Some Perspectives of the Major Biogeochemical Cycles
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CHAPTER 10

Socio-Economic Impacts of Carbon Dioxide Induced Climatic Changes and the Comparative Chances of Alternative Political Responses – Prevention, Compensation, and Adaptation

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ABSTRACT

Prevention of climatic change by changing human economic behaviour or compensation for climatically detrimental effects by technological solutions is not necessarily better than adaptation. In fact, there are good reasons to conclude that adaptation is the most rational political option, at the same time requiring least marginal action (i.e. least action specifically for reasons of climatic change). The problems resulting from carbon dioxide all appear at present to be marginal ones which arise, and should be taken care of, for other reasons than simply climatic. With respect to carbon dioxide induced changes, no more action is required than is already necessary for reasons of development policy.

Life in the industrialized countries is to some extent comparable to living in the city of 'Diaspar' in A. C. Clarke's novel 'The City and the Stars'. Diaspar is a triumph of technology, enclosed under a huge dome, a perfect sphere—so to speak—which may neither be left nor entered except for some entropy exchange with the rest of the world. In fact, people in the present-day industrialized societies live remarkably isolated from nature, and this applies especially to weather or climate developments. As a striking example, I may refer to our way of travelling over long distances—e.g. to scientific conferences. We use airplanes which are—for good reasons—air-conditioned; we arrive at an air-conditioned airport, take a few breaths of genuine or even natural 'atmosphere' but then (often enough) enter an air-conditioned taxi which brings us into an air-conditioned hotel or directly into

the air-conditioned conference centre. All this may give rise to a certain apprehensiveness particularly when the topic of the conference is the interface between climate and society and when, as once happened to me, moreover in the airplane you read an article stating that agriculture in the future will not necessarily have to be connected with activities outdoors, since what plants need to grow can be supplied to them by nutrient solutions and artificial light as well. Thus even the one basic activity which up to now was conspicuously dependent on climatic conditions could also be transferred, it seems, into the completely artificial environment of the almost-Diaspar in which the industrial societies are generally living and in which, among other things, we are talking about the impact of climate changes on our life.

However, the technological buffer to protect ourselves against the environment is still far from being impermeable or insensitive to outside changes. On the one hand, for many of us, it still makes a considerable difference to work in a room with or without windows, to sense the sunlight and to follow clouds in the sky.

Even if these were only aesthetic experiences they make us feel differently and are important elements of the quality of life. On the other hand, there are also impacts on economic and social activities which perhaps may be most suitably represented by distinguishing different levels of impact between the inorganic sphere, the biosphere, and the sphere of social activity. Such a 'taxonomy of impacts' has been proposed in a former paper (List *et al.*, 1978), the results of which I only very briefly summarize here.

One and the same climatic change basically may be described on five different conceptual levels. These are:

(0)	(1)	(2)	(3)	(4)
Climatic parameters	Environmental potential	Human material activity	Social interaction	Political process

Level (0), of course, refers to the observable atmospheric conditions as described by climatology. At this level, the climatic change in question is determined in terms of temperature, humidity, wind, rainfall, radiation, cloudiness, etc.

At *level (1)*, the environmental potential, a climatic change is described in terms of ecology and geography, considering the impact of the change in climatic parameters on the conditions of life which traditionally are characterized by the four elements soil, water, air, and energy (or light, or 'fire').

At *level (2)* the human species is taken into account as far as our activities in interactions with the environmental potential. Such activities include agriculture, the energy economy, tourism, transportation, construction, manufacturing, etc., and the changes are described primarily in terms of economics and technology. This, however, does not yet include how a given change of climate is expressed in changes of the social interaction among the members of our species. Social interaction is considered at *level (3)*. Effects to be taken into account here are, among others, employment or unemployment, migration, cultural shifts, and social conflcts, so that psychology and sociology may supply a valuable conceptual frame.

