13. UNDERSTANDING AND RESPONDING TO GLOBAL CLIMATE CHANGE IN FRAGILE RESOURCE ZONES

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Abstract

Global climate change, judging from the debate on the subject, is one of the major concerns of the world today. However, the concern of those closely following the debate is that it has created more panic than concrete strategies to abate and adapt to the global change. The situation seems to present a crisis where the uncertainties of predicted global change scenarios combine with the risk averse nature of decision makers to obstruct concrete action and encourage the "wait and see" approach. However, the cumulative nature of warming may not permit the luxury of "wait and see".

Hence, there is a need for action, despite the uncertainties of predicted changes; but action requires concrete contexts to facilitate anticipatory measures by the decision makers. In order to resolve the problem, one should look for certainty components in the complex of uncertainties that characterize the whole problem. This paper argues that such certainty components can be projected

* The author is grateful to Greta Rana for her valuable comments on the first draft of the paper.

by altering the current skewed perspectives on the problem. Taking the lead from recent conceptual work on "cumulative change," as against "systemic change," to properly understand global environmental change, the paper presents an approach to identify and use the "certainty components." The paper illustrates this approach with reference to the semi-arid tropical region of India and, to a limited extent, the Himalayan mountain region.

Based on work on sustainable agriculture in fragile resource zones in South Asia, the paper identifies concrete current problems and their possible solutions. The current problems and their remedial measures are linked to the impacts of future climate change in the regional context. Because of such linkages, measures to solve current problems will have the potential to facilitate adaptation to future climatic impacts, without exclusively planning for "uncertain" impacts. Though not a substitute for direct action against global warming, this approach can help insofar as the problem is accentuated by cumulative types of changes such as deforestation and desertification. Its strong point is that it helps to integrate the concerns of current problems with those of the future impacts of global warming, and advocates dual purpose strategies to treat the two without being unduly obstructed by the uncertainties of global change-scenarios.

13.1 Introduction

Judging by the amount of scientific discourse, the number of political resolutions, and the interest generated in the mass media, the projected global climate change, resulting from increased emissions of CO2 and other trace gases, is one of the major concerns in the world today. This is not without cause because, if these changes continue unabated, they will have the potential to erode all of the gains made by our current civilization. The phenomenon has elicited widespread concern, considerable resource allocation, serious scientific work and numerous exercises in policy advocacy. Despite these efforts, the progress, in terms of sufficient understanding of the phenomena and concrete steps to abate and adapt to the changes they produce, is extremely slow and insignificant.

In fact, persistent uncertainties concerning the precise extent of the predicted changes, as well as their temporal and spatial dimensions; the generation of panic rather than the promotion of concrete remedial measures by ongoing debates; and the frequent recycling of the same information and similar recommendations at global warming symposia tend to suggest a state of stagnation or crisis in the field. The purpose of this somewhat provocative statement is neither to belittle the ongoing serious research in this area, nor to underrate the complexity and enormity of the problem. The intent is rather to draw attention to the constraining framework that obstructs any real breakthrough in terms of precise predictions, as well as concrete steps by policy makers, to handle the problem.

In such a given situation, it is useful to diagnose the "crisis syndrome" (if the term is acceptable) and look for new perspectives and approaches to resolve the problems involved. This paper argues for the identification of options, the adoption of which will not be unduly obstructed by "uncertainties" and related problems. It indicates an approach that might facilitate the evolution of adaptation strategies to global change in a regional context, despite the persisting uncertainties of the change "scenarios". The focus of discussion is on:

(i) the identification of certainty-components within the complex of uncertainties associated with global change processes and scenarios;

(ii) the identification of responses with reference to (i) above; and

(iii) the possibility that the impacts of such responses or adaptation strategies, (i.e. ii) would extend to the uncertainty-components of the predicted change in some cases.

The approach is illustrated by references to some areas in South Asia. In a more practical context, the approach relates the current problems and their remedial measures to the possible negative impacts of future climate-change in the regional context. It is possible that options identified through such an approach, besides handling immediate development problems, may help to strengthen the regional capability to withstand the impacts of climate change, despite the unknown factors involved in such a change.

13.1,1 Outline of the Paper

In Section 13.2, the paper briefly discusses the factors obstructing the development of abatement and adaptation strategies to global climate change and their implications. Different dimensions of the crisis situation characterizing the "global warming debate" are commented upon.

Section 13.3 comments on the current perspectives on global environmental change (or global climate change) that reflect imbalances in the approach to the problem leading to underemphasises on the "certainty-components" of the change process. Taking a lead from the altered perspectives on the problem, Section 13.4 outlines an approach to facilitating adaptation measures, despite the uncertainties of climate change scenarios.

The approach is illustrated by references to the prevailing situation in the fragile resource zones of South Asia, i.e. the three dry tropical region of India, and to a limited extent, the mountain region of the Himalayas. In this paper, we use the terms global climate change and global warming interchangeably. In some instances global environmental change is used in place of global climate change although the former may have broader connotations.

