

Introduction

Global Warming: Problems and Perspectives

1. INTRODUCTION

The relations between the environment and processes of economic development have in recent years become increasingly complex. This is primarily due to the accelerated pace of economic development in many parts of the world in the last several decades, as manifested by the rapid rates at which basic statistical indicators such as gross domestic product, the volumes of industrial outputs, and the degree of urbanization have been increasing (see, e.g., World Bank 1999). This phenomenon is also closely related to the institutional arrangements, both in capitalist and former socialist countries, concerning the allocation of both privately owned and publicly managed resources.

During the last three decades, in particular, we have also seen a significant change in the nature of the social, economic, and cultural impacts on the natural environment during the processes of economic development. This is symbolically illustrated by the agendas of two international conferences convened by the United Nations – the Stockholm Conference in 1972, on the one hand, and the Rio Conference in 1992, on the other.

The Stockholm Conference was primarily concerned with the degradation of the natural environment and the ensuing health hazards caused by the processes of industrialization during the 1960s. Then the degradation of the natural environment was mainly caused by the emission of chemical substances such as sulfur oxides and nitrogen

oxides that by themselves are toxic and hazardous to human health and the biological environment. In the Rio Conference, on the other hand, the main agenda focused on the degradation and destabilization of the global environment such as global warming, the loss of biodiversity, desertification, and other global environmental issues stemming from intensified industrialization and extended urbanization. These effects are primarily caused by the emission of carbon dioxide and other chemical substances that by themselves are neither harmful to the natural environment nor hazardous to human health but at the global scale cause atmospheric instability and other serious environmental disruption.

The impact of global environmental degradation is most painfully felt by developing nations because agriculture and related sectors of the economy are the most sensitive to changes in climatic and ecological conditions due to global warming. Institutional arrangements and policy measures intended to remedy environmental degradation also are most likely to have an adverse effect on developing nations or those whose income levels are low, for that matter. Traditional economic theory is not particularly well-suited to handle these problems, which are primarily concerned with distributional equity and ethics – from intergenerational and international perspectives.

The changing environmental impact of the processes of economic development has forced us to reexamine the basic premises of economic theory in general and environmental economics in particular, and to search for a theoretical framework in which the mechanisms interweaving the natural and social environments with processes of industrialization and urbanization are more closely analyzed, and their social and policy implications more explicitly brought out. We are particularly concerned with the processes of economic development sustainable with respect to the natural environment and within the market economy and the analysis of the institutional arrangements and policy measures under which the processes of sustainable development may ensue. Such institutional arrangements are generally defined in terms of property right assignments to various natural resources with specific reference to the behavioral criteria for those social institutions and organizations that manage various natural and common resources.

One of the obvious implications of the changing environmental impacts on economic processes in the last three decades is that economic

incentives on the part of individual members of society are primarily replied on, and direct social control or coercion are neither effective in solving global environmental problems nor desirable from social and cultural points of view.

Abating Global Warming

Global warming evolves gradually, and the damage spreads widely – both geographically and over time. Global warming thus poses serious problems of ethics and justice from international and intergenerational perspectives. Particularly serious questions have been raised by d'Arge, Schultze, and Brookshire (1982), Lind (1982a,b), Cline (1992a,b, 1993), and others about the appropriateness of standard approaches such as the theory of dynamic optimum or cost–benefits analysis. As typically stated in Cline (1992c), their argument is based primarily on the presupposition that the scientific predictions involve such a serious degree of uncertainty that any substantial action of abatement today that incurs significant costs would not be warranted. They went further by observing that, even if the scientific predictions were entirely correct, the greenhouse effect would simply be too insignificant in economic terms to warrant such preventive efforts, as emphasized by Nordhaus (1982, 1993a,b) and others.

A strong consensus, however, is now emerging among economists and government officials in many countries that control of human-generated greenhouse gases would yield a global public good. Because unilateral approaches are unlikely to be sufficient, international solutions must be sought, as emphasized by Barrett (1990) and Hoel (1991, 1992), although the likely existence of free riders may make such international agreements or conventions extremely difficult to implement, as pointed out by Hoel (1994).