So far nothing has been said about causal relations. A particular change of climate which bears on the weather as well as on the environmental potential, human material activities, and social interaction, in every case can be described in these four different languages or frames of conceptual analysis–no matter whether natural developments or human activities (like burning fossil fuels) have brought about that particular change. The fourfold description may be considered simply as a kind of spectral analysis of one particular development with respect to the field of human knowledge, given only the necessary condition that the phenomenon (also) appears in climatic parameters (while it is not necessary that every change in climatic parameters will correspond to changes in human activities or interactions). Feed-back loops and analyses which consider changes as impacts of other developments (again like burning of fossil fuels), certainly must also be considered an interesting field of scientific enquiry. In the present context, however, causal relations are relevant only insofar as implications with respect to response strategies may be expected, which–as I shall show–is probably not the case with climate.

The political process is *level (4)* of our spectral analysis with respect to climatic changes. On this level climatic changes take the form of policy measures such as legislative action, research and development programme, economic incentives or restrictions, or international policies. Generally the political changes which go together with climatic changes can be described in terms of political science. Even at this level the impact may work both ways, as an impact of climate on political decisions or as an impact of political decisions on climate. Only the effect of *potential* developments is unidirectional in principle, since even the mere possibility of a climate change can elicit a response while possibilities of political developments will not influence climate.

In considering possibilities of CO_2-induced climate changes now, the question is how these changes can be represented in terms of alternative political responses. Of course, such a representation cannot be more reliable than the description of those changes in terms of climatic parameters. Generally it will be much less reliable, because political responses to possibilities of climate change depend on the intermediate representation of those changes on the levels of human activities, material and social. The extreme uncertainty of a political response to the possibility of unknown socio-economic implications of unknown climatic changes, the implications being fairly unknown even if the changes were well-defined with respect to climatic parameters, however, does not imply that it is premature to consider political responses at the given stage of knowledge. The reason is that not only does political action depend on prognostic climatological knowledge, but also the kind of knowledge which can give rise to political action depends on the spectrum of political options. Otherwise every thought in climatology would be politically relevant, which is obviously not the case.

Climatological information, however, will have to be the starting point, even if considerations have to be adjusted back and forth to bring about an adequate assessment. So, what do we know at *level (0)*? In the first place increased CO_2

concentrations in the atmosphere are a matter of intermediate storage since the CO_2 will untimately disappear in the oceans. For the time being, however, it seems to be fairly certain

- that from current and foreseeable developments a rise in global mean temperature by about $2 \pm 0.5\ ^{\circ}C$ must be expected before the middle of the next century as a result of doubling the CO_2 content of the atmosphere by burning fossil fuels and, to a lesser degree, by vegetation destruction and soil deterioration.

This increase in mean temperature would probably not manifest itself significantly at the other levels if it were not secondly connected with

- changes in precipitation patterns. According to Manabe's (AAAS, 1979) latest model, for instance, it is expected that precipitation will increase to the North of $55\ ^{\circ}$ latitude and that sizeable changes will also take place in other regions.

Considering the details, however, the state of knowledge is far from satisfactory. Moreover, the given implications are valid (if at all) only as far as anthropogenic effects are considered, while the actual development will be the result of the superposition of anthropogenic effects on natural developments, which nobody is capable of confidently forecasting either. To neglect this distinction gives rise to well-known ambiguities with respect to warming or cooling in the future. The same statement, 'The mean temperature will increase', may refer to the anthropogenic effects alone as well as to the result of the superposition, and while fairly reliably true in the first case is more doubtful in the second case.

According to Flohn (1977) it seems that we also have to expect at *level (0)* a general shift of the climatic zones toward the Poles going together with a melting of the Arctic Sea ice and an enhanced asymmetry between Arctic and Antarctic. Moreover, some (unknown) part of the continental ice in Greenland and in the Antarctic may slowly melt during the centuries of increased temperature in the polar regions. Finally, there is a remote possibility that the West Antarctic ice sheet will break off and cause a surge. This also must be expected independently of CO_2 variations, but possibly with a lower probability.

Even with the state of knowledge with respect to changes in climatic parameters being far from satisfactory, a not completely inconclusive representation at *level (1)* is possible. The result may be, for example, that in the Ruhr area in Germany we are going to have a climate more like the present climate of northern Italy, and—more important—that the habitat for humans in Canada and in northern Russia will be considerably improved. The break-off of the West Antarctic ice sheet may be represented at this level as a rise of the ocean surface by about five metres. In considering the South, it seems that in some regions a decrease in rainfall is to be expected, though so far it cannot be specified in which areas this decrease will occur.

