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Sharachchandra Lélé

Centre for Interdisciplinary Studies in Environment and Development
ISEC Campus, Nagarabhavi, Bangalore 560 072, India

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Interdisciplinarity as a three-way conversation: Barriers and possibilities[1]

Sharachchandra Lélé

Centre for Interdisciplinary Studies in Environment and Development
ISEC Campus, Nagarabhavi, Bangalore 560 072, India

Tel: +91-(80)-2321-7013
Fax: +91-(80)-2321-7008
Email: slele@isec.ac.in

1. Introduction

The title of this book suggests that the main disciplinary divide in research on 'CPRs' is between economists and anthropologists. But the acronym is itself open to two alternative expansions, viz., Common Property Resources and Common Pool Resources, that highlight the social and the biophysical dimension of the problem respectively (Stevenson, 1991). The starting point of this paper, therefore, is that interdisciplinarity in the context of CPRs has to be (at least) a three-way conversation between economists, anthropologists and natural scientists.[2] Implicit in this point of departure is also the idea that having this conversation and eventually a collaboration of some kind is desirable[3] and to some extent possible. The question therefore is not "whether" but "how". Answering this question requires a comprehensive understanding of the different barriers that prevent this three-way conversation from being a productive one. I believe that the barriers include not just differences in epistemology and method that have been well-debated in other chapters of this book and elsewhere, but differences of other kinds as well. I suggest a four-dimensional categorisation of these barriers, and then discuss the form and relative importance of each in the different sides of the conversational triangle using various illustrations. Finally, I suggest a few practical ways of overcoming these barriers. These discussions, illustrations and suggestions draw as much upon my personal experience in crossing disciplinary boundaries and conducting interdisciplinary research on forests, watersheds and forest-watershed linkages as upon the examples available in the CPR or broader environmental studies literature.

[1] This is a substantially revised version of a paper titled "Beyond ivory towers, hidden beliefs and turf battles: conceptualising and practising interdisciplinarity in research on natural resource management" presented at a workshop on "Conversations Between Economists and Anthropologists II: Approaches to Understanding Collective Action on the Commons" held at Goa, 1st-3rd August 2003. The paper has benefited significantly from discussions in the workshop, for which I am grateful to the organisers and the participants. Special thanks to Richard Norgaard, Esha Shah and an anonymous referee for their insightful comments, and to Esha also for supplying me with a set of readings on interdisciplinarity that I found invaluable.

[2] In this paper, I use the term 'natural scientists' as shorthand for natural scientists (e.g., ecologists or biologists), physical scientists (e.g., soil scientists, atmospheric scientists or environmental chemists) and engineers of all kinds. Similarly, I include the humanities under the rubric of the 'social sciences'. By calling for a three-way conversation, I assume that the 'natural sciences' can be treated as a relatively homogeneous block compared to the social sciences.

[3] Embedded here is a question of 'desirable for whom'. I shall argue later on that interdisciplinarity is desirable (and its quality or adequacy can be judged) only where there is an expressed societal need to address a particular pressing problem.

2. Barriers to 'interdisciplinarity'

At the outset, I would like to point out that the terms "discipline" and "interdisciplinarity" are slippery ones that can themselves become an obstacle to understanding the issue at hand. Conventionally, 'a discipline is a body of knowledge or branch of learning characterised by intersubjectively accepted content and methods' (Kockelmans, 1979). When the content (or subject matter) is distinctly different, the separation seems 'obvious'. Thus, the broad grouping of learning into the disciplinary 'blocks' of social and natural sciences seems to correspond well with our intuitive sense that understanding how human beings behave is a distinctly different exercise from trying to understand how the non-human world functions. It is usually assumed that this major difference in subject matter is correlated with (and perhaps causative of) differences in epistemology and method, notions of rigour and adequacy of proof, and so on. Hence C P Snow's famous description of these two blocks as 'two cultures' that do not, and almost cannot, communicate with each other.

Within these two blocks, however, disciplinary boundaries do not mean the same thing. In the natural sciences, it is true that the differences in subject matter are getting increasingly blurred—e.g., where does 'physical' end and 'biological' begin? However, there is an underlying belief that disciplines represent different (complementary) areas of enquiry. In the social sciences, on the other hand, the logic behind disciplinary boundaries seems much more confusing.[4] We were told that anthropologists study culture, economists study behaviour in the market, and political scientists study behaviour in the political arena (such as electoral politics). But increasingly, economists are studying all of these phenomena, and anthropologists have expanded far beyond the study of exotic tribes to examine behaviour in all spheres of contemporary society. Methodological differences are also getting blurred, with political scientists using game theory extensively and sociologists becoming highly quantitative. On the other hand, the sub-discipline of Marxist economics would seem much further away from mainstream (neoclassical) economics than the approach of many political scientists and even some anthropologists! Perhaps the time has come to "forget disciplines, think scientific communities" (Lélé and Norgaard, 2005). But given that most of us are brought up with the disciplinary labels, I will continue to use the major disciplinary categories or blocks (the "natural" and the "social" sciences) as a starting point, identifying the inconsistencies and subtleties as I go along. Similarly, I shall use the label of "economics" and "anthropology" loosely, sometimes as representative of the "quantitative" and the "interpretive" social sciences respectively and sometimes as representing alternative explanations of human behaviour that economics and non-economics social sciences offer.

The terms 'interdisciplinarity', 'multi-disciplinarity' and 'trans-disciplinarity' are also a source of confusion (Kockelmans, 1979). Broadly speaking, multi-disciplinarity is recognised as the simply the juxtaposition of the findings of different disciplines, without any attempt to reconcile or merge them. Interdisciplinarity and trans-disciplinarity are seen as 'stronger' efforts to link or merge existing frameworks or develop entirely new ones. Note, however, that 'simple juxtaposition' might seem adequate in some contexts (when the subject matters are complementary) but not in others (when the subject matter is the same). For the sake of brevity, I shall use the term

[4] As Jasanoff (2002,Jasanoff) points out, "disciplines" are not natural categories. They have histories and their names, content, and boundaries develop and change. In a hilarious, if apocryphal, illustration of this point, she quotes Jose Luis Borges' mention of a "certain Chinese encyclopedia" in which it is written that "animals are divided into: (a) belonging to the Emperor, (b) embalmed, (c) tame, (d) sucking pigs, (e) sirens, (f) fabulous (g) stray dogs, (h) included in the present classification, (i) frenzied, (j) innumerable, (k) drawn with a very fine camelhair brush, (l) et cetera, (m) having just broken the water pitcher, (n) that from a long way off look like flies! Without going to this extreme, the Gulbenkian Commission on the Restructuring of the Social Sciences (1996,Gulbenkian) has argued that the disciplinary separations in the humanities and social sciences have always been idiosyncratic and reflect a splintering that has been detrimental to their development.

'interdisciplinarity' as shorthand for all three versions--multi-, inter- and trans-disciplinarity—through most of this paper, and delve into the subtle differences only towards the end.

Moving from the semantic to the substantive,[5] I propose four broad types of barriers to interdisciplinarity. First, there is the problem of values being embedded in all types of inquiry and at all stages: in the choice of questions, theoretical positions, variables, and style of research. But certainly most natural scientists, and even many social ones, are loath to acknowledge the presence of value judgments in their work. Furthermore, in the context of contentious social issues such as 'sustainability', 'environmental degradation' or 'sustainable development', decision makers call on scientists to provide "objective" advice, making such acknowledgment even more difficult. Consequently, scientists may "talk past each other" in ways that no amount of theoretical or methodological flexibility can resolve.

