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Fifth Joint Conference on

Agriculture, Food, and the Environment

Proceedings of a Conference Sponsored by
University of Minnesota
Center for International Food and Agricultural Policy

Università degli Studi di Padova
Dipartimento Territorio e Sistemi Agro-forestali

Agricultural Development Agency - Veneto Region

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SESSION II: AGRICULTURAL POLICY AND SUSTAINABLE DEVELOPMENT

1. AN OPERATIONAL MODEL OF SUSTAINABLE DEVELOPMENT: SOME THOUGHTS ON GETTING THE INCENTIVES FOR PUBLIC POLICY RIGHT

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FOREWORD

This volume contains the papers presented at the Fifth Joint Minnesota/Padova Conference on Food, Agriculture, and the Environment held at Abano Terme, near Padova in Italy, June 17-18, 1996. This conference was organized by the Center for International Food and Agricultural Policy at the University of Minnesota and the Dipartimento Territorio e Sistemi Agro-forestali at the Universitá degli Studi di Padova (University of Padova) under their international collaborative agreement, along with the Agricultural Development Agency - Veneto Region, the University of Perugia, and the University of Bologna - CNR. The first Joint Conference was held in Motta di Livenza, Italy in June 1989, the second in Lake Itasca, Minnesota in September 1990, and the third in Motta di Livenza in June 1992. The Fourth Joint Conference was held in September 1994 at the Spring Hill Center in Minnesota.

This conference focused on topics of mutual interest in the areas of (1) agricultural and resource policy, (2) land markets, (3) the food and agricultural industry, (4) agriculture and the environment, and (5) agricultural production and environmental quality and sustainability. Although the conference was not intended to provide a comprehensive coverage of all the issues, this volume hopefully represents a useful contribution to current understanding and debate in the areas of food, agriculture, and the environment.

Judy Berdahl, secretary for the Center for International Food and Agricultural Policy at the University of Minnesota, assisted with these Proceedings.

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An Operational Model of Sustainable Development: Some Thoughts on Getting the Incentives for Public Policy Right

G. Edward Schuh* and Sandra O. Archibald**

As background for addressing agricultural policy and sustainable development issues, we address in this paper some general issues we believe it important to consider in developing a broad and consistent conceptual framework for the analysis of sustainability. The objective of this paper is to propose a comprehensive conceptual framework for bringing sustainability issues into practical public policy formulation. A "people first" view is proposed; one that assumes that the ultimate purpose of natural resources and the economic system is first the well-being of mankind. The definition of resources is broader and explicitly includes human capital investment policy as part of the overall set of policies that affect the sustainability of a development strategy. The priority as we see it is for "getting the incentives for public policy right," as opposed to economists' more narrow view of "getting the prices right." Such a view is in contrast to a focus on regulatory policy to achieving sustainability objectives.

We present an approach to the discount issue by recommending that if a system is to be sustainability it should transfer the maximum well-being from the resources of a given population (e.g., country) to the expected population of the next generation. We call for close cooperation between economists, biological and physical scientists in estimating the necessary relationships between agricultural production processes and environmental effects. This

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multidisciplinary work is essential to integrate sustainable concepts into policy analysis. An open economy/global perspective to addressing sustainability is key as well. Sustainability cannot be thought of as an autarkic world of self-sufficient nations. International trade has the powerful capacity to relax the pressure on fragile resources in countries that have a limited resource base. Also, trade is a powerful stimulant to economic development and helps reduce poverty in low-income countries. In this sense, the dynamic effects of public policy cannot be overlooked.

We argue that the domain of public policy must be broader if truly sustainable development is to be pursued. Macroeconomic policy, trade policy, factor market policy and science policy can all have a large impact on agricultural development. Perverse trade and macroeconomic policies can have a significant adverse impact on the sustainability of agricultural system.

Lastly, we emphasize the importance of research investments to develop new technologies to expand the substitution possibility, to increase productivity and to save scarce or fragile resources or factors of production. Much of sustainability literature considers science as part of the problem. Sustainable development will be dependent on public investments.

