arguments, Shrader-Frechette and McCoy put forward 'prima-facie' reasons for "giving priority, in situations of uncertainty, to public welfare and public decisionmaking",[174] which in other words is conservation/preservation rather than development. In sum they were "arguing that ecological rationality ought to encompass ethical analysis of *actions*, as well as epistemic or scientific consideration of *hypotheses*".[175]

Arguably, scientific rationality is conservative and associates itself with minimising type-I error in a situation of uncertainty. But, if the scientific rationality alone cannot provide the most appropriate model for environmental decision-making, as argued earlier, then certainly, there is a case for including ethical *along with* scientific rationality.

Scientific rationality, "[i]n its *narrowest* sense, […] focuses only on epistemic considerations, […] [while] in its *broadest* sense, […] [it] often encompasses the use of some type of *decision theory* to assess the various degrees of *expected utility* […], the various costs and benefits that are associated with competing hypotheses".[176] In a situation of uncertain data, such scientific rationality is may favour "an hypothesis with slightly lower probability, but whose expected utility, benefits over costs, were significantly greater than that of another hypothesis. In a similar situation, ethical

but also confront their own assumptions about how the world is structured". [Aaron M. Ellison, 2004, 'Bayesian inference in ecology', *Ecology Letters*, 7, pp. 509–520]

[174] Shrader-Frechette and McCoy, op. cit. 169

[175] Shrader-Frechette and McCoy, op. cit. 169; emphasis as in original.

[176] Shrader-Frechette and McCoy, op. cit. 192

rationality might dictate deciding in favour of an hypothesis that would lead to greatest ethical good".[177] To sum up,

> in any case in which one's own judgment about a hypothesis affects the interests of, and duties to, other persons, what is rational is not merely a matter of scientific rationality. What is rational is also a matter of moral and legal obligation, fairness, consent, voluntariness and so on. That is, when one moves from *"pure" science to applied science* affecting policy, what is rational moves from epistemological considerations to both ethical and epistemological concerns. Likewise, when one moves from considerations of *utility* to those of *ethics*, one moves from scientific rationality to ethical rationality.[178]

In the context of this paper, the following arguments can be advanced towards such ethical rationality:

One, as the pollution associated with the lifecycle of each of the hydrocarbons are hard to the reduced further at the present state of technology, we may wait for the future developments that may result in its more efficient use and less negative externalities.

Two, it is important for the society to find and develop, adequate and appropriate energy sources, which are relatively abundant and renewable. For operationalisation of sustainable development, Costanza and Daly (1992: 44) had put forward a few principles, which include among others, (1) to have technological progress that is efficiency increasing rather than throughput increasing, (2) for renewable natural capital, harvesting rates are not to exceed regeneration rates and waste emissions should not exceed the renewable assimilative capacity of the environment, and (3) for non-renewable natural capital, exploitation should be at a rate equal to the creation of renewable substitutes.[179]

Third, while it is important to acknowledge the fossil fuel powered economic growth especially after Second World War, distribution of its benefits has largely remained inegalitarian. For a better

[177] Shrader-Frechette and McCoy, op. cit. 192
[178] Shrader-Frechette and McCoy, op. cit. 193
[179] Robert Constanza and Herman Daly, 1992, 'Natural Capital and Sustainable Development', *Conservation Biology*, 6 (1), pp. 37-46

society, such energy sources are required to be developed whose initial endowment is more universal. Tapping renewable energy sources like sun or wind, involves substantial initial investment as well maintenance of equipment, even if the marginal cost is close to zero. Such improved initial endowment of this essential resource stock will certainly result in a better societal outcome, even if the differences in the utilisation potential and capacity to absorb the developmental opportunities on the part of the economic agents remain unaltered.

At a supra-national level, such investments in R&D for developing alternative energy sources will thwart the rise in negative externalities associated with rise in entropy[180] through use of the bottled sunshine, the fossil fuels. In other words, policies at the supranational as well national levels and subsequent regulations can be well justified, on the basis of ethical rationality, but not on the claimed but unsubstantiated scientific rationality.[181]

"Science may be morally neutral, but so is a traffic light; car drivers and scientists are not".[182]

[180] Order of degradation of a resource so that the same amount of work is not possible as it could have been possible in its original state.

[181]

> Global warming hype has led to demands for unrealistic efficiency standards for cars, the construction of uneconomic wind and solar energy stations, the establishment of large production facilities for uneconomic biofuels such as ethanol from corn, requirements that electric companies purchase expensive power from so-called "renewable" energy sources, and plans to sequester, at considerable expense, carbon dioxide emitted from power plants. While there is nothing wrong with initiatives to increase energy efficiency or diversify energy sources, they cannot be justified as a realistic means to control climate. Neither does science justify policies that try to hide the huge cost of greenhouse gas controls, such as cap and trade, a "clean development mechanism," carbon offsets, and similar schemes that enrich a few at the expense of the rest of us.
>
> Seeing science clearly misused to shape public policies that have the potential to inflict severe economic harm, particularly on low-income groups, we choose to speak up for science at a time when too few people outside the scientific community know what is happening, and too few scientists who know the truth have the will or the platforms to speak out against the IPCC. [NIPCC, op. cit., p. vi]

[182] C I Jackson, 1986, *Honor in Science*, Sigma Xi, The Scientific Research Society, New Haven, Connecticut, USA, p. 1-2, as quoted in Shrader-Frechette and McCoy, op. cit. 99