Second, researchers in different disciplines or sub-disciplines may study the same phenomenon but differ in their theories or explanatory models (and underlying assumptions). In the case of complex phenomena, it is not easy to prove the superiority of one theory over another in a particular case. Maintaining allegiance to one's school of thought may come to seem more important than openly exploring which explanation seems to work better in a particular context. This seems to be the case particularly within the social sciences, but it is also true for ecology.[6] On the other hand, sciences that have developed at the borders of the social–natural divide (e.g., agronomy in the natural sciences or agricultural economics in the social sciences) are required to make some assumptions about the processes that intrude from the other side (e.g., the decision-making process of the farmer or the nature of agro-ecosystems, respectively). These disciplinary assumptions about the "other" half of the system are usually simplistic, but not easily abandoned, creating a barrier even when the subject matter is on the face of it quite distinct and complementary.

The third type of barrier is the one that has been most emphasized in the literature on interdisciplinarity: the differences in epistemology and hence in specific methods, notions of adequate proof, and so on. As Bauer puts it, "Scientists (and engineers) believe implicitly in certain absolute truths, and further believe that given enough time and effort the ultimate truth can be found, whereas for some philosophers, sociologists and other [social scientists] there is no absolutely determinable truth" (Bauer, 1990). These differences may exist even between disciplines within each disciplinary block. Certainly a major difference between the approaches of anthropologists and economists is their differing perception about the objective versus subjective nature of knowledge and whether it is the context-specific or generalisable. Within the natural sciences, although positivism generally reigns supreme, scientists studying complex processes such as those in ecology have grappled with the question of how much is really knowable through reductionist models and experimentation (see, e.g., Botkin, 1992).

Finally, the manner in which society interacts with and organizes academia influences the production of interdisciplinary research. As Schoenberger (2001) and others have pointed out, the relative importance or 'validity' of a direction of enquiry or approach is not determined simply by some 'objective' recognition by academics of its ability to 'generate more valid knowledge than another'. Forces at work within the larger society outside academia shape the perceived importance of a particular discipline or of a particular kind of interdisciplinary crossing. This

[5] While acknowledging the link between them.

[6] The level of complexity of ecological phenomena, and hence the under-determinacy of the science, resembles the situation in the social sciences. "Ecology ... is more empirically and theoretically underdetermined than many other sciences....[it is characterized by a] bottom-up, case-study approach in ecological method, rather than a top-down, hypothetical-deductive approach...in part, because of the uniqueness and historical character of many ecological phenomena" (Shrader-Frechette and McCoy, 1993, p.109).

generates differences in attention to (and resources commanded by) different disciplines[7] and consequently conditions behavioural patterns, such as arrogance or defensiveness, amongst their practitioners. Society also influences the institutional arrangements within academia that create incentives (or otherwise) for interdisciplinary knowledge production.

The differences in normative concerns, models, methods and societal recognition are obviously not randomly distributed but significantly (though not entirely) correlated with each other. Values and models co-evolve (Lélé and Norgaard, 1996), and certain models are only amenable to certain methods (and vice-versa). And academia and society at large seem to accord greater respect to certain ways of doing science over others: currently, quantitative approaches seem to hold sway. Interdisciplinary conversations and crossings will generally have to grapple with a package of barriers simultaneously.

I shall now discuss what form and importance the different barriers take in the context of each of the sides of the triangular conversation around CPRs. Given, however, that the issues that arise in natural scientists conversing with economists overlap substantially with those that arise in their conversations with anthropologists, I shall divide the discussion into two major sections, viz., the problem of linking the natural sciences to the social sciences or to particular streams within them, and then the question of linking or reconciling the streams within the social sciences.

3. Linking the natural to the social

The main difficulties in natural scientists conversing with social scientists appear to revolve around the refusal of natural scientists to recognise the value-laden nature of applied science and the hidden assumptions that each disciplinary block carries about the other area. Issues of methodology are relatively easily worked out (partly through selective linkages), although practical difficulties in linking the two enquiries remain. Societal biases towards the natural sciences are, however, strong, especially in developing countries, even as the need for social science input in CPR management is being increasingly recognised in policy circles.

3.1 The value-laden nature of science

The belief in value-neutrality is strongest and most pervasive in the natural sciences (including engineering). Natural scientists 'essentialise' certain dimensions of natural phenomena and equate the preservation of these dimensions as 'good' CPR (or environmental) management, without realising that the choice is actually a social one. Take the example of tropical forest management. Tropical forests contribute a variety of benefits, but these benefits flow to different groups in society. Some of the benefits, such as fuelwood, fodder, leaf manure, timber, and minor produce, may flow to communities living close to the forests, while watershed services flow primarily to those living in the plains downstream, and carbon sequestration benefits accrue to the entire global community. Different ways of managing forests yield different mixes of benefits. Dense, undisturbed forests yield high levels of biodiversity and watershed services, but little by way of tangible products. Carefully managed, lopped forests might yield high levels of fuelwood, fodder, and leaf manure, but reduced levels of biodiversity and medium levels of watershed benefits. Monocultural timber plantations, on the other hand, would maximize timber production at the expense of most other benefits. Some of the benefits generated by forests, such as fodder or fuel, may also be obtained to some extent from non-forest land uses, such as coffee plantations or croplands. Thus, prioritizing forests over other land uses, and certain forest management systems over others, means valuing certain benefits and certain beneficiaries over

[7] Schoenberger (2001) calls this 'the social relations of knowledge production', and she elucidates this concept with much greater sophistication than I have done here.

others. When one decides which mix of benefits is best, one is deciding how the diverse needs of different sections of society and of present versus future generations should be valued. This decision is essentially a social or political one. Science can illuminate this social debate by generating clearer estimates of the trade-offs and complementarities between different benefits, but science cannot 'objectively' settle the debate.[8]

Unfortunately, debates in forestry have often been fruitless because of the refusal of the participants to recognise this point. The debates are really about what should be the goal of forest management, not about which method of forest management will or will not achieve a particular goal. For instance, in the Western Ghats region of India, after the British take-over of the forests, there was a major debate as to the appropriateness of the local practice of lopping or pruning forest trees for obtaining leaf manure and fuelwood. British foresters were up in arms against this practice:

> *The kind of [soppinabetta][9] that meets one at every turn …consists of open forest of mutilated stems from which the branches have been lopped close to the trunk, on which fresh shoots are allowed to remain for [a few years]…The induration, impoverishment and degradation of soil are necessary consequences…such land must become utterly barren (MacGregor, 1894)*

In contrast, a British agricultural chemist appointed to enquire into the state of Indian agriculture noted the same practice with approval:

> *I saw cultivators lopping around their own fields…Nor were the trees ruthlessly destroyed…some trees are most usefully grown for pollarding (Voelcker, 1897).*

Clearly, what is 'good silviculture' in the eyes of the agriculturally-oriented expert is not so in the eyes of the forester.

The forester MacGregor had predicted that "ruin and desolation will be the outcome of the present state of things". Foresters and ecologists in post-independence India seemed to concur (Gadgil, 1987a; Reddy *et al.*, 1986). However, subsequent rigorous field studies showed that even a century after these dire predictions, the extent of barren land was limited and the productivity of the intensively lopped forests was much higher than estimated earlier. Often (though not always) it was sufficient to meet the harvesting pressures. Where forest was in the form of pure grasslands, it was more often than not the result of conscious manipulation by farmers interested in promoting fodder growth than the result of poor management (Lélé, 1994;2000). Rather than being a scientific judgment about what harvesting and management practices are sustainable, the foresters' criticisms seem to be driven by their underlying value judgment that such intensive or different use of forests was inherently undesirable.