Making Sustainable Development Operational

Those who first articulated the concept of sustainable development did so in terms of maintaining or sustaining the underlying resource base, where the resource base referred to natural resources. For the most part, natural resources in this context generally referred to land, water, and forest. In general, focusing on the maintenance or sustainability of individual resources is not a realistic goal, however, nor does it make sense economically. Not only are important issues of pollution excluded, but substitution possibilities in production exist in almost all lines of economic activity. If one thinks about agriculture in the context of the more general economy, the quality of the air also becomes an issue since pollution of the air by the industrial or manufacturing sector

can also have deleterious effects on agriculture. Air pollution from low cost, poor quality fossil fuels used in inefficient processes, in particular, is a serious issue.

This calls attention to the importance of pollution issues more generally. It is now generally recognized that underground water supplies are polluted by the application of commercial fertilizers, pesticides, and herbicides. Less widely recognized, but perhaps more important, is the "pollution" of lakes, reservoirs, streams, and rivers with the run-off of silt from soil erosion. Pollution can destroy sources of water for production systems dependent on irrigation. Important in some parts of the world, is the damage to the environment from the spilling of radioactive wastes, either into underground aquifers or on the surface, as in the case of Chernobyl. This source of environmental damage may become more important in the future. Likewise, new technology can raise the productivity of natural or primary resources (land or labor) and thus provide for future increases in output. Finally, consumers can and do shift their consumption bundle in response to changes in per capita incomes and in relative prices. Given that factor proportions vary among commodities, the demand against the underlying resource base thus can change, either in response to increases in per capita income or in response to environmentally induced changes in the cost of production.

For these reasons, we take a broader definition of sustainability. We believe it should be defined in terms of *sustaining maximum welfare from available resources*. From this perspective, achieving sustainable development may involve changes in the economic structure, in organizations and institutions, and in the economic-ecological system. Such a definition properly reflects the maximization of a welfare function subject to a set of constraints (available resources). Available resources will be subject to change over time as new resources are identified, others degrade and disappear, and still others become too costly to be economically efficient in production.

This definition does not define away the sustainable development problem. The issues of maximizing social welfare from a limited stock of resources, of avoiding unnecessary destruction

of resources, and of optimizing the rate at which resources are used over time still continue to be important. Casting the problem in this way, in fact, makes sustainable development a more pervasive and in some sense more important problem. It also casts sustainability as a more tractable economic problem, without in any way reducing the significance of the political and social issues.

Operationally, implementing the goal of maximizing welfare within the constraints set by available resources requires that traditional economic development models be expanded to incorporate more fully the interactions between economic and biophysical systems. Although some to these interactions have traditionally been incorporated into welfare analyses, many others have been omitted. For example, the contribution of fertilizers or pesticides to production is now typically incorporated into the production function. But use of such inputs can also have adverse effects by damaging the underlying resource base or by polluting other natural and environmental resources. The traditional production functions, therefore, must be supplemented by *resource degradation functions* and *environmental damage functions*. Where damage can be repaired or mitigated by purposeful activity, *mitigation functions* should also be in the choice set.

The specifications of these functions must be accurate representations of the biophysical interactions between inputs used in the production process and the underlying natural resource base. It is important, therefore, that policy makers and social scientists work closely with biological and natural scientists. The latter have a great deal to contribute to the analysis of agricultural policies and their affect on sustainability.

Sustainable development was defined in 1987 by the World Commission of Environment and Development as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs." Our concept is perfectly consistent with that definition as long as one recognizes that the welfare objective that serves as the basis of our perspective involves an inter-temporal perspective.

The above concept was elaborated for the food and agricultural sectors in the following definition, adopted by the FAO Council in 1988:

> Sustainable development is the management and conservation of the natural resource base, and the orientation of technological and institutional change in such a manner as to ensure the attainment and continued satisfaction of human needs for present and future generations. Such sustainable development (in the agriculture, forestry, and fisheries sectors) conserves land, water, plant, and animal genetic resources, is environmentally non-degrading, technically appropriate, economically viable, and socially acceptable.

Our concept of sustainability is thus seen to be perfectly consistent with the definitions proposed by both the World Commission on Environment and Development and FAO. The difference is that ours tends to be more general, provides for the inclusion of all resources, including human capital (see below), and is somewhat more operational. Ultimately, we believe our concept is more powerful and will provide more "bite" in addressing these issues, precisely because it *is* more general and more operational.