13.2 Global Warming Debate: "Crisis Syndrome"

The ongoing debate on global warming, its consequences and remedial measures, reflects some kind of crisis. By this, one implies that a situation exists in which one knows about the problem and yet does not know enough about it to develop an effective remedy In the context of global warming, the complexities of the problem, the degree of uncertainty associated with predicted changes, and the general pattern of inaction (in terms of anticipatory strategies) tend to reinforce each other. The crisis is, therefore, related to both the science behind the debate and the action that should follow the debate.

13.2.1 Science Behind the Global Warming

The science-related elements of the "crisis" are reflected in the limitations of current models in terms of capturing the total reality of the change and its processes (Jager 1988, Wuebbles and Edmonds 1988, Schneider and Rosenberg 1989, IPCC 1990). For instance, although General Circulation Models (GCMs) are able to predict the increase in mean levels of global temperature following the accumulation of trace gases in the atmosphere, the regional dimensions of the extent of warming are still vague and uncertain. Similarly, there are several knowledge gaps and uncertainties regarding the time dimension of the change and the critical values of doses of trace gases that the system can absorb without reacting in terms of global climate change. The ability of such models to determine the role of other factors, such as cloud cover and global sinks (such as oceans and forests), is also questionable (Rogers and Fiering 1989, White 1990, Abelson 1990, Spencer and Christy 1990). Scientists dealing with the problem of global climate change are becoming increasingly aware of this problem. Everyone advocates more research on the subject in order to reduce the range of uncertainties. However, the problem lies in pushing for action (which may involve huge dislocation costs) without a precise understanding of the issues involved.

13.2.2 Confusion and Conflicts on the Action Front

Another important dimension of the "crisis syndrome" characterizing the global warming debate is the general failure to take any effective steps to solve the problem. Without belittling the progress made on the Ozone Treaty, the steps undertaken by individual countries in Europe and North America, and the useful spadework done by IPCC, WMO, UNEP and others on various aspects of the problem (Flavin 1989, UNEP and The Beijer Institute 1989, IPCC 1990), it can be stated that, when seen in the context of the enormity of the problem, the concrete measures necessary to control global warming or to facilitate the adaption to such changes are not yet visible. This lack of serious and concrete effort is reflected in the open or concealed indifference of policy makers to global warming issues; the persistent differences in the perspectives of developed- and developing-countries on the various dimensions of the problem (Agarwal and Narain 1991, Parikh 1991), the confusions and conflicts on perceived losses and responses to it (Glantz 1988, Gleick 1989), the priority given to debate over action and, most importantly, the choice of a "wait and see" approach by both developed and developing countries, albeit for different reasons (UNU and IFIAS 1989). Moreover, the risks involved in initiating action without concrete contexts (due to uncertainties of change - scenarios) are often used as an argument for inaction.

13.2,3 Pressures for Action

However, notwithstanding the uncertainties of global warming and their implications, the context for policy decisions is rapidly changing. Because of factors such as the strong concern-generating potential of the GW problem (i.e. doomsday scenarios); the percolation of scientific discourses into the mass media; the increased environmental awareness of the "informed" common man; the growing pressure of environmental NGOs; and the impacts of recent unusual weather events, such as severe droughts and hot summers (especially in developed countries); the "noise level" of the debate on global warming is much higher today than ever before. There may not be full awareness of the limitations of the scientific evidence on the subject, but the debate has acquired sufficient strength to force the policymakers into action.

Nevertheless, these changes have not radically altered collective anticipatory planning on global warming. Consequently, apart from agreements such as the Ozone Treaty and some initiatives by individual countries (UNEP and Beijer Institute 1989), most public responses are still confined to increasing resource allocation for scientific research on GW; progressive "globalization" with an increased number of global warming meetings; the gradual upgrading of the political status of such meetings; and efforts to disentangle the involved dilemmas (through official and non-official working group). Substantive action on the problem, in the form of focussed and collective strategies, is still non-existent, notwithstanding the World Bank, UNEP, and WMO initiatives leading to environmental safety tags on project files.

In fact, the crux of the problem lies in the fact that the choice for a concrete action in unknown or uncertain contexts goes against the general risk-averse nature of human beings, unless they happen to have strong gambling instincts. In addition, the problem involves the "global commons." Thus, such decisions involve the concurrence of the whole community of nations, and they all have diverse perspectives, resource capacities, and perceptions vis a vis the issues involved (Dorfman 1991). Moreover, the perceived potential costs of economic dislocation, changes in consumption, and investment decisions associated with possible action-strategies against global warming, are too high, and they further discourage the actions, even in a "speculative mode". Consequently, "wait and see" is the preferred option of most countries under the existing circumstances.

13.2.4 Is "Wait and See" an Option ?

A product of the uncertainty of global change scenarios and the risk-averse, (and calculative) nature of policy makers, the "wait and see" approach to global warming seriously conflicts with the cumulative nature of the "warming" problem. Despite other uncertainties, scientific understanding is more certain on the heat trapping potential of trace gases and their increasing accumulation in the atmosphere. Consequently, waiting for more precise predictions on global change before embarking on abatement/adaptation strategies would mean committing the earth to additional warming and its consequences i.e. increased risks and costs (Jager 1988; Flavin 1989, Pearce *et al.* 1990, IPCC 1990).