But natural scientists are generally uncomfortable with the idea that "sustainable resource management" or more generally "environmentally sound development" is not a self-evident, value-neutral concept. They have attempted to hang on to the cloak of value neutrality in different ways. For instance, in the context of ecosystems, some scientists argue that sustaining biodiversity automatically sustains all other products and services. Or that concepts such as 'ecological integrity' or 'natural capital' are somehow fundamental and so do not involve value judgements. Or that one can somehow 'objectively aggregate' the subjective notions of environmental soundness into a Green GDP or a Global Sustainability Index. In this, they have

[8] Note that judgments about what is socially valuable (what kind of forest should be sustained over what period of time) are almost inextricably linked to the subjective choices of the dependent variables, the likely set of independent variables, the functional form of the model, and the scale of analysis. That these are value-loaded choices becomes clear when one thinks of how different ecologists might respond to the question, "What constitutes a good forest?" The chances are that community ecologists might define this as a highly diverse forest, whereas energetics modelers might define it as a highly productive forest.

[9] *Soppinabetta* is the Kannada term for forests over which farmers are given rights for harvesting leaf-manure, fuelwood, etc.

been abetted by policy-makers, who also prefer to cloak their decisions in the armour of scientific-ness so as to escape facing awkward questions about the values they are espousing. But it can be easily shown that such sleight of hand does not get rid of value judgements. Each of these concepts is relevant only with respect to a particular choice of what is ultimately of value, or particular notions of how disparate values within society should be aggregated (see Lélé and Norgaard, 1996, for a detailed discussion; also Rykiel, 2001).

When one attempts to link the natural to the social (either individually or collectively), such hidden value judgments can cause serious problems. If social scientists are insensitive to the value judgements embedded in the natural science, they may take the natural scientists' assessment at face value, as an objective assessment of the quality of resource management, and end up going astray in the analysis of social cause of this quality. For instance, in the case of the heavily used forests in the Western Ghats, Nadkarni *et al.* (1989) assumed that the forests were degraded (à la MacGregor) and then struggled to explain why these individually controlled forests suffered a tragedy that is supposed to be restricted to the "commons" (Lélé, 2000).

On the other hand, when social scientists do point out the possible ways in which natural science may be value laden, natural scientists are likely to become upset and defensive. For instance, in a programme aimed at exposing social scientists to basic hydrology that I co-organized,[10] the hydrology expert introduced the concept of "groundwater potential" and "sustainable utilization." The latter was defined as the situation in which groundwater extraction does not exceed the rate of groundwater recharge. At this point, an economist pointed out that this definition was debatable, because if communities living in the upper part of the watershed (typically where most of the rain falls and recharge occurs) were to extract the entire recharge, it would leave no water for downstream communities or for base flow in the river. The hydrologist took quite some time to understand the empirical point being made and, even then, insisted that the official definition of sustainable utilization was "correct."

3.2 Hidden assumptions about the other

Prima facie, one might not expect to encounter a clash of models between natural and social scientists, because their models are (supposed to be) about distinct parts of reality. But research on CPRs cannot be *purely* natural or *purely* social. Natural scientists have to characterise human intervention in biophysical processes before attempting to model its impact. Social scientists have to make assumptions about how natural processes are to be represented in the analysis of social cause and effect. Out of some combination of ignorance, convenience and arrogance, the tendency has been to represent the 'other' part of reality by drawing upon the set of assumptions that have become embedded in their own traditions, rather than upon cutting edge research from the 'other'.

Natural scientists have often been the first to point out environmental problems of enormous social consequence. Naturally, they participate in, and often lead, societal efforts to address these problems. Charged with providing policy recommendations, they have to make judgments about how society works. They do not have adequate training to do this, but they are perhaps emboldened to do so by their position and are likely to adopt simplistic models of social dynamics. As a recent article in Nature put it, "Few of us know much about the dynamics of the cosmos, but we all know plenty about human nature—or at least we think we do" (Anonymous, 2005, p.1003). So some natural scientists have applied models of biological carrying capacity to human systems (e.g., Pandey and Singh, 1984; Kessler, 1994), even though, unlike animals, human beings constantly innovate, respond to resource scarcity by varying their levels of

[10] "Hydrology for Social Scientists", a cross-disciplinary exposure programme organized on behalf of the Indian Society for Ecological Economics in December 2001 in Bhopal.

consumption, and import materials across most system boundaries . Similarly, the concept of "demand-supply gap" has been repeatedly used in the literature on fuelwood scarcity, wherein "demand" is calculated on the basis of "per capita requirement times the number of people" and the per capita requirement is a constant, not dependent upon the price of fuelwood or the cost of its collection. This ignores a basic economic maxim that, at equilibrium, supply must generally equal demand and that demand cannot generally be estimated without knowing what the price is (see Masera, 1994).

The above may be seen as examples of explicit disciplinary crossings that failed, rather than of hidden assumptions by natural scientists about the other. However, there are several examples of models that more implicitly "biologize" the causal analysis. For example, analyses of rangeland degradation in the Sahel have tended to focus exclusively on stocking rates, ignoring the major influence of rainfall and the complex relationship between grazing and rangeland productivity. Consequently, degradation is seen simply as resulting from the imbalance between livestock population and range resources. And the growth of livestock populations is treated solely as a biological process, controlled by herd demography and range productivity. A host of predator-prey models were developed and used to question the ecological sustainability of Sahelian pastoral systems, with tragic consequences for pastoral communities (for a detailed exposition, see Turner, 1993). The same is the case with studies of deforestation. When forest ecologists use simplistic production-harvest comparisons to establish the fact of deforestation, they are implicitly highlighting the quantity consumed and quickly inferring that the size of the human population is the problem (e.g., Singh *et al.*, 1984), rather than (say) the method or timing or form of extraction and therefore the question of forest rights. But as in the case of the Sahelian rangelands, where it was the timing of grazing that was a crucial factor (Turner, 1999), qualitative factors are often as or more significant than quantitative measures of extraction when it comes to forest degradation. In the Western Ghats, for instance, individual and exclusive forest rights, social status and economic purchasing power combine to enable elite farmers to reduce their degrading pressure through a combination of tactics that include adopting gobar-gas technology, stall-feeding cross-breed cattle and investing in fencing. On the other hand, middle peasants and landless households are unable to make these transitions and appear to cause more degradation (Lélé, 1993a;2000). Simple technical solutions advocated by ecologists (e.g., Gadgil, 1987b) could not and did not work.

Belittling or oversimplifying the other is, however, by no means the preserve of the natural sciences alone. Many social science theories and their adherents have tended to ignore or underplay the constraints imposed by natural resources and processes on human actions. Even today, many economists continue to use arguments based on economic models that assume an infinite substitutability among resources through technological change (e.g., Lomborg, 2001). For others, such as hard-line Marxists, technology matters but is entirely determined by social structure, so it is not necessary to understand the relationship between technologies and environmental systems.

A more specific case is that of the models of renewable resource dynamics being used in resource economics. Several decades ago, economists adopted the logistic growth model to depict the relationship between the standing stock and the natural rate of growth of a resource. Though very convenient to analyse, this model (and its variants) seems applicable to only certain kinds of resources under very special circumstances, and patently inapplicable to many other resource use situations, such as grazing in annual grasslands or leaflitter extraction from forests where changes in standing stock of the biomass that is being extracted do not directly affect future production of that biomass (Lélé, 1993b). While there is now some recognition among economists of the complex relationship between forest stock and the flow of ecosystem services of different kinds, in the routine practice of economic modelling (such as in adjusting GDP estimates for environmental degradation) they tend to revert back to simple stock-based indicators.