Developing A Global Perspective

Technological breakthroughs in the transportation and communication sectors, plus the computer revolution, have contributed to giving us a global economy. International trade has grown in the post-World War II period about twice as fast as global GNP. Trade has increased at a faster rate than global GNP in every year except for five during this period, and those five exceptions were years of severe economic recession.

In addition, national economies have become increasingly well integrated by means of an emerging international capital market that links almost all national economies in ways they have not been linked ever before in history. Similarly, although not as well developed or as advanced, an international market for labor is also emerging in the global economy. This international labor market serves both highly skilled and well-trained members of the labor force as well as the less well skilled. Workers now migrate from one country to another on almost all continents and often in relatively large numbers. For example, it is currently estimated that some 4 million citizens of

relatively small Mozambique reside outside the country as a consequence of the internal war it has experienced over the past 15 years.

Two features to these emerging market linkages are especially important. The first is that much of the previous isolation and segmentation of national economies is now breaking down, not only in the previously centrally planned economies, but also in other countries that are shifting to an increasing reliance on market forces to allocate resources and to distribute income. Second, the potential of the technological breakthroughs in the transportation and communication sectors and the computer revolution is far from being fully exploited. Most developing countries have not fully availed themselves of these new technologies, and the same applies to the previously centrally planned economies. Thus the scope for further expansion of international trade, and for the further development of international capital and labor markets, is vast. As one looks to the decades ahead, the expectation is that national economies will become increasingly well integrated with each other.

The significance of these developments to the sustainable development issue is that this increased integration through international markets creates the potential for large efficiency gains from the international division of labor, increased specialization in production, and the realization of comparative advantage. The efficiencies from these processes will release the resources essential for realizing sustainable economic development on a scale not realized in the past. Moreover, the gains from increased specialization go far beyond the static gains usually accounted for in assessing the benefits of trade liberalization. The *dynamics* of trade liberalization, now reflected in the newly emerging endogenous growth models, will result in far larger economic gains than those attributed to static effects, especially as they make possible the increasing returns identified by Ernest Young in 1929 and only now being traced to investments in human capital. Failure to recognize these potential gains will be to miss most of what will be important in the coming decades.

The growing linkages among countries also raise the issue of the level at which sustainability should be pursued. In a closed system, all resource flows must originate and end within the system. Such a system is therefore ultimately limited by its own resource base. In an open system, on the other hand, resource flows can originate and end outside the system. Growing international trade has converted what had once been distinct, essentially closed, systems into open systems. Ultimately, of course, the global resource base defines the welfare that can be supported in the long run. Individual countries, however, are no longer limited by that subset of the global resource base which falls within their boundaries. Countries can import resources which they lack or which are in short supply locally, and thereby "import sustainability." Countries can also, however, "export sustainability" by exporting pollution, such as in the case of acid rain, or exporting waste materials.

A number of issues might be raised about taking this global perspective to the sustainability issue. A common argument is that some developing countries have no comparative advantage. By the very definition of comparative advantage that cannot be the case. The issue is not one of *absolute* advantage, but rather of comparative or relative advantage. If it appears that a country does not have a *comparative* advantage, it is because the exchange rate of the country is grossly overvalued or the country has a serious case of the Dutch disease.

The Dutch disease classically occurred when a country had an unusually competitive export sector, which gave it a strong currency. This strong currency was detrimental to other sectors of the economy, leading to either unbalanced development or slow growth. In today's world, a strong currency can result from large inflows of capital. For example, the Dutch disease often occurs in Africa when large inflows of foreign aid give a country a relatively strong currency. Such pathological situations often contribute to lack of sustainability, and should be analyzed from this perspective. The advantage of the global perspective we propose is that it makes it possible to identify such cases and address the problem by appropriate means.

A number of observers have argued that the global perspective is relevant to the developed countries, but not to the low-income developing countries. This perspective is puzzling because in many cases the developing countries are more dependent on international trade than are the developed countries. Moreover, the relative size of the trade flow is not the main issue. So long as a country is connected to the international economy, it is in its own best interest to allow markets to adjust its economy to the trading opportunities provided by that international economy. To do anything less is to sacrifice national income and in turn the potential for sustainable development.

Finally, trade and exchange-rate policies are often the root cause of lack of sustainability in development processes. Such policies shift the domestic terms of trade in directions that weaken the sustainability of current growth processes. To recognize this is to recognize that price incentives can be an important means of promoting sustainable economic development and that distorted prices create unsustainable development.