As argued by Rosenzweig and Parry (1994), the benefits and costs are not uniformly distributed across nations. The developing countries, especially island nations, would suffer most primarily because the damage due to global warming tends to be most serious for agriculture, fisheries, and related industries. Still they are not the ones who emit large amounts of greenhouse gases. Regional differences in the impact of global warming are so significant that reaching an international agreement becomes almost impossible. Although regions with a cold

climate might generally benefit from global warming, the Scandinavian countries, such as Sweden and Norway, would greatly suffer from a significant decrease in temperature because the warm Gulf Stream would stray away from the Scandinavian Peninsula.

The burdens of controlling greenhouse gases will be felt more severely in developing nations than developed nations, as examined in detail by Whally and Wigle (1991). Arid regions generally tend to become more arid, making an ever greater portion of land infertile desert. Generally speaking, food production in developing countries would significantly decrease with the advent of global warming, and consequently a serious food crisis during the twenty-first century would almost certainly arise.

Mendelsohn, Nordhaus, and Shaw (1994) have estimated that the damages in the United States would be slight because higher-valued crops could be substituted for the more vulnerable crops currently being cultivated. Their estimates are based on an optimistic presupposition that farmers in the United States would employ all the possible strategies to adapt to changes in climatic conditions, which is an assumption too optimistic even for the most rational and enterprising American farmers.

Contrary to the optimistic estimates of Mendelsohn et al. (1994), the estimates for the magnitude of the damages to farmers in the developing countries are pessimistic. According to Rosenzweig and Parry (1994), for example, farmers in developing nations would suffer greatly from global warming.

The Commons

The idea that the problems of externalities may best be solved within the conceptual framework of the theory of the commons was strongly criticized as the “tragedy of the commons” as originally put forth by Lloyd (1833) and elaborated by Hardin (1968). The “tragedy of the commons” dispute was followed by numerous contributions to the search for those institutional arrangements whereby the “tragedy of the commons” might effectively be avoided. Among them, there are two influential papers, each of an entirely opposite view: Scott Gordon’s study of the commons in the marine fishing industry (Gordon 1954) and Ronald Coase’s classic paper (Coase 1960).

The institutions of the commons have been much criticized by some economists such as Demsetz (1967), Furubotn and Pejovich (1972), and Godwin and Shepard (1979) among others. A typical statement is the following one made by Demsetz (1967, pp. 354–5):

Suppose that land is communally owned. Every person has the right to hunt, till, or mine the land. This form of ownership fails to concentrate the cost associated with any person's exercise of his communal right on that person. If a person seeks to maximize the value of his communal "right," he will tend to overhunt and overwork the land because some of the costs of his doing so are borne by others. The stock of game and the richness of the soil will be diminished too quickly.

It is difficult to find the commons described by Demsetz. The commons of the barbarian age might have matched his conception, if we use the terminology of another Chicago economist, Thorstein Veblen (1899), but it is extremely difficult to find such commons in modern times. Any commons would have a set of rules governing the way members might use the common property resources to ensure that they would be sustained for a long time, as documented in detail by McCay and Acheson (1987) and Berkes (1989).

Contrary to the arguments presented by Demsetz and others, more reasonable and sane views were forcefully put forward by Sen (1973), Dasgupta (1982b), Cornes and Sandler (1983), Leggett (1990), Uzawa (1992b), Barrett (1994), and others.

However, Demsetz's criticism is valid regarding the earth's atmosphere – the largest commons all the people on the earth share. As Barrett (1994) has pointed out, the theoretical arguments for supposing that international cooperation for the stabilization of the earth's atmosphere will not develop are compelling, but they can hardly be complete. Cooperation occasionally take place, as the successful case of the *Montreal Protocol on Substances That Deplete the Ozone Layer*, 1987 illustrates.

Coase's Theorem

Coase (1960) argued that the institutions of private property rights would induce an efficient allocation of scarce resources. Coase's theorem, however, was derived under the presupposition that the wealth effect is zero and that there are no transaction costs. Coase's arguments

are based on the proposition that, if the conditions of private ownership were to prevail, the result would be the same whether polluters had to compensate the victims of pollution for the damage suffered or the victims had to pay to the polluters to induce them to stop the operation or to clean the polluted air, soil, or water. We understand that Coase's theorem was intended to point out the unethical and unrealistic basis of neoclassical economic theory, but it actually was often understood differently, as in Demsetz (1967).