Changes in habitat or in the conditions of life as described in terms of ecology and geography do not only refer to the human species. Our own species, however, is the one whose future we are most immediately concerned with, so that a political response is liable to occur—if at all—most easily if human material activities are

affected by climatic change. By this I do not in any way want to suggest that we should not feel responsible for other species. We should feel a responsibility, especially if they are jeopardized by human activities, but not only then. However, given that reasoning with respect to specific developments in this area is very weak so far, it may still be legitimate to conceive in the first place of political responses with respect to the human species and to other species only insofar as they contribute to human welfare. This presupposes a representation of the *level (1)* developments at *level (2)*.

10.1 IMPACTS ON HUMAN MATERIAL ACTIVITIES

The subject at *level (2)* is human activity, not restricted to social interaction as such, but also involving 'material' impacts on the natural environment. We are concerned with a two-ended relationship, human society being on the one end and the material (more or less natural) environment on the other. Since the state of a relationship is dependent on both ends, it follows that the impact of climatic changes on this relationship—i.e. on human activities—depends on the structure of the particular society as well as on the kind of climatic change. As an example: it has been suggested by Burton *et al.* 'that the most vulnerable societies are neither the poorest and least developed, nor the wealthiest and most highly developed, but those societies in the process of rapid transition or modernization, where the traditional social mechanisms for absorbing losses and sharing them among the community has been eroded away and have not been replaced by the accumulated wealth and response capacities of more modern societies' (Burton, 1979). The ability of a society 'to bounce back', as Burton put it, when adversely affected by climatic effects, for example, is called *resilience*. Again, the resilience of a society does not occur in isolation but always refers to specific impacts, as a 'resilience (or vulnerability) with respect to . . . '. Warrick *et al.*, for instance, have argued that even if a livelihood system is insulted from recurrent climatic *fluctuations* as a result of increasingly elaborate technical and social systems, these in turn 'increase the vulnerability to *catastrophe* (my italics) from both natural and social perturbations of rarer frequency' (Warrick *et al.*, 1979).

Understanding resilience and vulnerability as a conditional property of a society with respect to external changes means that these qualities depend on the technology and, it seems to me, on the religious basis of a society, not less than on the particular character of, for example, climatic changes. Different vulnerabilities may result in a twofold disadvantage for the developing countries, since not only is their technological potential less advanced than that of the industrialized countries but also it must be expected that the CO_2-induced changes in climatic parameters for the developing countries have to be represented at *level (2)* as a more severe change in agricultural productivity than in the industrialized world. In fact, the European peoples are not only privileged with respect to wealth but proposed changes in the mean temperature by $\pm 2\,^{\circ}C$ appear less likely to influence precipitation patterns in

a way that will cause serious change in agricultural productivity. Most of the developing countries, on the other hand, are highly vulnerable to even minor variations in water supply, since they are already working at the margin of productivity, water being the main limiting factor of vegetation all over the world except for a few areas, among which only the humid tropics are in the developing world. To some extent the argument also applies to the industrialized world, for instance, since Kazakhstan in the USSR is situated in a semiarid area, and food surplus areas of the USA and Canada are vulnerable to changes in rainfall. On the whole, however, it may be concluded that

- the rich countries not only own the more advanced technologies to cope with changes in agricultural productivity but they are less liable to get into a situation where these means would have to be applied;
- while the poor countries not only lack the technological response capacity they also are the ones which would probably need this capacity.

Finally because agriculture is a relatively minor part of the economic activity of many industrialized countries, while in most of the developing countries the whole economy is still basically dependent on agriculture, it must be concluded that the conflict potential between North and South could be considerably enhanced by CO_2-induced climate changes, because the already existing inequalities in distribution of wealth may tend to be increased.

Apart from agricultural losses–which within a few years may amount to a very considerable proportion of the former productivity if precipitation falls below a minimum–the developing world may also be affected by changes in marine productivity and by losses in (rainfall dependent) hydroelectricity.