3.3 Epistemologies and methods: practical issues

Much has been said about the epistemological differences between the two disciplinary blocks (the 'two cultures' of C P Snow). Most natural scientists certainly continue to perceive the social sciences as being 'qualitative' and hence 'less rigorous'. As the Gulbenkian Commission's report puts it, during the 19th century, the disciplinarization and professionalization of knowledge was accompanied by its division into two domains. This division "took on the flavour of a hierarchy, at least in the eyes of natural scientists - knowledge that was certain (science) versus knowledge that was imagined, even imaginary (what was not science)" (Gulbenkian Commission on the Restructuring of the Social Sciences, 1996, p.5).

But amongst the social sciences, economics (or at least its mainstream) took it upon itself to become as naturalistic (i.e., quantitative and mathematical) as possible. Consequently, natural scientists have shown a greater willingness to collaborate with economists than with other social scientists. And yet, other approaches such as political ecology and ecological anthropology are flourishing, suggesting that individuals have made the necessary crossings, giving the lie to the seriousness of the qual-quant divide. Sufficient exposure to the 'other' might be enough to clear the misconceptions that give rise to this particular barrier.

I believe that more than the misconceived qual-quant divide, it may be practical issues in combining natural and social research that inhibit cross-disciplinary work. Understanding environmental change caused by human actions (e.g., the effect of deforestation on hydrology) requires sampling across different intensities of human-induced environmental changes (e.g., watersheds with different levels of deforestation), keeping other variables (e.g., rainfall and soils) constant. But to understand how these environmental changes affect human communities and, more important, what factors influence human response to environmental change, researchers need samples wherein the extent of environmental change is similar (e.g., similarly deforested watersheds) and only one social factor varies (e.g., the strength of collective-action institutions). Finding adequate samples of such situations in the real world is virtually impossible (Kiran Kumar *et al.*, 2006), and studying even limited samples may require enormous resources. Moreover, ecological or biophysical data collection often requires more equipment and human resources than the collection of socio-economic data. At least in my experience, estimating the effects of grazing practices on grass production or of fuelwood extraction practices on forest regeneration or measuring streamflow and associated hydro-meteorological parameters was much more time and resource consuming than conducting even large sample household surveys. All of this can lead to tensions within interdisciplinary projects about which questions to prioritize and how to practically make the linkages.

Using 'nested' designs, where the biophysical research is conducted in a carefully chosen subset of socio-economic units (e.g., individual farm plots or forest plots with a larger sample of households or villages) or with careful simulation of typical resource management practices (e.g., clipping experiments to simulate the effects of grazing on grassland productivity—see Turner, 1992) is one approach that might work in some situations. Recent advances in remote sensing and geographical information system (GIS) techniques have also opened up the possibility of relatively rapid assessment of ecological conditions across a large number of socio-economic units (Liverman *et al.*, 1998), although the limitations of these techniques also need to be kept in mind (Lélé *et al.*, 1998; Lélé, 2001).

3.4 Socialisation and organization

There are significant differences in the manner in which society treats the two disciplinary blocks. These differences are reflected in the incentives and support provided, attention paid to, and hence attitudes cultivated. In most countries, the natural science-social science divide is reinforced early on. India is perhaps an extreme case, where students are forced to choose between "science" and "arts" as early as the 11th year of schooling and where exposure to the

arts, humanities and social sciences in the undergraduate science or engineering degree programmes is minimal and the undergraduate courses in the social sciences completely bereft of the "natural". But I believe this pattern is true in most developing countries that were ruled by the British. For instance, at an international conference on biomass energy resources which was attended mostly by natural scientists and engineers, I noticed that those from south Asia and Africa tended not to engage with or even see the socio-political dimensions of various issues, whereas those from Latin America were more comfortable and willing to do so. The liberal arts approach to education in the United States may be at the other end of the spectrum, but the divide is present even there.

More than just lack of exposure to the 'other', it is the clear signals of superiority or inferiority' communicated by society to the practitioners (and by them to their students) that are a problem. Many societies, especially Asian ones, are constantly telling students that 'science' is superior to 'arts'.[11] This signal is reinforced at the undergraduate stage by the half-hearted manner in which the social sciences are taught in most professional courses in these countries. Naturally, the social sciences are seen as irrelevant, boring and non-rigorous. Conversely, the social scientists, because they supposedly were not good enough to get into the 'science stream', are often in awe of the natural sciences. At least two senior Indian social scientists have told me that they believe that a person with an undergraduate in the natural sciences can still become a social scientist, but not vice versa.[12] Part of this aura of superiority certainly stems from the general myth that natural sciences are quantitative and hence more rigorous. But part of the aura of the natural sciences stems from their much greater capacity to predict phenomena accurately and to increasingly manipulate these phenomena with enormous dexterity to generate benefits for humankind, at least in the short run. That social processes are enormously more complex and unpredictable than biophysical ones is conveniently forgotten.

The belief of the superiority of the natural scientists is so deep-rooted that whenever social problems have the slightest technical dimension, politicians have traditionally called on only technicians—the natural scientists—to help solve them. Until the latter half of the 20th century in the developed world, and more recently in the developing world, most governmental committees on natural resource management were constituted solely of natural scientists and engineers. The Intergovernmental Panel on Climate Change was initiated by (and its leadership is dominated by) natural scientists, even though the origins and impacts of climate change are ultimately highly social. One may attribute part of this to simply the pioneering role played by natural scientists in identifying such crises. Certainly, recent years have seen some attempts by policy-makers to pay more attention to the social dimension of environmental problems. But even as late as 2003, when the Government of India set up a National Forest Commission, it was headed by a retired judge and included activists (both social and wildlife), an eminent botanist, two foresters and a bureaucrat, but no social scientist (economist or non-economist). Moreover, the biases inbuilt into the Indian educational system do not seem to be changing at all, and the increasing importance being given to mathematics and computers in the US schools does not bode well for the future of liberal arts education.

4. Economists and anthropologists—the bigger divide

The differences between economists and anthropologists have been characterised by some as differences between the quantitative and the interpretive social sciences, and hence as arising

[11] The message may be meant to convey only that "a science education is more likely to give you a secure job than an arts education" but the resulting bias is unfortunately more sweeping.

[12] Again, this may not be a universal phenomenon but rather specific to countries where, as mentioned above, undergraduate programmes are more narrowly conceived and provide less exposure to the interpretive social sciences and humanities.

from this difference in epistemology and method. This suggests that a merging of methods will provide fuller insights into what is essentially the 'same problem' being investigated—poverty (as in Conversations-I: (Bardhan, 1989)) or CPR degradation (as in this book). But as I have argued at the outset, disciplinary differences are multi-dimensional and interrelated, and simple labels are inadequate to capture them uniquely. Disciplines, sub-disciplines and schools within them conceive or characterise problems differently and explain them in different ways. These implicit differences in normative concerns and explicit disagreements over models of human behaviour seem to be bigger barriers to interdisciplinary conversations within the social sciences. A streak of hegemonism similar to the hidden assumptions that natural scientists have about social phenomena makes these differences even more difficult to resolve.