To conclude this section. it is worth noting that an implication of the above discussion is that "openness" must be considered at all levels of the system. Taking a global perspective means that the trade and resource flows that occur among households, among regions within a country, and among rural and urban areas must be taken into account in developing policies for sustainable development.

Incorporating Macroeconomic Policy

There is a tendency in examining issues of sustainable agricultural development to think only in terms of sectoral economic policies. In today's globally interdependent world, macroeconomic policies are in general far more important than sectoral policies in shaping the use of resources and in influencing the distribution of income in national economies. That is because, as noted above, relative prices are an important determinant of the rate at which resources are used, while at the same time influencing resource or factor proportions.

Consider three sets of issues. The first is the efficiency of resource use at the level of the global economy. Two patterns of agricultural policy have emerged in the post-World War II period. In the developed countries such as the United States, members of the European Union, and Japan, economic policy tends to shift the domestic terms of trade in favor of agriculture. Farmers tend to receive prices for the major commodities that are above international border price levels. Although in some cases elevated in part by domestic commodity programs, prices are established in practice by a variety of protectionist measures, encompassing both tariff and nontariff barriers.

In the developing countries, the reverse is the case. Economic policy tends to discriminate against agriculture. The policy means by which this occurs includes large and in some cases draconian overvaluation of national currencies. An overvalued currency is an implicit tax on exports and an implicit subsidy for imports. Distortions in foreign exchange markets are complemented by a whole series of explicit export taxes, embargoes on exports, *confiscos*, and complicated export rules, all designed to dam domestic production up in the domestic economy and to produce lower prices for domestic consumers. The net result of these policies is to shift domestic prices for agricultural commodities below their international border price equivalents.

The combination of these two policy stances is to produce a gross inefficiency in the global use of agricultural resources. All too much of the world's agricultural output is produced in the high-cost developed countries, and all too little is produced in the low-cost developing countries. This tendency is exacerbated by the export subsidies which further lowers the domestic prices in the developing countries. This dumping takes place both through food aid programs and through more direct export subsidies.

Reducing these distortions within the global agricultural sector will result in the realization of significant efficiency gains. Realizing these efficiency gains can contribute importantly to global sustainability. Failure to take a global perspective to the sustainability problem will result in failure to address this significant global issue. Similarly, failure to take account of trade and

exchange-rate and other macroeconomic policies will result in the same omission. If we are to be concerned about sustainability, we must be concerned about global sustainability. To do anything less will miss much, if not most, of what is important.

A second set of issues involving macroeconomic policies includes the environmental damage created in each set of countries by macroeconomic policy-driven distortions in resource use. In the developed countries, for example, shifting the domestic terms of trade in favor of agriculture leads to the excessive use of fertilizers, pesticides, and other modern inputs. This excessive use leads to the pollution of both underground and aboveground water supplies, in the latter case including lakes, reservoirs, streams and rivers.

The discrimination against agriculture in the developing countries has similar consequences. In this case, shifting the domestic terms of trade against agriculture causes land to be undervalued. This reduces the incentives for producers to husband this important resource. They have very little incentive to invest in contours or terraces to reduce soil erosion; nor do they have incentives to make investments in the land through appropriate tillage and cultural practices. Such investments which ensure sustainability are driven in large part by profitability. Relative profitability is shaped in large part by relative prices.

Still another set of macroeconomic policies important in the developing countries is associated with import-substituting industrialization policies. Those policies, some of which have already been described, tend to carry a strong anti-employment bias to them. They tend to involve large subsidies on physical capital and thus establish factor price ratios that are distorted away from their social optimum. Similarly, they lead to enclave development, with output in the manufacturing sector growing rapidly while employment grows slowly, with only limited creation of new employment opportunities.

The inability of farm families to obtain gainful employment in urban areas causes them to seek a subsistence living on the extensive margin of agriculture. Thus they press onto marginal

lands, into forests and up the hillsides and slopes, producing the well-known environmental damage associated with counties pursuing such policies. Alternative development policies would create more employment and absorb more workers into nonfarm employment. This would reduce the pressures on the land.