Considering the industrialized countries, I certainly do not want to suggest that they will be unaffected. Obviously we feel climatic variability–and as a first order approximation the same would apply to climatic change, or variation–in food prices, tourism, heating expenses, etc. Also the construction business (buildings, roads, etc.), like agriculture, is dependent on seasonal changes. However, in the long run the basic dependency of mankind's cultural and economic development on climatic changes, as has been suggested by Bryson (1978) for the past, in my opinion most probably does not apply to the future of the industrialized world. One cold winter, for instance, may be bad for the construction industry, but many cold winters or any other climatic changes including increases in variability may even be an economic incentive, especially if corresponding information is available early.

So much about *level (2)*. At *level (3)*, the representation of climatic changes in social interaction and international relations has already been assumed to be a rise in the conflict potential between North and South.

At *level (4)*, the remaining question is, what kind of political response(s) would be appropriate to the climatic changes in question?

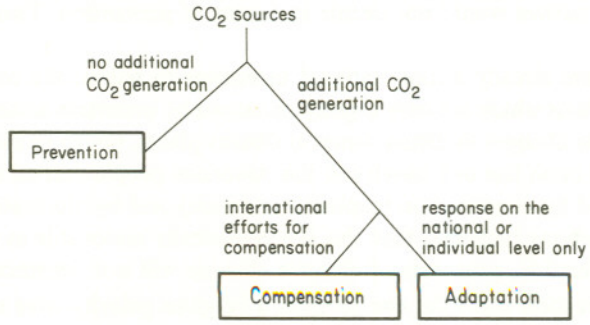
Appropriateness with respect to a political response generally means that its political 'cost' does not exceed its political benefit. Naturally these costs cannot be expressed in monetary terms but are to be understood as social costs in the broader

sense introduced by Kapp, so that alternatives have to be compared in several dimensions. These alternatives are, as Corbett (1979) put it, basically the adaptive, the curative, and the preventive approaches. Adaptation means that nothing is done against the climatic changes in question but that it is our task to fit our activities into a changing climatic pattern. Prevention is to be understood as suspending or restricting the activities which are responsible for undesirable implications. The third approach comprises all possibilities between these two and perhaps should most suitably be called compensation–especially by 'technological fixes'.

Compensation, however, is open-ended with respect to prevention and to adaptation, so that the trichotomy is not satisfying so far. On the one hand, prevention of climatic change may be achieved by originally preventing additional CO_2 generation as well as by preventing CO_2 emission from burning fossil fuels into the atmosphere (alternative disposal of stack gases) as well as by preventing increases of the atmospheric CO_2 content (compensation of additional sources by additional sinks). On the other hand, adaptation to climatic change may range from passive acceptance to global efforts of compensating for the (potential or actual) undesirable impacts of that change on all peoples. To avoid an overlapping between prevention and compensation as well as between compensation and adaptation, in my view it seems reasonable to define

(i) Prevention as prevention of CO_2 generation (for example, by substituting alternative energy forms for fossil fuels);
(ii) compensation as a suspension of undesirable effects of CO_2 generation by global efforts (international activities and budgets);
(iii) adaptation as responses to undesirable effects of climatic change on the national or individual level.

The specific difference between the first two strategies is, therefore, given by CO_2 generation or non-generation, while the two latter strategies differ in the level of response and payment (international versus national or individual). The reason to draw the second distinction with respect to the coordination and payment level is that climate is international and adequate countermeasures against climatic changes must be internationally coordinated, while programmes below the international level can be only piecemeal reactions and may suitably be called adaptation. On both levels, however, anticipatory as well as subsequent reactions are possible.



It is important to recognize that prevention, compensation, and adaptation are basically equivalent options, so that it would be a mistake to consider, for instance, prevention as being in principle better than adaptation. What is 'better' only depends on the (social) costs involved (except for taking into account the distinction between 'better for mankind' and 'better for nature', including mankind). The distinction between the three strategies also indicates two basic problems connected with any political response to potential as well as actual climatic changes

(i) The one is that a decision can hardly be identified as the relatively optimal solution without referring to what a future optimum would look like. Since the different parties—especially in international relations—usually do not agree on common goals, the 'least marginal action' (least change in behaviour) will be favoured, which in most cases is expected to be adaptation.