4.1 Differing normative concerns

One would expect social scientists to be quite aware of idea that all knowledge of reality (and therefore nature) is socially constructed and therefore value-loaded. But even within the social sciences, the recognition of how one's science is 'value-loaded' varies across disciplines. Mainstream economists are most prone to holding illusions of value-neutrality. For instance, mainstream welfare economists aggregate costs and benefits imposed by a particular policy change on different members or sections of society to come up with a measure of net change in aggregate social welfare. In the textbooks on welfare economics, it is admitted that such aggregation actually requires 'prior agreement on the social welfare function' so as to determine the relative weights to be given to the impacts felt by different members or sections (which is a social and political process). It is accepted that market prices will not reflect marginal social values if (for instance) income is not evenly distributed (Broadway and Bruce, 1984, p.292). Classic texts on applied welfare economics such as Dasgupta *et al*. (1972) suggest that while deriving and using different relative weights for each individual would be very difficult, common weights can be assigned to groups of individuals with similar incomes, and the effects of different weighting schemes can be explicated. In practice, however, virtually all valuation studies and benefit-cost analyses use market prices for the aggregation exercise without any differences in the weights assigned to the rich and the poor. No attempt is made in these studies to point out that the choice of weights is arbitrary, or to do a sensitivity analysis by changing the weights (see Howarth, 2001, for an exception). Yet, most practising economists insist that their benefit-cost analysis provides an 'objective' basis for decision-making, when in fact decisions based upon such benefit-cost analysis reflect a one-rupee-one-vote approach.[13] The pervasive discourse about "getting prices right" is another illustration. The belief that there is one right price contradicts basic economic theory, because different distributions of rights, or income, result in different combinations of efficient market prices.

Other social scientists are less likely to insist that their position is value neutral, but they are nonetheless rarely explicit about what values they espouse, and thus end up talking past each other. This problem is likely to be more acute in a discussion on CPRs than on, say, poverty alleviation (the subject of Conversations-I) because CPRs are an inherently more multi-dimensional and hence more contestable phenomenon. In a detailed review of the literature on CPRs, Menon (1999) has pointed out how different streams in this literature talk past each other because their underlying normative concerns are different: the collective action stream focuses on efficiency improvements in resource management (e.g., Ostrom, 1990), the environmentalist

[13] The textbook by Broadway and Bruce blandly states that "much of the literature in cost-benefit analysis, and most of the issues we wish to deal with here, are involved with using 'efficiency' criteria for project evaluation. Consequently, we shall assume for the purposes of this chapter that the economy can be treated as if all persons are identical, so that no distributive weights are needed"! Others argue that if the aggregate benefit minus cost of a particular policy or project is positive (when measured in the conventional manner) then, by the Hicks-Kaldor compensation criterion, that policy is clearly Pareto-improving and hence socially desirable. This ignores the fact that there could be policies that are not Pareto-improving (as they involve making somebody worse off) but that could be considered socially more desirable, i.e., Pareto optimality may not be the preferred criterion for decision-making.

stream focuses on 'ecological prudence' or sustainability (e.g., Gadgil and Guha, 1992), and the poverty stream focuses on the distributive impacts, on impacts of CPR degradation on the poor (e.g., Jodha, 1986). One can detect a reasonable correlation between these three streams and their disciplinary/sub-disciplinary roots: the collective action stream being linked to the rational-choice folks in political science, the environmentalist approach having strong links with the natural sciences, and the poverty focus being characteristic of old-school economists and sociologists.

Of course, this correlation is by no means one hundred percent. Some differences are sub-disciplinary and others are at the level of individuals. Kanbur (2002) argues that the perception of neoclassical economists being unconcerned about distributional consequences is not correct. He says it is just that they strongly believe that distributive issues are best achieved through 'income transfers' by the state rather than by choosing 'inefficient' projects. To me, this is still evidence of the weak commitment of neoclassical economists to distributive justice and an indication of how values correlate with models, because income transfers do not question the status quo on property rights.

In any case, the fundamental problem remains: that much of academic debate on the commons starts off on the wrong foot by not explicating what each participant's normative concerns and priorities are, and an equal failure to recognise how their individual models make it difficult to accommodate other normative concerns. As Menon and Lele (2003) point out, this failure to clarify the normative concerns in the beginning and also to actually measure these ultimate variables of interest (rather than some proxy such as 'institutional persistence') has led to much confusion in the debate on which institutional arrangements are likely to be most 'successful' in CPR management.

4.2 Models: Explicit disagreements and moving targets

All social science disciplines are ultimately attempting to understand the same phenomenon, viz., human behaviour. At the cost of some simplification, one might say that each social science discipline makes different assumptions about the key driver(s) of human behaviour: e.g., some believe it is an eternal quest for income or profit maximisation, others believe it is a quest for power, while yet others believe behaviour is highly conditioned by cultural norms and value systems that differ across communities. These basic assumptions are *prima facie* mutually incompatible, and disagreements within the social sciences are therefore extremely deep-rooted. Note that one is using the term 'disciplines' very loosely here. The differences in causal models may correlate better with sub-disciplines, rather than disciplines. That is, there are 'materialists' within economics as well as sociology, and there may be economists who allow for the role of cultural factors.

Research on CPRs or environmental issues in general clearly shows these fundamental differences in causal explanations, whether one correlates them to disciplinary or sub-disciplinary categories. Neo-classical economists insist that the problem lies in missing markets or improper setting of prices of resources and pollutants (Repetto, 1986; Pearce, 1998). Political economists focus on the fact that different economic classes have differential access to natural resources and that the material consumption and pollution by the powerful classes comes at the cost of the less powerful (e.g., Agarwal, 1985; Blaikie, 1985). Institutionalists explain resource degradation in terms of the failure of institutions to solve free-rider problems (Hanna and Munasinghe, 1995). Eco-feminists have argued that environmental degradation is related to the domination of women by men (Mies and Shiva, 1993), while ecological anthropologists have argued that it is related to how human beings perceive their relationship with nature (Merchant, 1989).[14] In the "Conversations II" workshop also, several anthropologists insisted that human

[14] Given the vastness of this literature, the references given in this paragraph are purely indicative, not comprehensive.

behaviour is driven largely by a cultural politics, not a material one. Similarly, David Mosses's paper in this book is an attempt to sift through competing explanations for the presence and absence of functioning community institutions for minor irrigation tank management in Tamil Nadu, south India. He rejects the explanation of institutional economics, viz., that the institutions exist where the material benefit-cost calculus of collective action is positive, by showing how an explanation based on tanks as a symbol of power in a caste-based society has greater explanatory power, explaining the failure of institutions even where the material benefit-cost calculus is favourable.

In such a situation, what does interdisciplinarity mean? That depends upon how one sees the relationship between these explanatory perspectives and reality. One approach would be to think of each of these as partial explanations, i.e., explaining part of the problem. This would mean that the apparently competing explanations can co-exist, and even be reconciled as part of some kind of meta-theory of human behaviour. Indeed, it has been argued that the social sciences *were* in fact one single holistic science enquiring into "the nature and varieties of humankind" till the mid-19th century when this enquiry "split into separate and [unequal] specialities and disciplines". [It was at this point that the] "severance of social relations from the economic, political and ideological contexts in which they are embedded and which they activate was accompanied by the assignment of the economic and political aspects of human life to separate disciplines" (Wolf, 1982, quoted in Harriss, 2002). It should therefore be possible, in theory, to restore this holism—an ambition that fields like 'development studies' and perhaps 'gender studies' (Jackson, 2002) seem to be based upon.

Certainly an acknowledgement that one's explanation may be partial would be a good beginning towards better explanations. But merging the entire set of explanations seems rather difficult. Simply running multiple regressions with all these variables on large datasets, which is the methodological response of economists and rational choice theorists, seems inadequate because the variables do not simply operate at the same scale or are linked to each other through more complex chains or do not seem to emerge from any linearizable model. Nevertheless, as Mosse's paper suggests, it might be possible to collect data at different scales to test different explanations and the relations between them. But this would require some kind of a 'meta-theoretical procedure' for choosing between explanations in a specific context. To use the example of Mosse's paper again, one should not insist that caste-based social relations will explain the presence or absence of collective action institutions around CPRs in every context. For instance, in the Himalayas where caste-based conflict is known to be much less of an issue (though not entirely absent) and the material conditions favouring collective action much stronger, one would have to allow for the possibility that caste-based social relations do not turn out to be very significant determinants of the presence of collective action, although they might yet influence the distribution of benefits. This would clearly require extensive training in or familiarity with different social science theories, without absorption of the dogmas of each so that one is open to alternative explanations to begin with.