Finally, export taxes, implicit in overvalued currencies and explicit in the form of direct export taxes, tend to create a particular pattern of production in the developing countries. What one tends to find is that land productivity tends to be low on large farms and high on small farms. This pattern of land productivity reflects a number of factors that go beyond our present interests. However, in part it tends to reflect the fact that large farmers can escape export taxes by organizing their resources to produce on an extensive scale. The small producer, on the other hand, tends to be hemmed in by imperfect factor markets. Thus they are driven to exploit their small plots of land by making more effective utilization of the supply of family labor at their disposal. In both cases there may be serious environmental consequences.

There is a related issue associated with the chronic inflation that has tended to dominate countries in Latin America. The lack of a full range of viable capital market instruments creates incentives for asset owners to protect their assets by investing in land as a hedge against inflation. Extensive production patterns may again result, with serious environmental consequences in some cases.

Finally, the third set of issues involves the way macroeconomic policies influence national economies when international capital markets are important and countries use flexible exchange rates. Under these circumstances, changes in monetary and fiscal policies are reflected for the most part in changes in the real exchange rate and not in changes in domestic interest rates. This is because such changes in macroeconomic policy induce capital flows among countries. The changes in real exchange rates in turn induce shifts in resources into and out of the tradable

sectors. In effect, the tradable sectors (export and import-competing) bear the burden of adjustment to changes in monetary and fiscal policy.

The significance of this is that in most countries agriculture is a tradable sector. Most countries either export or import some agricultural commodity. In many cases they do both. Thus, changes in monetary and fiscal policy impose instability on agriculture. Depending on how unstable monetary and fiscal policies are, agriculture can become rather unstable. The risk and uncertainty created by this instability in policy leads to less that efficient use of resources and can lead to negative environmental consequences.

In this context, it should be noted that not all such shocks come from *domestic* monetary and fiscal policies. They can come from changes in monetary and fiscal policies in other countries as well. Moreover, when a small economy has fixed the value of its currency to one of the major reserve currencies, the shocks from abroad can be rather severe.

Addressing the Discount Issue

One of the difficulties in addressing sustainability issues is the lack of agreement about the appropriate discount rate to apply in converting future streams of income and costs to present values. Another is the risk and uncertainty surrounding economic decisions when one looks to the future. Risk and uncertainty are important from the perspective of both household and production units. Equally important, great uncertainty surrounds the relationships among resource use, degradation and depletion, and assimilative capacity.

The approach we propose in the next section largely abstracts from these issues by proposing a comparative statics perspective. However, there are two sets of discount rate issues that merit discussion.

Developing countries are often criticized by observers in the developed countries for not giving enough attention to environmental and sustainability issues. For the most part, this reflects a failure to recognize that market rates of interest in developing countries tend to be higher than

those in the developed countries. This higher interest rate gives a short-term bias to policy making and decision making. It causes incomes in the present to be valued significantly more highly than income in the future. Developed countries had similar proclivities earlier in their own history.

More fully integrating the developing countries into the international economy is one means of addressing this issue since it will make for equalization of factor prices across national boundaries. Alternatively, one might consider interest rate subsidies for the developing countries. Such subsidies often lead to distortions in factor use, however. Moreover, the main point we want to emphasize is that the prevailing real discount rate is an important determinant of the weight policy makers and private citizens place on the future in making their economic decisions.

Explicit consideration of time in the analysis of sustainability issues adds enormous complexity to the problem. For example, there is some emerging evidence that resource dynamics themselves critically determine the optimal resource-use path over time, "swamping" any effects of discounting. Similarly, the proper time horizon over which sustainable choices should be considered depends on the availability of back-stop technologies, the emerging research outputs likely to be at hand, and the fragility and potential for irreversibility in any given economic/ecological system. For example, unique ecosystems such as tropical rainforests should probably be examined over an infinite time horizon.

We opt for a more pragmatic approach. There is a way the discount rate issue can be addressed without entering into the seemingly intractable argument about the appropriate rate to use in assessing sustainability issues. That is to take as the goal of policy to transfer to the next generation a resource base equivalent to what the current generation has. This issue will be discussed in more detail in the third part of the paper on implementation.

Understanding Ecological Issues

The analysis of sustainability issues must begin with an adequate understanding of the relevant bio-physical or ecological system. This puts the biological and natural scientists at the

center of the process of identifying policies that will lead to sustainable economic development. They have multiple roles to play.