Coase's presuppositions that the wealth effect is zero and that there are no transaction costs are critically related to the theoretical framework of neoclassical economic theory. They in particular preclude the existence of social overhead capital. The earth's atmosphere is one of the more crucial components of social overhead capital, and the analysis of global warming begins with the recognition that social overhead capital generally precludes private ownership arrangements, but not necessarily. When the rights to utilize social overhead capital itself or the services derived from it are assigned to individual members of the society, the central issue is how to realize the pattern of allocation and the resultant distribution of welfare in a way that will be acceptable in terms of the prevailing sense of equity and social justice.

As pointed out by Bromley (1995), when wealth effects exist, the initial assignment of property rights is crucial in determining the welfare distribution of outcome, as is precisely the case with global warming. The world faces a genuine choice to be made among alternative future climates, as argued, for example, by Rosenberg et al. (1989).

Regarding the principle to judge the distribution of welfare among individual members of a society under the presence of public goods in the Samuelsonian sense or of social overhead capital in general, an important role is played by the concept of the Lindahl solution, which was originally introduced by Lindahl in his classic paper (Lindahl 1919). The Lindahl solution is realized when the amount of public goods or social overhead capital actually provided by a society is precisely equal to the amount that each member of the society wishes to have under the budgetary constraints each member is subject to.

Many contributions have since been made to reinforce the proposition that the concept of the Lindahl solution concretely formulates the sense of equity and social justice prevailing in society. It has turned out, however, in the case of the market for tradable emission permits,

that the Lindahl solution has a tendency to reinforce rather than to mitigate the inequality in the initial distribution of welfare among individual members of the society. Because the concept of the Lindahl solution is defined so esoterically as to obscure this basic property of the Lindahl solution, only a few thoughtful economists have noticed it and made oral comments about it. Indeed, this observation will be one of the major conclusions in Chapter 3, where the function of markets for tradable emission permits will be examined in detail.

Policy Instruments for Global Warming

As argued by Bertram (1992), the institutional and policy arrangements to curtail the emission of greenhouse gases may be categorized into three types: direct quantitative emission restrictions, carbon taxes, and tradable emission permits.

Direct quantitative emission restrictions are not only ineffective in abating the processes of global warming but also tend to obstruct the freedom of individuals only to enlarge the domain of bureaucratic control. The primary policy instruments now are environmental taxes, such as carbon taxes, and markets for tradable emission permits or some other form of pricing scheme by which market institutions in a broader sense may effectively bring in to play the role of allocative mechanisms. With respect to global warming and other global environmental issues, these problems were extensively examined by Markusen (1975a,b), Warr (1983), Bergstrom, Blume, and Varian (1986), and Copeland and Taylor (1986), among others.

Several policy instruments have been proposed by Grubb and Schenius (1992), Hoel (1991), Pearce (1991), Victor (1991), Rose and Stevens (1993), and Weyant (1993) to combat the greenhouse effect, and theoretical analyses have been developed by Poterba (1991) of carbon taxes and by Tietenberg (1985, 1992), Barrett (1990), Barrett et al. (1992), and Bertram (1992) of tradable emission permits. Hoel (1991) and Pearce (1991) have proposed levying a uniform carbon tax and then distributing targeted reimbursements. However, the underlying assumption is that there is an international agency that can be relied on to do this efficiently.

As argued by Grubb (1989), of all the instruments examined, the system of tradable emission permits may be the most promising. It is

flexible in operation and efficient in abating global warming. Bertram, Stephens, and Wallace (1989) argued that a global system to regulate greenhouse gas emissions over timespans of several decades should start from a strong presumption in favor of the long-term property right of the world population to inhabit a sustainable global ecosystem.

As pointed out by Bertram (1992), the concept of tradable emission permits emerged from a theoretical debate over the economics of externalities (Dales 1968 and Baumol and Oates 1988). Bertram et al. (1989) argued that a world-wide system of tradable mission permits could be an effective way of advancing the interests of developing countries in harmony with the global community's interest in protecting the atmosphere. This view was expounded on and reinforced by Grubb (1989, 1990), Hoel (1991), and others.

The main advantages of the institution of markets for tradable emission permits are their ability to achieve environmental aims with a minimal bureaucratic apparatus. The central problem with most such schemes is determining the initial allotment of tradable emission permits. The costs of alternative permit allocations have tentatively been calculated by Larsen and Shah (1992, 1994) and others.

The reliance on market institutions and private incentives, however, may occasionally bring about unstable and socially unjust outcomes in the distribution of income, both nominal and real. The consequences are particularly undesirable for the economic health of developing nations, occasionally resulting in a decisive widening of the gaps between developed and developing nations.