Even if the goal of holistic, multi-dimensional explanations seems far-fetched at present, the importance (and difficulty) of getting individual disciplines or models to state their assumptions clearly and accept their limits should not be underestimated. Indeed, I believe that the difficulty in interdisciplinarity within the social sciences lies not so much in the fact that different disciplines or sub-disciplines have competing models for the same phenomenon, but that at least some disciplines refuse to stick to a clear causal model which can be the basis for a meaningful debate. The major culprit here is the sub-discipline of neo-classical economics. In its typical hegemonic style, it claims to have long ago abandoned the model of human beings as strictly 'profit-maximising' or 'consumption-maximising' and moved to a 'utility maximising' framework, which creates room for incorporating all other models of human behaviour. This claim has only limited validity. First, even though the utility function approach allows for (say) altruism to be part of the person's rationale, other assumptions about what constitutes 'rational' behaviour (e.g., that people maximise not satisfice, a la Herbert Simon) as well as the tendency

to equate rigour with mathematical models limit the capacity of economics to actually represent diverse behavioural situations. Second, in practice, most analysts eventually write the utility function in terms of consumption or imputed income or some other simple material benefit. I would argue that economics as a theory of human behaviour has some explanatory power only when it is cast in such concrete terms; once material considerations are replaced with 'utility', it is impossible to predict human behaviour since utility is unmeasurable and could mean different things to different individuals. It would therefore be easier to hold a meaningful conversation if economists were to state their causal model at the outset, rather than to act as if any causal model is welcome but then impose a particular method of data collection and hypothesis testing that might rule out most non-material explanations. This is also the essence of Harriss's critique of the distortion of the concept of social capital through economistic analysis (Harriss, 2002).

4.3 Epistemology and method

The above is not to suggest that the epistemological and methodological divide between the interpretive and the quantitative social sciences (what Kanbur calls the 'qual-quant' divide—see Kanbur, 2001) has been bridged. I shall, however, not dwell on it here. One reason is that it has been more exhaustively treated by the other papers in this book and by other elsewhere (e.g., Kanbur, 2002). But another reason also is that the focus on the qual-quant divide seems to have distracted us from the more fundamental questions of rigour (Harriss, 2002), viz., the realism of the assumptions that are necessarily made when theory and data are forced to be articulated through, and hence 'reduced' by, the quantitative method of economics. As Kaushik Basu said in the Conversations II workshop, economists tend to ignore phenomena or processes that cannot be put into a mathematical form. Unless this rigidity in neoclassical economics is weakened, one cannot hope for a truly interdisciplinary exploration. What will remain then is the hegemonistic approach of economists, where anthropological methods of *data collection* alone are used to somehow 'thicken' the explanations of economic models (Raghavendra Rao's paper in this book).

Thus, promoting genuine interdisciplinarity within the social sciences will require a methodological (and theoretical) pluralism that ecological economists have been arguing for (Norgaard, 1989) and neoclassical economists have been consistently opposing (hence the rejection of ecological economics hard-nosed 'environmental economists', especially in the USA). This applies to the hard-core political ecologists or others as well—see e.g., Vayda (1996).

4.4 Academic organization and social standing

One would have expected that, even if natural science undergraduates do not get exposed to the social sciences and vice-versa, there would be significant exposure to disciplines within the same block. Unfortunately, the situation within the social sciences does not seem to be much better—cross-disciplinary exposure, especially across the econ-anthro divide, is limited and the hostility palpable (Karanth, 2002; Guha, 2002). Moreover, as in the case of the natural-social divide, policy-makers seems to value economists more than anthropologists, especially in developing countries, if one goes by the proportion of funds provided for the two categories of social sciences.[15] And the clout of economists, or neoclassical economists to be precise, in the international donor community needs no highlighting, notwithstanding the inclusion of some anthropologists and sociologists into the World Bank. It would be hard to estimate how much of this difference in the social standing of different social science disciplines and sub-disciplines is due to the qual-quant divide and the layperson's belief that quantitative is more rigorous, and to what extent it is due to the fact that the neoclassical economists' overriding attention to

[15] For instance, most of the institutions supported by the Indian Council for Social Science Research are dominated by economists.

efficiency and their models that (for instance) deify markets are aligned with the interests of the powerful actors in society today. As mentioned earlier, these things come in packages. The fact remains that this situation aggravates the disciplinary divides.

5. What the econ-anthro divide means for the links with the natural sciences

With above analysis of the differences within the social sciences in mind, we can re-examine the social-natural linkage to see how the barriers may vary depending upon which kind of social scientist the natural scientist is conversing with. To the extent that non-economists are somewhat more sensitive that economists to their own value positions, I speculate that anthropologists may be able to detect the value judgements of natural scientists more quickly and flag these issues early on in a conversation as compared to economists. For instance, the fundamental problem with the colonial concept of "scientific forestry", viz., that it is scientific with respect to a particular socio-political objective of forestry, was flagged by Ramachandra Guha, a sociologist-cum-historian (Guha, 1985). And to the extent that the method of anthropologists requires spending much more time in the field, one should and does find that anthropologists are generally more sensitive to and careful in representing the biophysical context of a problem. The emergence of ecological anthropology (e.g., Vayda and McCay, 1975) and political ecology (Blaikie and Brookfield, 1987) as major streams within the non-economics social sciences before the emergence of ecological economics (Costanza, 1989) is an indication of this phenomenon.

It is therefore ironical that, when natural scientists or engineers attempt to cross boundaries and engage with the social aspect of environmental problems, they generally tend to adopt the economics perspective (e.g., Perrings *et al.*, 1995). This seems to follow from their 'natural' affinity with the quantitative and mathematical treatment in modern neoclassical economics.[16] The exceptions are those within ecology that still adhere to the natural history approach (rather than mathematical modelling), who then seem to find it easier to talk to anthropologists (e.g., Maffi, 2001).

6. Conclusion: Ways round the barriers

Conversations between economists and anthropologists have tended to get bogged down in the question of whether interdisciplinarity is possible at all. In the context of CPRs, by emphasizing the inextricable biophysical dimension and thereby calling for a three-way conversation, I have tried to push the debate from 'whether' to 'how'. I have tried to provide a bird's-eye view of the barriers to such interdisciplinarity in practice, which include not just differences in epistemology and method but perhaps more serious ones of value judgements, models and social standing. While the many examples of interesting social-natural integration provide us with hope, the depth and multiplicity of the barriers, especially within the social sciences, may make us pause. Thus, before concluding how one might get around these barriers, it might be worth briefly re-examining the assumption we began with, viz., that the some amount of interdisciplinarity is desirable and feasible. If the barriers are as significant as described above, one would be justified in asking whether the game is worth the candle. In response, one may begin by noting that interdisciplinarity is not an end in itself. It is necessary only when one wants to understand a problem 'comprehensively', which in turn is necessary only when the ultimate motivation behind the research is a wish to bring about some lasting *change*, i.e., in a problem-solving context. In the Conversations-II workshop, David Szanton narrated how efforts by the U.S. Social Science Research Council to promote interdisciplinary research worked only when there was a concrete

[16] But it also might be reinforced by the increasing support being provided to ecological or environmental economics (as compared to, say, political ecology) by the state and by donor agencies—a phenomenon that may have more to do with affinities in values and models than the inherent worth of this particular interdisciplinary crossing.

and pressing social problem to focus on. Kanbur (2002) makes essentially the argument when discussing how to promote interdisciplinarity in development studies. And CPR degradation is clearly an important and urgent social problem with an inextricable biophysical component. A three-way conversation is therefore necessary. And based upon the preceding discussion, some suggestions may be made to make such a conversation more fruitful.