A detailed look at the factors affecting the choice (in terms of waiting or acting), summarized by Pearce *et al.* (1990), suggests that there are more factors favouring anticipatory environmental policies. However, the time preference or discounting procedures, the usual tools in investment decisions analysis, would favour waiting. Similarly, the cost-effectiveness of responses that are directly linked to an improvement in information on global warming would favour waiting. But other factors, like the cumulative nature of the warming and associated escalation in costs; the possibility of irreversible changes in some cases; the uncertainty of impacts, which may take the form of shocks and catch the society unprepared; and the imperatives of incorporating environmental concerns into narrowly focused conventional development strategies (Dorfman 1991), are the factors that are compelling enough to support a choice for concrete policies and action strategies regarding global warming.

Moreover, there are other factors that do not favour a "wait and see" option. Firstly, waiting (as against action) tends to dilute the concern, commitment, and enthusiasm for the problem and, hence, slackens the preparedness to act at the appropriate time. In the global warming context, this may mean the slackening of support for the conduct of scientific research necessary for reducing the range of uncertainties. The past history of resource allocation for different research activities, fluctuating according to the changing whims and biases of decision-makers, would bear this out.

Secondly, it is difficult to imagine how long a waiting period is involved in the "wait and see" approach. Despite remarkable improvements in the human capacity and the means to document and simulate the behavior of nature, the latter is too complicated to be fully understood within a short enough period to facilitate concrete policy decisions. Hence, the time lag involved cannot be overstated. The pressure for even tentative action strategies and provision of a more concrete focus to scientific work may probably reduce it somewhat. In the past, there have been cases where pressure for concrete output (implied by certain policy decisions) has changed the pace and perspective of scientific research.

The third issue again relates to human nature as it is reflected at the negotiating table. The history of international treaties shows that the preparation and finalization of major agreements (unless they are between victors and vanquished) is a long drawn-out process. Depending upon the gains and losses perceived, and rigidities associated with the respective positions of involved parties, progress on international treaties is slow and in instalments. Treaties on global warming, both due to its complexities, as well as the involvement of nations with diverse perceptions, may take a very long time and add further to the waiting period (even after scientific understanding of the problem has improved). The Ozone Treaty (in terms of the relatively short time it took) is of limited value as a precedent, because the issues and potential adjustment costs involved in the control of CFCs are far lower than those involved in controlling global warming.

To sum up, the cumulative nature of the global warming problem and its associated risks do not permit the luxury of a "wait and see" option; if such an option is chosen, the waiting period will be far too prolonged and the situation might acquire irreversible proportions during this period, especially if the change takes the form of major "shocks" or "surprises". Hence, unless the community preference is for inferior options, implied by forced adaptations to global warming, there is no choice but anticipatory actions to address the situation, even if its precise details are not yet available (Jager 1988, Flavin 1989, Pearce *et al.* 1990, IPCC 1990, Gleick 1990).

13.3 Acting Despite Uncertainties

The risks associated with the "wait and see" approach on the one hand, and the difficulties and costs of developing and implementing abatement/adaptation measures without concrete contexts on the other, are in a way, the core of the crisis on the global warming action front. If society needs anticipatory planning for global warming, to be relevant and effective, such planning needs contexts with reasonable degrees of certainty and definitiveness. To resolve this dilemma, there needs to be a focus on the possible options and approaches where problems of uncertainty, time preference (or discounting), and informations gaps are somehow overcome. The process of searching for such options to facilitate "action despite uncertainties" can start with a search for certainty-components within the complex of uncertainties associated with the pace and pattern of global environmental change and its impacts. The response strategies, then, could build upon the certainty-components of the problem.

The decisions about and management of certainty-components (not obstructed by the conjectural nature of change scenarios) may also have a slow and small impact on components of the problem with strong uncertainty attributes. Thus, under circumstances that discourage concrete action on global warming, such an approach can form a basis for evolving "dual purpose" strategies to handle the problems of global warming (Cooper 1989). The important components of such strategies would involve the following steps:

(i) Identify the certainty-components within the overall complex of causes, processes, and consequences of global warming.

(ii) Focus on measures directed to "certainty-components" that have the potential to extend to "uncertainty-components."

(iii) In order to make (i) and (ii) above operational, (a) identify linkages between current problems and potential climate change impacts; (b) understand the extent of convergence between measures directed against current problems and potential responses to regional impacts of climate change, and, finally, based on steps (a) and (b) above, (c) identify short-term response strategies (which are less affected by the uncertainty of change scenarios and associated problems) that have the potential to mitigate the risks of long term climate change.

Thus, a search for certainty in a complex of uncertainties and its consequences is the essence of the approach suggested by this paper. This will be illustrated by reference to specific areas in South Asia. However, the whole approach outlined above begs a significant question: Are there any certainty-components in the whole process of global warming and its impacts that may serve as a basis for concrete action strategies? This may call for a close look at the current overall perspectives on the problem.

13.3.1 Global Environmental Change: The Skewed Perspectives

Global environmental change has several dimensions in terms of the multiplicity of causative factors and involved processes, the manifestations of consequences, and the diversity of potential response approaches. However, owing to certain historical and institutional reasons (such as the involvement of specific scientific disciplines in the initial work on the subject), the newness of the problem, as well as the "noise potential" of specific aspects of the problem, only some dimensions of the global environmental change phenomenon have received the major focus of scientific work, debate in the media, and policy advocacy exercises. These are also the dimensions (involving complex biogeochemical variables and their interactions) that have a greater degree of uncertainty associated with them. Thus, uncertainty, in the context of global change-scenarios, could be partly a product of imbalances in the current perspectives on the subject.