2. GLOBAL WARMING

In the last 20 years or so, we have been warned continuously by geophysicists and meteorologists of numerous symptoms indicating that the atmospheric equilibrium is being disturbed on a global scale. The phenomenon of global warming is such a symptom – apparently one of the most serious – and will have enormous implications for virtually every aspect of human life on earth, affecting not only current but all future generations.

The Industrial Revolution ushered in a new phase in the history of mankind. Scientific inquiries have stimulated the development of new technologies, which, in turn, have been utilized effectively by

avid entrepreneurs for large-scale production of goods and services – ostensibly to enrich the lives of people. In spite of many breakdowns in the process of economic development, the living standard of the average person – at least one not residing in a despotic country – seems now to have reached an unprecedentedly high level. However, advanced technologies and their large-scale applications, if not properly managed, tend to inflict intense and irrevocable damage to natural environments.

The new technologies brought in by the Industrial Revolution are characterized by the massive consumption of fossil fuels – particularly coal and oil. Recently, several scientific studies have demonstrated that excess burning of fossil fuels disturbs the atmospheric equilibrium and brings about a global warming of the earth's surface.

Increase in Global Average Surface Air Temperature

The extent of global warming may best be indicated by the global average surface air temperature, which has continuously risen during the approximately 200 years since the Industrial Revolution with an accelerated rate of increase in the last three decades.

The temperature on the earth's surface is rather difficult to identify. It varies a great deal between the regions. The seasonal variations are large and so are the yearly changes. However, the historical data show an evident long-term trend for an increase in global temperature. Among the many studies made concerning the mechanism by which the global average surface air temperature changes, we may cite a few: Hansen et al. (1981), Fraser, Elliott, and Waterman (1986), Hansen and Lebedeff (1987, 1988), and Conway et al. (1988).

The global average surface air temperature has increased 0.3°C – 0.6°C in the last hundred years. The early studies by Hansen and Lebedeff (1987, 1988) indicate that the rate of increase in the global average surface air temperature has increased from -0.5°C in 1880 to 0.2°C in 1980 on the 5-year moving average basis. According to the second report issued by the Intergovernmental Panel on Climate Change (IPCC 1996a,b), the global average surface air temperature will most likely increase by 1.0 – 3.5°C during the period from 1990 to 2100. The third IPPC Report predicts a much higher increase of 1.4 – 5.8°C during the same period (IPCC 2001a,d). This is a disturbing phenomenon if

we note that the global average surface air temperature had risen only 0.7°C during the nearly 10,000 years since the end of the last Ice Age to the time of the Industrial Revolution. As suggested by Dickinson (1986), the actual warming equilibrium would be an increase in magnitude comparable to the increase the earth has experienced in the 10,000 years since the last Ice Age.

An increase in the global average surface air temperature of such magnitude will bring about alarming changes in rainfall patterns and other climatic conditions, resulting in serious ecological disequilibrium. An immediate impact of global warming is a rise in sea level. Gornitz, Lebedeff, and Hansen (1982) have reported that the sea level has risen about 10 cm because of the increase in surface air temperature from 1880 to 1980. The first IPCC report predicts that the sea level could rise about 20 cm (10–32 cm) by 2030 and about 45 cm (33–75 cm) by 2070 (IPCC 1991a). The second IPCC Report predicts that the sea level will rise 13–94 cm during the period from 1990 to 2100 (IPCC 1996a), and the third IPCC Report predicts a slightly lower increase of 9–88 cm during the same period (IPCC 2001a). A sea level rise on the order of 20–60 cm would have an almost catastrophic impact on human life because the majority of human settlements are located either near the seashore or by rivers. It is estimated that more than half a billion people would be directly affected by such an increase in the sea level.

The strength and frequency of hurricanes and typhoons would also intensify, and the distribution of rainfall would become more unstable. Climatic changes accompanied by global warming would place a particular hardship on farmers and fishermen because the choice of crops and the mode of cultivation have been adjusted to suit climatic and soil conditions slowly over many years and the availability of fish is delicately correlated with the natural environment. Tropical or subtropical climatic conditions would spread farther to the north (or the south for those in the Southern Hemisphere), thus disseminating the danger of tropical diseases and insects.

Atmospheric Concentrations of Greenhouse Gases

The principal cause for global warming is the atmospheric concentration of radiative forcing agents, which keep infrared radiation from the earth's surface and warm the surface air temperature. The radiative