Clearly the first and foremost requirement is for researchers to be much more self-reflective about the value judgements embedded in their work. Given that they are trying to contribute towards 'solving' socio-environmental problems, it is essential that they ask what 'problem' it is that they are trying to solve and what concerns underpin this problem definition and influence their choice of variables of interest and causal models. For instance, rather than take collective action as 'obviously good' and thereby making it the dependent variable every time, they might ask who benefits from collective action and who does not (such as those owning land in the command area of an irrigation tank and those who do not), what concerns might not be met simply because collective action occurs (such as the biodiversity concerns of a community beyond local forest users) and which of these concerns may be legitimately brought into the picture. Rather than give such issues the usual short shrift (the mandatory opening paragraph that goes something like "tropical deforestation is a matter of concern because …"), researchers should take them up as seriously as questions of theory and methods. And when working in teams, significant amount of negotiation will be required to figure out which concerns should be addressed in the particular enquiry; otherwise it will be hard to maintain the motivation required for what can be an exhausting effort.

Second, researchers will have to examine and unlearn the hidden assumptions one makes about the 'other', and re-learn the more nuanced explanations that the other disciplinary block has about its area of enquiry. When working across the natural-social divide, this would lead to biophysical models that are better informed about the nature of social interventions in ecosystems and the social values derived from them, and social models that better reflect the complexities of biophysical systems. In either case, the choice of 'linking variables'—variables that the critical social aspect of natural processes to the critical natural aspect of social practices—would be crucial. Forest ecologists studying the impact of fuelwood collection on forests would then presumably distinguish between differences in harvesting practices, such as the ratio of green wood to deadwood extraction or the girth of saplings felled, rather than simply focusing on 'tonnes of biomass' (for details, see Lélé, 1993a). Hydrologists would identify exactly which portion of streamflow or infiltration is socially useful to which community, rather than giving gross values for the variables. And political scientists would presumably be more sensitive to the ecological dynamics of a resource before trying to link group size or other variables to the presence of collective action. This 'multi-disciplinary' form of research would eventually emerge lead to more 'interdisciplinary' insights that actually modify the individual disciplinary models to some extent. For instance, anthropologists working in the Sahel have contributed as much as ecologists to the overturning of the 'equilibrium' model of grassland ecosystems in favour of the 'disturbance' model (see Mace, 1991).

Adequately linked multi-disciplinarity is not, however, a useful model for integrating economic and anthropological research. This is because their insights, when independently arrived at, are more likely to be conflicting than complementary. Even if concerns are notionally the same (such as poverty alleviation), the assumptions and value judgements inextricably tied to their models introduce significant differences in nuance and emphasis. Much more openness, exchange of methods and ideas and a strong belief in pluralism will be required before much progress can be made. Notions of rigour tied exclusively to quantitative analysis will have to be loosened up, and economists would have to begin spending much more time in the field. Anthropologists would have to be more willing to make specific recommendations for policy and/or action than they do today, while simultaneously economists think twice before they crank out the next generalisations for policy makers. Given the difficulty (if not impossibility!) of such crossings happening on a large scale, interdisciplinarity here might be restricted to a few selective

crossings by individuals, rather than the possibility of team work that might exist (and be essential) across the social-natural divide.[17]

This is not to suggest that shared concerns, greater self-reflectivity, and cross-disciplinary exposure will suffice. To promote interdisciplinary research at large, changes at the individual- and team-level must be complemented by strategies with major institution-level changes in curricula, incentives, evaluation criteria, and accountability. These may not be in the hands of individuals who seek to do interdisciplinary work; however, some of these constraints could be eased at the outset of major interdisciplinary projects (e.g., by getting parent institutions to agree that the outputs that emerge should not be evaluated by conventional disciplinary or departmental standards). Eventually, larger society will have to realize the importance of generating a truly interdisciplinary understanding of CPRs and provide the necessary pressure, institutional space and recognition for carrying out these efforts rigorously.

[17] Even for such multi-disciplinary teams spanning the social-natural divide to function, I have found that having one truly 'interdisciplinary' person who knows enough about each discipline to be able to 'communicate' with each of the disciplinary specialists is very useful.

REFERENCES

Agarwal, A., 1985, "Politics of Environment-II", in A. Agarwal and S. Narain (Eds.), The State of India's Environment 1984-85: The second citizen's report, Centre for Science and Environment, New Delhi, pp.362-380.

Anonymous, 2005, "In praise of soft science", Nature, **435**(7045): 1003.

Bardhan, P. K., Ed., 1989, Conversations between Economists and Anthropologists: Methodological Issues in Measuring Economic Change in Rural India, Oxford University Press, Delhi.

Bauer, H. H., 1990, "Barriers against interdisciplinarity: Implications for studies of Science, Technology and Society", Science, Technology, & Human Values, **15**(1): 105-119.

Blaikie, P., 1985, Political Economy of Soil Erosion in Developing Countries, Longman, London.

Blaikie, P. and H. Brookfield, Ed.s, 1987, Land Degradation and Society, Methuen, New York.

Botkin, D. B., 1992, Discordant Harmonies: A New Ecology for the Twenty-First Century, Oxford University Press, New York.

Broadway, R. W. and N. Bruce, 1984, Welfare Economics, Blackwell, Oxford, UK.

Costanza, R., 1989, "What is ecological economics?" Ecological Economics, **1**(1): 1-7.

Dasgupta, P., A. Sen and S. Marglin, 1972, Guidelines for Project Evaluation, United Nations Industrial Development Organization, Vienna and New York.

Gadgil, M., 1987a, "Depleting Renewable Resources: a case study from Karnataka Western Ghats", Indian Journal of Agricultural Economics, **42**: 376-387.

Gadgil, M., 1987b, "An operational research programme for integrated development of microcatchments in Uttara Kannada district: a proposal", Technical Report no. 49, Centre for Ecological Sciences, Indian Institute of Science, Bangalore.

Gadgil, M. and R. Guha, 1992, This Fissured Land : An ecological history of India, Oxford University Press, Delhi.

Guha, R., 1985, "Scientific forestry and social change in Uttarakhand", Economic and Political Weekly, **20**(45-47): 1939-1951.

Guha, R., 2002, "Barriers to inter-/trans-disciplinary research", in S. Lélé, G. Kadekodi and B. Agrawal (Eds.), Interdisciplinarity in Environmental Research: Concepts, Barriers and Possibilities, Indian Society for Ecological Economics, New Delhi, p.34.

Gulbenkian Commission on the Restructuring of the Social Sciences, 1996, Open the Social Sciences: Report of the Gulbenkian Commission on the Restructuring of the Social Sciences, Stanford University Press, Stanford.

Hanna, S. and M. Munasinghe, Ed.s, 1995, Property Rights and the Environment: Social and Ecological Issues, Beijer International Institute of Ecological Economics and the World Bank, Washington, D.C.

Harriss, J., 2002, "The case for cross-disciplinary approaches in international development", World Development, **30**(3): 487-496.

Howarth, R. B., 2001, "Climate rights and ecological modeling", in D. C. Hall and R. B. Howarth (Eds.), The Long-Term Economics of Climate Change, Elsevier, Amsterdam,

Jackson, C., 2002, "Disciplining gender?" World Development, **30**(3): 497-509.