To elaborate on these issues, we may take the lead from some recent conceptual work on the subject. Turner *et al.* (1990) discuss two dimensions of global environmental change (i) "systemic" changes and (ii) "cumulative" changes. Broadly speaking, a systemic change is one that takes place in one locale with implications for the system elsewhere. The underlying activity need not be widespread or global in scale, but its potential impact is global in the sense that it influences the operation and functioning of the whole system, as manifested through the subsequent adjustments in the system. CO2 emissions from limited activities that have impacts on the great geosphere biosphere systems of the earth and cause global warming is the prime example. Cumulative types of changes refer to localized, but widely replicated, activities where a change in one place does not effect change in other places. When accumulated over time, they may acquire a scale and potential to influence the total global situation in specific ways. Widespread deforestation and extractive land use systems with their potential impacts on global environment serve as examples. Both types of changes are the products of nature/man interactions and they are linked to each other in several ways.

Other conceptual leads, which facilitate a critical look at the current approaches and thinking on global changes, relate to (i) geocentric perspectives and (ii) anthropocentric perspectives on the change, its causes, and consequences (Price 1990, Turner *et al.* 1990, Clark 1988, Chen *et al.* 1983). The key focus of the former is on the earth and its geobiophysical variables - with all of their complexities and unknowns, as emphasized by natural scientists. Anthropocentric perspectives, on the other hand, emphasize nature-society interactions, as well as the processes of change that have a primary focus on their importance for society.

The "cumulative type of changes" and "anthropocentric perspectives" present a situation that is much simpler and involves less uncertainties and unknowns. It is much easier to relate these perspectives to the human approach to constraints and opportunities presented by the environment Yet, since they are not sufficiently emphasized in global - change related work, their potential for guiding response strategies remains underutilized (Kasperson *et al.* 1989). Table 13.1 presents some details indicating the skewed nature of perspectives on global change and their implications. Many more details and concrete examples can be pooled under the major categories presented in this table.

Besides referring to the above-mentioned imbalance in perspectives, the primary purpose of alluding to the above concepts is to highlight the possibility of evolving approaches based on the "cumulative" type of changes and of using them as a basis for exploring "action strategies, despite the uncertainties of the change scenarios" discussed earlier. As Table 13.1 shows, cumulative changes are easy to understand; it is also easy to evolve response strategies to manage them and adapt to their impacts.

Furthermore, the impacts of response strategies on cumulative changes may also extend to systemic changes and their consequences. This is because of the linkages between cumulative and systemic changes, especially when the former acquire large-scale and widespread dimensions (Turner *et al* 1990). Table 13.2 illustrates the above linkages. Accordingly, large-scale deforestation (especially of tropical rainforests), various forms of desertification and extractive land use systems that are extended particularly throughout the developing countries (Anon 1990), in their respective ways, can either contribute to the components of systemic change (e.g., growth of greenhouse gases) or reduce the capacity of natural sinks (e.g. forests) to absorb CO_2.

The same factors may indirectly contribute to systemic changes by creating circumstances that generate pressure on socioeconomic systems to engage in activities (e.g. technologies, industries) that create more employment and income, but also contribute to the emission of trace gases. Seen from this perspective, some of the phenomena (directly unrelated to use/misuse of the biophysical resource base), such as third world poverty, indebtedness, and unequal trade/exchange arrangements, also indirectly contribute to global "systemic" changes. The understanding of such linkages can help in developing an approach that can integrate the concerns about global environmental change and current problems of third world poverty and hunger, (Kates 1990, Dorfman 1990).

TABLE 13.1. *Indicators of the Skewed Perspectives on Global Environmental Change**

Elements Prominently Focused	Elements Under Emphasised
"Systemic" type of change:	"Cumulative" type of change:
Focus on biogeochemical variables and their interaction processes relating to the functions and operation of geosphere biosphere systems of the earth.	Localised and widely replicated changes in different variables and process of resource use, (when accumulated) influence the global systems.
"Geocentric perspective":	"Anthropocentric perspective":
Focus on physical dimensions, typically in the natural science framework; concentration on geobiological variables and their complex interaction patterns, with little direct incorporation of human dimension of changes and change-processes.	Primacy of nature-society interactions with focus on their importance to the society; potential mechanism for understanding and handling "cumulative changes" (with some possibility of influencing impacts of "systemic changes".
Other associated aspects:	Other associated aspects:
Emphasis on long time horizon (decades/ centuries) and inter-generational issues; focus on terminal impacts involving selected variables (e.g. sea level, and temperatures rise, shift of climatic zones etc.) affecting fundamental equilibrium of world system and atmosphere; analytical methods and material used involve high degree of complexity and sophistication, information on several unknowns, limited transparency (for uninitiated ones), multiple uncertainties, and conjectural nature of predictions.	Sensitivity to both intra-generational and inter-generational issues; analytical approaches simpler and oriented to integration of change processes in current problem-solving mode; predictions, action/advocacy focus on short or medium planning horizon, greater ease and possibility of associating causes, consequences of and responses to change; greater possibility of integrating geocentric and anthropocentric perspectives.
Advocacy and action:	Advocacy and action:
High "scare and noise" potential of issues covered, (e.g doomsday predictions); approaches to abate/adapt to changes: obstructed by uncertainty of change scenarios, induce higher discounting of the potential options, inject vagueness about gains and sacrifices and create more panic and debate than concrete action.	Possibility of evolving options within the received (and modified) framework of handling current crisis situations in local contexts; greater scope for clearly associating cost and benefits, greater certainty of potential options and their easy acceptability to decision makers; possibility of dual purpose options to handle current and future "impacts".