First, both nonrenewable and renewable resources need to be explicitly incorporated into the analysis. Inventories of quality-adjusted stocks and flows of such resources are essential in identifying current and future constraints to the expansion of output. Renewable resources that are directly harvested, such as forests, fisheries, and wildlife, should be included in these analyses. An important feature of these inventories is that they should be developed from the perspective of what is economically available or what is available at alternative supply prices.

Second, the waste and pollution products that result from production activities should also be identified. These externalities feed back dynamically, and in many cases negatively, on the available stock of natural resources, on the regeneration of such resources, or on the quality of the available supply, as in the case of water pollution. The specific inclusion of bio-physical natural resource systems such as those for soil and water and the feedbacks to the production and resource system of waste or pollution externalities must characterize the analysis of sustainability. Identifying and measuring these relationships is an important role for biological and natural scientists.

Third, traditional production functions must be expanded to include (or be supplemented with) resource degradation functions, environmental damage functions, and mitigation functions that explicitly link the externalities of productive activities to the underlying resource base. These concepts are familiar to environmental economists but for the most part have been left outside of traditional development economics. They are, however, derived directly from the physical or "material balance" models of the ecologists.

Mitigation functions are pertinent in those cases in which damage to the environment can be repaired by purposeful activity. The allocation of labor and capital to cleaning up contaminated or silted waterways or to reversing soil erosion are important examples. These activities have

explicit costs and benefits. The biological and natural scientists have an important role to play in helping to identify these costs and benefits.

The identification and measurement of these feedback relationships need to be an accurate representation of the bio-physical interactions between modern inputs, production activities and the underlying natural resource base. The research and information demands to make the incorporation of such functional relationships into the analysis of sustainable development feasible is quite great.

An important empirical research issue is the degree to which these important relationships are location-specific, or whether they can be borrowed from one region or area and applied to another. Preliminary evidence suggests that they tend to be location- or ecology-specific. Soil loss rates from erosion and the conservation options available are important examples. This location specificity greatly increases the knowledge demands for developing policies to promote sustainable development. It also provides an important role for biological and natural scientists in the development of such policies.

Economic Growth and Sustainability

Another controversial issue that comes up in the discussion of sustainable growth is the allegation that economic growth and development are the cause of environmental damage. These arguments often take the form of anti-growth postures, with the implication that environmental damage could be reduced or eliminated if we would only forego economic development.

There is little evidence for such a position. Moreover, it tends to be mischievous. At least three issues seem to be important. First, a ranking of countries by their level of per capita income would tend to show that environmental problems are more serious at low levels of per capita income than at high levels. Second, the “taste” for a cleaner environment tends to be associated with higher per capita incomes. It is only at later stages of economic growth and development that the citizenry begin to demand a cleaner environment and greater attention to sustainability issues.

Third, economic growth provides the means by which environmental and sustainability issues can be addressed. Thus, given that the world's population seems to grow inexorably, the only alternative seems to be to promote economic development in sustainable ways, not to forego economic growth.

An issue that often arises in discussions of sustainability is the interrelation between poverty and sustainable economic growth. That relationship is an important issue, for in the case of agriculture it is often the poor who scramble onto marginal lands and in the process create environmental damage. Moreover, the poor are often subject to capital rationing and thus cannot use economically efficient production practices.

The solution to this problem lies in addressing poverty as an important policy issue. Development processes and policies should be directed to the benefit of the poor and disadvantaged. This can for the most part be done without sacrificing aggregate economic growth. The pursuit of such policies will reduce, and in many cases eliminate, the trade-off between growth and income distribution. In fact, if socially optimal investment policies are pursued, optimal growth will occur while the welfare of the poor and disadvantaged is improved.

Providing Proper Policy Incentives

Economic incentives have a key role to play in establishing sustainable economic and agricultural development. Getting the prices right is critical to obtaining an efficient allocation of resources. The pervasive shift to a greater dependence on markets around the world is a reflection of the loss of confidence in social engineering and a reflection of the need to allow markets to shape costs and benefits and to provide the incentives for economic agents to act in their own best interests.

The advantage of placing greater dependence on markets and economic incentives is that they provide incentives for change on a pervasive basis and in such a way as to reflect both costs and benefits. An important example is in the cases of exchange-rate and trade policies which, if

designed properly, will reflect to the economy as a whole the trading opportunities faced by a given country.