(ii) The other is that the different options generally, or in most cases, may turn out to be options of different parties involved so that for instance, the question is whether country A takes a step for prevention or whether country B takes a step for adaptation. International activities for compensation will also be viewed differently by the different parties involved. Obviously, international bargaining does not necessarily bring about the best solution, which would be the objective of an international authority.

Finally, the three options—prevention, compensation, and adaptation—are connected with quite different time scales. Prevention by its very definition takes place much earlier than compensation, while adaptation again generally may be left to a later time than compensation. Therefore, by way of discounting future costs to the present, the already given bias in favour of adaptation strategies will be even more enhanced with consideration of time.

10.2 PREVENTION OF CO_2 GENERATION

Can we expect that the structural bias in favour of adaptation will be counterbalanced by comparative savings of prevention or compensation strategies in relation to the costs of adaptation—be it only in the interest of the whole, an entity which is not represented by any of the different individual parties? I fear that even a hypothetical international authority charged with making the choice between the different alternatives would not decide in favour of prevention. Two basic reasons are that

(i) there are already strong national incentives to reduce the consumption of fossil fuels which are only slightly enhanced by uncertain assumptions about climatic changes in distant times at distant places. Or, to be more explicit: if the oil crisis has not convinced the American people that oil should be substituted by conservation (capital investment) and by alternative (carbon or non-carbon) fuels and that this is economically reasonable as well as technically feasible, prospects of climatic changes will not convince them either. Conservation and solar energy should be given priority over nuclear energy

insofar as nuclear energy cannot be used to substitute for oil until forms of storage or of transforming nuclear energy into fuel are developed. As far as coal is concerned, CO_2-emission per energy unit is 50 per cent higher than from oil, but this will not prevent the substitution of oil by coal wherever possible. Thus in my judgment energy development within the next 40–50 years will by itself not bring about a four-fold increase in the CO_2 content of the atmosphere, but again by itself cannot be prevented from bringing about a two-fold increase;

(ii) few changes are to the disadvantage of everybody. There are likely to be quite a few countries, including some in the Third World, which are going to receive net benefits from climatic change. Therefore, the political conflict may as a first order effect turn out to be a distributional conflict, even within the Third World, with some countries developing migration pressures with respect to others.

In any case, it is most improbable that the industrialized world will slow down economic activity by energy restrictions for reasons beyond those which already exist and that other countries will stop burning forests to prevent CO_2-induced climatic changes. After all, events like the Sahelian drought or a Peruvian El Niño irregularity should be considered bad enough to elicit action so that the irregular becoming regular probably will not bring about changes in human behaviour either. Different reasons or causes for similar results do not seem to change this situation.

My conclusion, however, is only that prevention should not be expected at any considerable price. To the extent that CO_2-induced climatic changes can be prevented by way of a joint production of benefits, by piggybacking CO_2-oriented measures on to measures which are accepted for others reasons, the costs of which do not rise significantly by bringing about that additional benefit, even preventive steps may reasonably be expected. The joint production of benefits from reducing oil consumption (and thereby perhaps imports) and CO_2 emissions at the same time is a good example, for certain countries, of a piggy-backing strategy.

10.3 COMPENSATION BY INTERNATIONAL EFFORT

If CO_2 generation which would double the CO_2 content of the atmosphere within the next 40–50 years cannot be prevented, the next question is whether something can be done so that at least the undesirable implications will be prevented. This is a field where considerable amounts of technological fantasy and imagination are called for.

First I may refer to Marchetti's famous 'Gigamixer'. The idea is to put the stack gases from electricity generation as well as from heat generation centres (by burning fuels with pure oxygen or by filtering out CO_2 and other components) into a current which is at the ocean surface at Gibraltar and then disappears in the deep sea—being supposed not to show up again within the next five hundred years, after which overloading the atmosphere with CO_2 will not be a problem anymore,

because by then mankind will have run out of fossil fuels. A similar idea is to use the stack gases as a fluid for tertiary recovery in exhausted oil fields (Marchetti 1979).

Secondly, one may think of replacing rainfall by irrigation, even if this were extremely expensive in terms of money as well as energy.

A third idea is to redesign biological species or their geographical distribution so that agricultural production under changed climatic conditions will be similar to today's production from today's species.