a. For various issues and examples which could fit into the following grouping of perspectives see Price (1990), Turner *et al.* (1990), Kates (1990), Flavin (1989), Jodha (1989), Glantz *et al.* (1988), Wuebbles and Edmond (1988), Clark (1985), Chen *et al* (1983), Garcia (1981).

TABLE 13.2. ***Global Environmental Change: Linkage Between "Cumulative" and "Systemic" Types of Changes***

Cumulative type of changes (Examples)	Cumulative[a] change supporting systemic[b] change		Cumulative change accentuating impacts of systemic change		
	Directly[c]	Indirectly[d]	Types of Impacts[e] 1st order[e]	2nd order[f]	3rd order[g]
Deforestation, overgrazing; depletion of biomass potential; reduced biodiversity; etc.	x	x	x	x	x
Desertification, soil erosion; soil/water salinisation; ground water depletion; frequency/ intensity of droughts/impacts; disturbance to hydrology; etc.		x	x	x	x
Land use changes, reduced agricultural diversity/flexibility, and resource regeneration processes; resource extractive crops/technologies; increased external dependency; etc.	x	x			x
Third World poverty; indebtedness; trade barriers, unequal exchange; etc.		x			x

a) Localised and widely replicated changes with potential for impact at global level.

b) Even a small change in one place affects changes in other places; and has potential for directly influencing the operation and functions of the fundamental systems of the earth (e.g. CO_2 emission; see text).

c) By adding to emission of greenhouse gases and/or reducing their "sinks".

d) By generating pressure on the economic/social system for additional resource-generation through activities contributing to global warming.

e) Impact on physical resource base and production environment of agriculture (e.g. moisture regime, soil erosion hazards, seasonality, length of growing season).

0 Impact on components of farming systems (e.g. adapted cultivars, crop combination, soil-moisture/agronomic management).

g) Impact on macro level agricultural systems/policies (e.g. irrigation, R and D, relief etc). (For sources to find examples on the above, see note under Table 13.1).

The potential links between the impacts of "cumulative changes" (listed under Table 13.2) and the impacts of "systemic changes" (i.e. global climate change through trace gases) are still stronger and relatively easy to understand. To illustrate this, we can refer to the likely impacts of global climate change on agriculture - the dominant sector in the developing world. The impacts of changes in precipitation patterns, temperature, and humidity etc. following or during global warming would influence the resource base and production environment of agriculture (called first order impacts); the structure and functioning of farming systems (called second order impacts); and macro-level agricultural policies, infrastructure, and support systems (called third order impacts).

The cumulative changes (e.g. deforestation, desertification etc) also have impacts that fit into these first, second and third order impacts. For example, deforestation, by influencing the hydrology of the region, influences the resource-base and production environment of agriculture. By weakening the "forestry-farming linkages" it affects the farming system. By constraining biomass supplies, it affects the macro-level policies on fuel and energy options. Similar examples can be given for other variables. Hence, these cumulative changes have the potential to accentuate the impacts of global climate change and vice versa. This perspective can help link the issues of current and local (or regional) concerns with those of future and global concerns. This, in turn, can facilitate the resolution of the problem of "inaction" on global warming issues, by approaching them through current problem-perspectives, especially in developing countries. On the basis of the aforementioned linkages, one can identify strategies to manage the emergence and impacts of cumulative changes, and this may extend to systemic changes in some cases. In the next section this will be elaborated in the context of a concrete regional example.

However, before moving on to the regional context to indicate the possibility of making the above framework operational, it can be added that the anthropocentric perspective, which in a practical context focuses on human survival and welfare considerations while dealing with different phenomena (including global change), may prove instrumental in generating concerns and components for evolving strategies to manage cumulative changes. Thus, cumulative types of changes and anthropocentric perspectives have some form of complementarity and this can be harnessed while evolving strategies to "act despite uncertainty" on global warming scenarios.

13.4 Regional Adaption Strategies

The approach outlined above can be illustrated by reference to any region for which details on current crises with long term implications are available. For the following reasons, the fragile resource regions of the world are eminently suitable cases for this purpose. Because of the fragility of their biophysical resource bases, they are very vulnerable to rapid decline from even a small disturbance. The current pressure of population and market forces has already initiated resource degradation processes in such areas. One can quite easily identify a degree of convergence between the impacts of these processes and their remedies, on the one hand, and the impacts of future climatic change and adaptations to them, on the other.