None of this means that observed market prices always reflect the true social costs or value of a given good or service. When divergences between social and private value occur, bounties or taxes are required to assure that externalities are internalized. These taxes and bounties are part of providing the appropriate incentives to use the resources in an efficient way.

A more complex issue in promoting sustainable development is that the definition of welfare needs to be expanded to include the values of natural amenities, improvements in environmental quality, and reductions in pollution and waste. The value of intergenerational equity must also be taken into account.

The valuation of non-market goods and services, including the amenity value of certain resources and natural systems, is complex and controversial. Resolution of this issue is beyond the scope of the present report, even though there is growing recognition that a wider range of values must be assigned to both inputs and outputs if sustainable development is to be realized. One way this valuation problem is often resolved is to establish auctions that determine the value of rights to amenities or the costs of reducing pollution. This is by no means a complete solution to the problem, however.

Investing in Science and Technology

Technology and its role in attaining sustainable development is another important issue. some observers believe that modern production technology is an important part of the environmental problem in agriculture and that abandoning such technology will help create a sustainable agriculture.

There are at least three issues here. The first is that with current population growth rates in many developing countries it would not be possible to feed the growing population without the use of new production technology. If such technology were not made available, demand would tend to grow faster than supply and the real price of food would tend to rise. This imposes real income losses on low-income people and ultimately can add to the environmental problem.

Second, it is somewhat naive to assume that new technology is the source of all sustainability problems., as is implied by the suggestion that modern production technology be abandoned. To cite only one example, maize yields in the United States have tripled since the end of World War II. This has been in large part due to the adoption of hybrid varieties that facilitated the substitution of land with commercial fertilizers.

The important issue is that without the adoption of these modern inputs, the production of maize alone would probably have spread up the hillsides of Appalachia and the Rocky Mountains and onto other marginal soils. Instead, almost 100 million acres of land have been pulled from production in the United States during this period. Much of that land has been allowed to revert to uses that do more to conserve the underlying soil resources. The adoption of new production technology has thus contributed much to sustainability, even though there obviously can be negative environmental effects from that technology.

The solution to this problem is not to throw the baby out with the bath water. Instead, the challenge is to refine the production technology so as to reduce or mitigate its deleterious effects.

This may involve, for example, finding new ways to make more efficient use of the fertilizers so that smaller applications are needed.

This latter proposition makes it clear the extent to which new technology can be a positive force in the search for sustainability. In addition to helping raise productivity so the demand on the underlying resource base is less, new technology can be a directed instrument for improving sustainability. Another example of such a positive role for technology is to breed for disease resistance so as to minimize the need for applications of chemical controls. Still another is the biological control of insects to reduce the need for modern pesticides.

In conclusion, the development and use of new technology can be a key instrument in attaining sustainable economic growth and development. Technology is needed to raise the productivity of the primary inputs so as to reduce the underlying demand against the physical resources. Technology is also needed to help address the direct environmental problems associated with modern production practices. It has been critical in the control and reduction of pollution. In the future it may be even more important in rebuilding forest and fishery stocks and in mitigating other environmental problems.

Assuring the Sustainability of Human Capital

Most of the discussion of sustainability has been expressed as a concern for the physical resources used in production. The anomaly of this perspective is that over time an ever larger share of the increases in output of the global economy, both for agriculture and for the non-farm sector, is accounted for by investments in science and technology. Moreover, over time the price of commodities, raw materials, and natural resources have declined in real terms. That is contrary to the notion of a growing resource scarcity, as is implied by those who focus all their attention on the issue of physical resources.

As we look to future decades, the fundamental issue of sustainability may be associated with issues surrounding human capital. There are a number of important issues here. The first is

that the easily added accretions to new knowledge may already be behind us. This is reflected in the increasing costs of research in universities and research institutes, especially in terms of the increasing costs of equipment and instrumentation. Second, in the case of biological research for agriculture, there is some evidence that an ever larger share of the total research budget must go for maintenance purposes. In other words, and ever larger share of the research budget has to go just to sustain the gains realized in the past as microorganisms and insects develop resistance to past treatments. Finally, research is for the most part a pure service sector of the economy. It has traditionally been difficult to raise productivity in the delivery of pure services. This is another reason why the costs of doing research, and of producing a given accretion to our stock of knowledge, may rise over time.