Others have proposed planting 10^{12} trees or 'moving a metre of topsoil from Iowa to where Iowa's climate will then be' (L. Lave at AAAS, 1979) on a global scale. Finally, the most appealing idea to the modern mind—appalling, however, when accepted as a general principle—may be to venture into 'global climate management'. In fact, having agreed on so much resource management already, be it water, energy, or the environment in general, there seems to be no conclusive reason why our domination of nature and our treatment of nature as a 'resource' should not be extended to climate. On the other hand, we are beginning to realize that technological solutions of problems are generally tied up with social commitments and that there are good arguments in favour of the recommendation to consider these social commitments not less but even much more carefully than the technology itself (Meyer-Abich, 1979).

Apart from these more philosophical considerations, the chances of compensation measures depend on the costs involved and on agreement among the different parties as to who will be charged which share of the total costs. Considering the price of technological fixes, Marchetti has estimated that electricity production would become about 30 per cent more expensive if the stack gases were transferred to his gigamixer. If one takes into account that new technologies tend to be π times more expensive than originally calculated, this may be a large amount of money. Global climate management—basically cloud and rain distribution management—will not necessarily be a less expensive solution. These costs, however, are not high or low by themselves but are high or low only with respect to the benefits in question.

The benefit of preventing climatic changes by technological compensation may be given as the opportunity costs minus the benefits of a climatic change (if there are any). The opportunity costs are to be understood as the additional benefits which would have occurred if the climate had not changed, or as losses brought about by climatic change. Within the Climate Impact Assessment Program (of the US Department of Transportation), d'Arge (1974) has ventured to calculate such opportunity costs for some parts of the global economy, on the basis of a scenario with a 1 °C decrease in mean annual temperature. Pretending any accuracy and reliability at all for such partial or further extended calculations has been strongly criticized by Margolis (1978), and I agree with him. This criticism even applies to calculating opportunity costs of climatic changes with respect to present activities with given objectives in a given climate. It applies, therefore, even more

- *to future* activities the goals of which are unknown, so that nobody knows whether climatic changes can be held responsible for missing political goals to this or that extent or whether they contribute to achieving them. Or, if goals were made explicit, again it would be an open question whether they will be missed on account of climatic changes. A country, for instance, might claim to have been prevented by climatic changes from becoming the wealthiest country in the world. It may well be that this claim, 'iffy' as it is, could hardly be refuted; to stating deviations with respect to a reference case which is ill-defined in itself, since the climate is also changing by natural developments. The benefit of compensating for anthropogenic effects on climate obviously is ill-defined when natural fluctuations of the same order of magnitude may be expected which nobody can predict or exclude so far.

Finally it must be pointed out that even if the opportunity costs and benefits of climatic changes were known or at least conceptually defined, the political problem of charging different parties with costs of the technological fixes in relation to their particular responsibilities as well as to their costs and benefits would be practically insurmountable. Climate cannot be nationalized. It is essentially an international concern, so that any climate management or compensation strategy involves economic externalities–positive or negative–with respect to national borders. Investments to compensate for climatically harmful activities, therefore, will be almost without returns generally if not endeavoured on the basis of international cooperation, excluding 'free rider' policies as much as possible. The implication is that something like the 'polluter pays principle' from environmental policy also should be applied in climatic matters. It is at this point and so far only at this point that the question of different national liabilities with respect to climatic changes arises. Since not even the benefits of technological compensation strategies can be determined, however, the question of cost distribution according to differential national liabilities may be considered irrelevant. Also it may be argued that costs should be distributed according to the expected benefits instead of the shares in pollution.

10.4 ADAPTATION TO CLIMATIC CHANGE

As Glantz (1979) has pointed out, climatic change by CO_2 production would be another of those low grade, but continually increasing, insults to the environment for which a pluralistic society '. . . has not yet found an effective policy-making process'. If the problem–as it seems–cannot be taken care of by prevention or technological fixes (compensation), the chances of adaptation depend on developing policies with respect to 'impending crises'. As Mann (1979) put it: 'What we need is not a massive decision but a gradual learning process'. This process may lead to

- migration into those regions which are favoured by the climatic changes in question. Though it is very hard to live as an immigrant, this is the traditional solution to such problems in the history of mankind;

- vocational re-education and industrialization. This is going to happen anyway and will also allow for an increase in population density or make up for decreases of agricultural productivity.