Accordingly, we examined the situation in the fragile resource zones in south Asia namely, arid and semi-arid tropical region of India and the lower and middle hill areas of the Himalayan Region. Despite being very different ecosystems, the two regions share a number of commonalities, such as inaccessibility, marginality, internal diversity, specific niche and human adaptation experiences in generally high risk, low productivity environments. Moreover, in both the cases, their increased integration with mainstream market systems and rapid population growth have similar impacts in terms of resource degradation and emerging indicators of unsustainability. Moreover, the key operational elements in the proposed approach to adaptation strategies to climate change (based on convergence between the impacts of (i) current crises and (ii) regional climate change, and convergence between remedial measures against the two), consist of those indicators of unsustainability that have been studied by the author in the case of both regions (Jodha *1991a*). Hence, despite various ecosystemic differences, the framework presented in this paper can be illustrated by references to both or any of the regions covered. However, the following discussion uses the example of the dry tropical region only.

13.4.1 Regional Climate Change

The scenarios for future climate change in the dry tropical areas share the general limitations of change-scenarios for other regions. Accordingly, there are no concrete predictions. Yet, on the basis of projections by various general circulation models (GCMs) on the arid and semi-arid tropical regions (35°S to 35°N), temperature increases in the order of 0.5 °C to 4.0°C are predicted. Increases in precipitation are predicted for most, but not all, of the semi-arid tropics. This increase is expected to take the form of convective rainfall, which could imply a higher intensity, but not necessarily an increased frequency, of precipitation. Thus, the seasonally dry tropics would have potentially high rainfall, high runoff, (high soil erosion in plantless areas with undulating topography) and high evaporation, without necessarily having a lengthened or improved growing season. In view of the existing high variability of seasonal and annual rainfall, any trend towards decreased precipitation would have significant negative impacts in terms of prolonged and recurrent droughts (Jager 1988).

Beyond the above conjectural information, not many details on future climatic changes are available from the GCMs. However, lack of certainty about change-scenarios, as mentioned earlier, is the key reason for suggesting the approach to adaptation strategies put forward by this paper. In keeping with the idea of "cumulative" changes as a focal point in evolving regional strategies to tackle future global climate change, we refer to certain dimensions of current realities faced by the dry regions (and mountain regions). The dimensions representing negative processes are, however, not unique to these two regions alone, but can be observed, and have been documented, in several similar ecosystems in the developing countries (Price 1981, Blaikie and Brookfield 1987, ACTS, 1990, Allan *et al.* 1988, Dregne 1983, Glantz 1987, Grainger 1982, Rieger 1981, Gracia 1981). Being so pervasive, when pooled over space, they have significant direct or indirect impacts at the international level. Internationally, the growing magnitude of the problem of "climatic refugees", the vanishing resilience of traditional farming systems and sustenance strategies of the people, the increasing need for large-scale and perpetual subsidization (in biochemical, physical, and economic terms) of agriculture in fragile resource zones, the rapidly widening gaps in food supplies, and worsening ecological conditions in fragile areas are some of the manifestations of localized cumulative changes that have begun to acquire a global dimension. The potential contribution of these processes to "systemic" changes and the accentuation of the latter's impacts in the global context (Table 13.2) is not difficult to imagine.

13.4.2 Indicators of Unsustainability

As a part of our enquiries into conditions for sustainable agriculture in fragile resource zones (Jodha 1991a), we were alerted to over two dozen variables showing verifiable or measurable negative trends during a period as short as four to five decades. Some of them, such as the increased extent of landslides in the mountains and the deepening of water tables in dry tropical plains, were related to the resource base. Others were related to production flows, such as the decline in crop yield and biomass availability from grazing lands in both the mountains and the dry plains. Yet other negative trends were related to the infeasibility of resource-regenerative agricultural management practices (e.g. specific rotations and crop diversification) in both areas. Some of these changes are more visible (e.g. the extent of landslides and the decline in crop yields) than others (e.g. the substitution of shallow-rooted crops for deep-rooted crops due to the erosion of topsoil). Again, some represented the consequence of negative processes (e.g. reduced diversity), while others formed part of the processes themselves (e.g. encouragement of monocropping through new technology). In totality, they manifest reduced production prospects for the present generation compared to past generations. When viewed in the context of the central element of the "sustainability" phenomenon, i.e. inter-generational equity, the above changes represent the emergence of inter-generational inequity and, hence, we call them indicators of unsustainability (Jodha 1991a).

Enquiry into the factors and processes associated with the above negative changes indicated the following:

- The disregard of the specific resource and environmental characteristics of these areas (fragility, marginality, diversity and so on) by private and public intervention resulted in the emergence of unsustainability indicators.
- The pressure generated on resources by population growth, market forces, and public interventions encouraged the disregard of regional resource specificities.
- The redundancy (due to infeasibility or ineffectiveness) of traditional technologies and the failure to develop new technological options, which could enhance the use-intensity and productivity of land resources without degrading them, was another factor responsible for the negative changes.
- Climate is part of the regional resource endowment, but, in the overall context of the functioning of the regional agricultural system, the role of climate-related factors in some of the negative changes (e.g. those related to ground water recharge and drought) could be separately identified (Table 13.3).