It is true that there have been improvements in the technology of doing research. The various components of biotechnology are an excellent example. Moreover, we know very little in a systematic way about the technology of doing research or about the costs of doing it. As the share of increases in output accounted for by investments in science and technology grows, these issues will become increasingly important in the sustainability debate.

Recognizing the Importance of the Household

It is still commonplace to ignore the household in much economic analysis. Whatever attention it receives is largely reflected in identifying and measuring the demand for the goods and services of the economy and the supply of labor services to the market economy. Even in those cases, the usual approach is to focus on the individual rather than the family or household unit.

This neglect of the household is important for two reasons in the context of the present report. First, in developing countries the household and the production unity in agriculture are almost inseparable for most farm production units. One cannot really understand the production units without understanding the resources supplied by the household, such as labor services, and the constraints the household imposes on the production unit.

Second, the household produces an important part of an economy's output of goods and services, and in a sense some of the most important such goods and services. These include the nutrition and health of the members of the families, the provision of an important share of the education and training of the youth of the family, and recreational activities. The fact that these goods and services are not measured in conventional estimates of gross domestic product is no reason to ignore them.

The failure to consider the household also explains why the role of women in the production unit tends to be neglected in the analysis of development problems. Women are often responsible for the livestock in the production unity and play an important role in the management of natural resources such as water, fisheries, and forests.

For all of the above reasons, the household needs to be given a central role in the development of policies to promote sustainable development. Policies and other incentives must be compatible with decision-making at this level.

Developing an Optimal Investment Strategy

If we assume that the goal of sustainability policy is to transfer the equivalent of the current resource base to the next generation, the issue of optimal investment policy comes to the fore. The goal is to obtain efficient economic growth with sustainability issues taken into account. Addressing the issue of poverty has the same implication. Thus, developing an optimal investment policy for a country, or establishing the conditions for optimal investment, becomes an important component of sustainable development policy.

Designing Institutional Arrangements

Much of the above discussion has had important implications for the institutional arrangements in the society. The social dynamics within human populations generate social and institutional structure. These social and institutional structures produce plans, policies, and management strategies which modify and control the ecological/economic systems. Institutional

capacities, including constraints and opportunities, should be explicitly considered in the analysis of sustainability issues and in the design of policies to promote sustainable development. Long-established patterns of resource use, and even the valuation of these resources, may be in need of change. New institutional arrangements will likely be needed to bring about such changes.

One set of institutional arrangements deserves to be singled out for special attention. That set involves those institutions that have to do with transferring the current endowment of resources to the next generation. These include inheritance laws, informal inheritance rules, savings institutions, other capital market instruments, and property rights. The analysis of these institutions must be an important part of any attempt to analyze sustainability issues.

Conservation or Pollution?

There is a long history of cycles of concern about environmental issues. Those concerns usually surfaced when there were commodity scarcities, and the prices of such commodities rose. The problem was typically articulated in terms of resource scarcity and a concern that the underlying resource base was being eroded. Thus the usual response was a conservation movement.

The current challenges to the global environment are of a different nature. For the most part they involve pollution issues, not issues of resource scarcity in the conventional sense. Examples include acid rain, the problem of chlorofluorocarbons, and the problem of global warming. Each of these tend to be persistent problems. They are not likely to go away as economic development proceeds. To the contrary, they may tend to become more important as per capita incomes tend to rise into the future. Even if there should be a rise in the real price of food in the future, with the implication of growing scarcity, the solution to that problem will have to be sought in raising resources productivity, not in the conservation of land and water. The challenge will be to make efficient use of the land and water and raise their productivity.

Concluding Comments

Developing an operational concept and approach to sustainability is obviously not an easy task. We have found it necessary to draw on the perspectives provided by economic development theory, international trade theory, and the literature on ecological sustainability. The human systems of societies, their institutional arrangements, and the basic resource endowments all play important roles in obtaining sustainable economic development. The knowledge gaps on each of these issues are quite great, as it is on the inter-relationships among the various systems.

Awaiting perfect knowledge on each of the issues will be the counsel of despair. Policy makers can take important steps to make their current policies more effective in promoting sustainable development.