Obviously, the adjustment of economies adapted to the present climate to a different climate and the migration of hundreds of millions of people again imply considerable costs. These costs are highly dependent on early information about the developments to be expected so that forecasting climate—allowing for active rather than passive adaptation—can save enormous amounts of money, and they will occur only within decades. In the context of present development debates, however, it seems that with respect to the next 40–50 years

- neither are we confronted with a new problem, since the overburdening of productivity capacity by high population densities is happening already and has been a problem for a long time;
- nor are any monetary claims involved which would change the present situation as far as development policies are concerned.

Compared to the already existing problems in development policy, the possibility of CO_2-induced climate change, therefore, seems to be a 'marginal' problem in the sense of not being qualitatively different, while quantitatively not significantly increasing the already given tensions. For example, the recommendation to increase food reserves (requiring higher production in the industrialized world), reasonable as it is with respect to possible climatic changes and food shortages, is eminently reasonable with respect to the present situation as well. The same applies to Elise Boulding's (1979) recommendation 'to draw on skills that are now hidden from policy makers', reviving 'traditional knowledge stocks of peasant and nomadic communities, of ethnic groups in industrialized societies, or minority-status groups in all societies, including particularly women and children'.

Of course, nobody can exclude that crop yields in some developing countries will drop by, say, 50 per cent within five years for reasons of climatic change. A fifty per cent decrease in productivity corresponds to a hundred per cent increase in population density, and this—at a rate of two per cent per annum—would be reached only in thirty-five years, so that the assumed climatic change comes out to be something like 'seven times worse' than that population increase. But again, even if we knew such a drop in crop yield were to be expected at some future time, we could not do better than do what should be done already for reasons independent of CO_2.

So far the gist of my argument is that even an international authority with definite political objectives—except for piggy-backing strategies—would not decide in favour of

- prevention because the already given incentives are only marginally enforced by the climatological argument, and because further prevention has not been shown to be better than non-prevention on a global scale;
- compensation because the benefit of those expensive programmes is ill-defined, not to mention the distributional problems, while the costs of adaptation are

distant, are again only poorly defined, and in any case are marginally charged on account which is grossly imbalanced anyway.

A comparative cost evaluation of the three strategies, therefore, cannot be conclusive. The situation would be different if for reasons of climatic change catastrophic developments of the same kind and order of magnitude as those which have to be expected now, or undesirable developments of a new quality were to emerge beyond 40-50 years. As Flohn (1977, 1979) and others argue, this may very well be true, even if to some degree uncertain with present knowledge. At the same time, however, it is not a political issue requiring additional decisions now.

Adaptation, therefore, seems to be the most rational political option for the time being. It also requires the least marginal action (i.e. least action specifically for reasons of climatic change and not also or mainly justified for other reasons). No problems have been identified so far with respect to CO_2—or otherwise induced climate change—which change the political situation and which should not be emphasized and taken care of for better and more urgent reasons as well. Politically, the CO_2 problem is like chalk on a white wall—or rather like some additional darkness in the night. To blame only the marginal darkness for the gloom is politically misleading or even deceptive. This result, however, should be taken only as a first order representation of possible CO_2-induced climatic changes at the political level. Much more consideration will have to be given to interactions among the different levels to achieve an adequate assessment. The next step may be to look for climatological representations of political conflicts, taking into account, for instance, that the industrialized world

(i) may be blamed for food shortages in the developing countries because of CO_2 changes, even if there is no sound climatological justification. There is so much talk about CO_2 or other man-induced climatic change that minor climatic irregularities already give rise to the question whether 'this is it' (S. Schneider, personal communication);

(ii) is generally experiencing a growing concern about being responsible for social and technological commitments of mankind in the very distant future, so that the concern about climate may be only one element or a symbol of a more deeply rooted uneasiness.

In this sense, the climatic concern beyond itself may become an important focus for social and political concern about not adequately doing what should already be done for reasons which have nothing to do with CO_2.

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