13.4.3 Search for Sustainability

The restoration of the "sustainability" of agriculture in both the regions implies arresting and reversing the negative trends mentioned above. For this, one has to understand the factors and processes associated with the indicators of unsustainability. Thus, the problem of sustainability is approached through unsustainability. Looking at the nature and extent of unsustainability indicators, one can devise technological and institutional options to manage the current situation and plan for sustainability. Such options may be focussed on resource protection, upgrading, and scientific management; growth and stability of crop production; and diversity and flexibility of resource use practices.

Such measures, besides strengthening the resource regeneration processes and resilience of farming systems in the regions, can help satisfy the conditions associated with sustainability. The latter means the ability of the agricultural system to maintain or enhance its production performance, without damaging "the essential ecological integrity of the system". More importantly, because of the aforementioned potential complementarity between the indicators of the current crisis and the negative impacts of regional climate change, it is possible to use remedial measures to current problems as a part of the strategy to mitigate the impacts of regional climate change. Thus, measures directed to restoring the sustainability of fragile-resource agriculture can also help strengthen its capacity to withstand the negative impact of regional climate change. Such possibilities are broadly illustrated in Table 13.3. However, to understand this fully, it will be useful to elaborate upon the climatic impacts with which we are dealing.

13.4.4 Climate-Impacts

The potential climatic impacts, listed along with their sequential interactions (Jodha 1989a), are called first, second, and third order impacts (see Table 13.3). Among the important climatic variables subject to change as a result of global warming are temperature, solar radiation, precipitation, humidity, evapotranspiration, soil moisture and runoff. Their likely immediate impact will be on the major components of the physical resource base and the production environment of agriculture (in our illustration). They are called first order impacts and they would cover variables such as moisture regimes, growing seasons, micro-climatic stress, seasonality and stability of weather, disease and pest complexes, biomass potential, photosynthesis, plant-input interactions, soil chemistry, and erosion hazard.

In turn, the changes in the above variables will influence the components and features of farming systems. Covered under second order impacts, they will relate to adapted plant and animal species, combinations and linkages of agricultural activities, moisture management and water security measures, farm activity calendars, agronomy and input practices, risk management mechanisms, production flows, and yields and returns.

TABLE 13.3. *Some Measures Directed Against Current Problems with Potential to Mitigate the Negative Impacts of Regional Climate Change in Dry Tropical Region of India*

Current Problem[a]	Possible technological/institutional areas of intervention	Negative climate impacts likely to be affected by interventions		
		1st[c]	2nd	3rd
Deepening/salinisation of ground water (C, T, N, D)[b]	R & D on water conservation, management; irrigation development, wateruse regulations	x	x	x
Top soil/fertility erosion, plantlessness, sand movement, (T, D)	Land rehabilitation programmes, technologies for marginal lands, silvi-pastoral programmes/ technologies	x	x	
Land depleting usage, cropping patterns, technologies (T, N, D)	Resource/ crop technologies for soil building/binding/productivity, institutional support systems	x	x	x
Reduced crop/animal yields, per capita land etc (T, N)	Crop/resource-centred technologies, for high yields; population/ employment programmes		x	x
Increased drought frequency/severity, relief-dependency (c)	Drought resistant crop technology, resource conservation programmes; alternative employment; linkage with stable areas/markets		x	x
Infeasibility of resource stabilising, regenerative practices (T, N)	Reorientation of agricultural R & D and support systems with focus on sustainability		x	x

a These problems represent "cumulative type of changes" (see text).

b Capital letters indicate the causes:

C = Climate-related factors;

T = Technological failures;

N = Institutional (population, market, state intervention related factors);

D = Disregard of use capabilities of resources, and non-availability of relevant technologies.

c First order impacts related to the resource-base and production environment of agriculture. Second order impacts related to components of the farming system. Third order impacts related to macro-level agricultural and related policies, programmes (see text for details).

TABLE 13.4. *Areas of Convergence Between Regional Climate Change Impacts and Current Agricultural Problems Focused through Orientation of R & D in Dry Tropical Region, India*

Selected areas of potential negative impacts of regional climate change	Selected current problems					
	Ground water depletion	Soil erosion	Crop yield decline	Forest, pasture health	Protection against drought	Income employ-ment
1st order impacts:						
Weather aberrations	R[a]	R	H	H	R	N
Length of growing season			S		R	
Plant-input interaction		R	S	H		
Soil erosion hazard		R	S	H		
2nd Order Impacts:						
Adapted cultivars	R		R		R	
Agronomic practices		S	S	S	S	
Risk adjustment				R	S	N
Yields/returns		R	R			R
3rd Order Impacts:						
Irrigation systems	R				R	N
Relief policies				H	S	R
Agrl. support systems			N		N	N
Income/emp. policies			N		N	N

a The capital letters indicate the broad areas of R and D. More than one R and D area could be relevant for specific situations indicated by the Table. However, we have indicated the most relevant one in each case (see Jodha 1991a for details).