Jasanoff, S., 2002, "Reading between the lines: the disciplines and the environment", in S. Lélé, G. Kadekodi and B. Agrawal (Eds.), Interdisciplinarity in Environmental Research: Concepts, Barriers and Possibilities, Indian Society for Ecological Economics, New Delhi, pp.3-5.

Jodha, N. S., 1986, "Common property resources and rural poor in dry regions of India", Economic and Political Weekly, **21**(27): 1169-1181.

Kanbur, R., Ed., 2001, Qual-quant: qualitative and quantitative poverty appraisal--complementarities, tensions and the way forward, Cornell University, Ithaca, NY.

Kanbur, R., 2002, "Economics, social science and development", World Development, **30**(3): 477-486.

Karanth, G. K., 2002, "Economics and sociology: Staying on or merging the borders–reflections on the sociology side of the boundary", in S. Lélé, G. Kadekodi and B. Agrawal (Eds.), Interdisciplinarity in Environmental Research: Concepts, Barriers and Possibilities, Indian Society for Ecological Economics, New Delhi, pp.44-46.

Kessler, J. J., 1994, "Usefulness of the human carrying capacity concept in assessing ecological sustainability of land-use in semi-arid regions", Agriculture, Ecosystems & Environment, **48**(3): 273-284.

Kiran Kumar, A. K., A. Menon and I. Patil, 2006, "Methodological Challenges of Social Science Research on Land Use Change and Watershed Services: Insights from the Western Ghats", in J. Krishnaswamy, S. Lélé and R. Jayakumar (Eds.), Hydrology and Watershed Services in the Western Ghats of India, Tata McGraw-Hill, New Delhi, pp.249-264.

Kockelmans, J. J., 1979, "Why interdisciplinarity?" in J. J. Kockelmans (Ed.), Interdisciplinarity and Higher Education, Pennsylvania State University Press, University Park,

Lélé, S., 1993a, "Degradation, Sustainability, or Transformation: A case study of villagers' use of forest lands in the Malnaad region of Uttara Kannada district, India", Ph.D. Thesis, University of California.

Lélé, S., 1993b, "Private property rights and forest preservation in Karnataka Western Ghats, India: Comment", American Journal of Agricultural Economics, **75**: 492-495.

Lélé, S., 1994, "Sustainable use of biomass resources: A note on definitions, criteria, and practical applications", Energy for Sustainable Development, **1**(4): 42-46.

Lélé, S., 2000, "Degradation, sustainability or transformation?" Seminar, **486**: 31-37.

Lélé, S., 2001, ""Pixelising the Commons" and "Commonising the Pixel": Boon or Bane?" The Common Property Resource Digest, (58): 1-3.

Lélé, S. and R. Norgaard, 2005, "Practicing interdisciplinarity", Bioscience, **55**(11): 967-975.

Lélé, S. and R. B. Norgaard, 1996, "Sustainability and the scientist's burden", Conservation Biology, **10**(2): 354-365.

Lélé, S., G. Rajashekhar, V. R. Hegde, G. P. Kumar and P. Saravanakumar, 1998, "Meso-scale analysis of forest condition and its determinants: A case study from the Western Ghats region, India", Current Science, **75**(3): 256-263.

Liverman, D., E. F. Moran, R. R. Rindfuss and P. C. Stern, Ed.s, 1998, People and Pixels: Linking Remote Sensing and Social Science, National Academy Press, Washington, D.C.

Lomborg, B., 2001, The Skeptical Environmentalist: Measuring the Real State of the World, Cambridge University Press, Cambridge (United Kingdom).

Mace, R., 1991, "Overgrazing overstated", Nature, **349**(6307): 280-281.

MacGregor, J. L. L., 1894, "Letter No. 6237 of 1893-94 from the Conservator of Forests, Southern Circle, to the Commissioner, Southern Division", Government of Maharashtra (Archives).

Maffi, L., Ed., 2001, On Biocultural Diversity: Linking Language, Knowledge, and the Environment, Smithsonian Institution Press, Washington, D.C.

Masera, O., 1994, "Socioeconomic and environmental implications of fuelwood use dynamics and fuel switching in rural Mexico", Ph.D. Thesis, University of California.

Menon, A., 1999, "'Common property studies' and the limits to equity: some conceptual concerns and possibilities", Review of Development and Change, **4**(1): 51-70.

Menon, A. and S. Lélé, 2003, "Critiquing the Commons: Missing the Woods for the Trees?" The Common Property Resource Digest, (64): 1-4.

Merchant, C., 1989, Ecological revolutions : nature, gender, and science in New England, University of North Carolina Press, Chapel Hill.

Mies, M. and V. Shiva, 1993, Ecofeminism, Zed Books, London.

Nadkarni, M. V., S. A. Pasha and L. S. Prabhakar, 1989, The Political Economy of Forest Use and Management, Sage Publications, New Delhi.

Norgaard, R. B., 1989, "The case for methodological pluralism", Ecological Economics, **1**(1): 37-57.

Ostrom, E., 1990, Governing the Commons: The Evolution of Institutions for Collective Action, Cambridge University Press, New York.

Pandey, U. and J. S. Singh, 1984, "Energy-flow relationships between agro- and forest ecosystems in Central Himalayas", Environmental Conservation, **11**(1): 45-53.

Pearce, D., 1998, Economics and environment: Essays on ecological economics and sustainable development, 2nd edn., Elgar Publishers, Cheltenham, U.K.

Perrings, C. K., K.-G. Mäler, C. Folke, C. S. Holling and B.-O. Jansson, Ed.s, 1995, Biodiversity Loss: Economic and Ecological Issues, Cambridge University Press, Cambridge (United Kingdom).

Reddy, A. N. Y., D. Sarmah, P. Pande, G. B. Narvekar, B. S. Gouda and K. Yekanthappa, 1986, "Integrated approach for eco-development of Uttara Kannada district", Mimeo, Office of the Conservator of Forests, Canara Circle, Karnataka Forest Department, Dharwad.

Repetto, R., 1986, Economic Policy Reforms for Natural Resource Conservation, World Resources Institute, Washington, D.C.

Rykiel, E. J., 2001, "Scientific objectivity, value systems, and policymaking", BioScience, **51**: 433–36.

Schoenberger, E., 2001, "Interdisciplinarity and social power", Progress in Human Geography, **25**(3): 365-382.

Shrader-Frechette, K. S. and E. D. McCoy, 1993, Method in Ecology: Strategies for Conservation, Cambridge University Press, New York.

Singh, J. S., U. Pandey and A. K. Tiwari, 1984, "Man and forests: A Central Himalayan case study", Ambio, **13**(2): 80-87.

Stevenson, G. G., 1991, Common Property Economics: A general theory and land use applications, Cambridge University Press, Cambridge [England].

Turner, M., 1992, "Life on the margin: Fulβe herding practices and the relationship between economy and ecology in the inland Niger delta of Mali", Ph.D. Thesis, University of California.

Turner, M., 1993, "Overstocking the range: A critical analysis of the environmental science of Sahelian pastoralism", Economic Geography, **69**(4): 402-421.

Turner, M. D., 1999, "Spatial and temporal scaling of grazing impact on the species composition and productivity of Sahelian annual grasslands", Journal of Arid Environments, **41**(3): 277-297.

Vayda, A. P., 1996, "Methods and Explanations in the Study of Human Actions and their Environmental Effects", CIFOR/WWF Special Publication, Centre for International Forestry Research and World Wide Fund for Nature, Jakarta, Indonesia.

Vayda, A. P. and B. J. McCay, 1975, New Directions in Ecological Anthropology, vol. 4, Annual Reviews,Inc, Palo Alto CA.

Voelcker, J. A., 1897, Report on the Improvement of Indian Agriculture, Office of the Superintendent of Government Printing, Calcutta.