R = Resource-centred R & D: physical/biological measures to manage-slope, drainage, soil, moisture; soil binding building plants/crops; fast growing, high yielding annual/perennials, local resource renewability

S = Systems-oriented R & D: for combining conservation and productivity, crop-resource centred management options, diversified interlinked resource use

H = R and D focused to harness "niche', comparative advantage, and resource diversity; sensitive to resource capabilities; wider adaptation of crops, stability and growth of biomass (especially perennials)

N = Institutional measures - policies, programmes, projects (related to technological and other measures)

The changes in the structure and functioning of farming systems would directly or indirectly induce changes in macro-level agricultural systems, policies, and strategies. Designated as likely third order impacts of climatic change, they include irrigation systems and strategies, relief policies and programmes, agricultural infrastructure, input supply systems, research and development (R and D) priorities and strategies, marketing and trade systems, intersectoral linkages, agricultural planning strategies, and employment and income distribution.

With the help of the above details on climatic impacts, it is not difficult to understand that the negative orientation of any of the above impacts can further aggravate the crisis situations manifested by indicators of unsustainability in the region. Similarly, the severity of the climatic impacts will be much greater if the current negative trends in the regions cannot be reversed. The crucial point in the above context is that, despite potential links between the two, the present crisis is more definite, while the projected negative climatic impacts are uncertain; consequently, measures against the former are more easily acceptable by policy makers. Besides, any improvements, such as land resource upgrading, technologies against yield reducers (such as salinity or drought), increased diversity and flexibility of agriculture and promotion of off-farm employment and income generation, while solving the current problems, may equip the regions to withstand future climatic impacts better, without explicitly planning for them. Finally, since there is no exclusive effort involved in developing adaptation strategies to climatic change, there are no costs and risks in terms of redundancy and wastefulness of the effort, if the predicted change-scenario does not materialize.

We illustrate this for the dry tropical region in Table 13.3, which focuses on some of the components of the current crisis (indicators of unsustainability). It also lists the broad areas of technological and institutional interventions necessary to manage the current problems. These interventions have the potential to influence or mitigate the likely negative impacts of regional climate change. For instance, measures directed at dealing with emerging salinity of ground water and declining of water tables in terms of R and D on water management, irrigation development and water use regulation, can also provide protection against the relevant impacts of climate change. The latter include disturbance in the length of growing season, increased frequency of weather aberrations (first order impacts); disturbance to moisture management systems and agronomy (second order impacts); and irrigation systems and water pricing policies (third order impacts). Similarly, interventions in terms of alternative crop technologies, land rehabilitation programmes, and public relief programmes that are directed to current problems, can have mitigating impacts on the different negative impacts of climatic change.

The details presented in Table 13.3 can be presented differently. Accordingly, as indicated by Table 13.4, the areas of convergence between current and (climatic impact-based) future problems can be seen through the orientation of agricultural R and D in the dry tropical area. Table 13.4 presents areas of convergence for R and D and institutional support that have direct links with current problems and likely climate-impacts. The promotion of technologies with this focus can act as a major component of adaptation strategies to regional climate change, despite the uncertainties associated with it.

The above discussion presents a broad picture of the situation in dry tropical areas of India where, by using available information on current problems and currently contemplated (or even adopted) remedial measures, one can relate the current problems to future climate-change impacts. In addition, one can identify measures that are primarily directed towards handling the current problems, but which can have some mitigative influence on the problems created by future climate-change impacts. Thus, the approach can serve a dual purpose.

13.4.5 Summary

To sum up, the present paper has attempted to illustrate one approach for developing adaptation strategies to global climate change in the regional context, despite the uncertainties of predicted change scenarios. The approach tries to identify certainty components of the problem, by using the lead offered by concepts such as "cumulative types of change" and "anthropocentric perspectives" on the problem. This approach, illustrated by reference to the dry tropical areas of India and to a limited extent mountain region of the Himalayas, can help link the current problems in a regional context to problems associated with future global climate change. Remedial measures, conceived for current problems, can also offer a by-product in the form of the increased ability of a region to withstand the impacts of climate changes.

One can identify a number of current measures in sectors other than agriculture (e.g. restriction on exhaust emissions from vehicles as a part of better living conditions in urban areas or a greater emphasis on non-conventional energy sources due to the high cost of crude oil) that will fit into the framework presented in this paper. The only key requirement is the understanding of the linkages between the current problem and its remedial measures and the aspects/impacts of global warming. With the help of more specific situations from different sectors, the focus of the approach can be further sharpened. Apart from the diminished role of "uncertainties" in obstructing action on the current problem, the approach has a number of other advantages:

- Options are easy to conceive and acceptable to decision makers, particularly in the developing world where efforts are concentrated upon current problems.
- The problems caused by inter-country differences in perspective and externalities (in terms of the inability to restrict the gains of remedial measures to oneself) would not obstruct action under this approach.
- Under this approach there are no risks of redundancy of options and associated resources if predicted change-scenarios do not materialize, because the remedial measures are not designed to handle unknown and unidentified factors.

However, it should be noted that this approach cannot substitute for the measures and approaches required to deal directly with the global warming problem. This approach is helpful only to the extent that "cumulative" change plays a role in global warming and the accentuation of its impacts. Its strong point is that it helps in integrating the concerns of current problems with those of the future impacts of global warming and advocates dual purpose strategies to treat the two, without being unduly obstructed by the uncertainties of change scenarios.

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