# The Role of Natural Resources in Economic Development

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**Abstract**

In recent years economists have recognized that, along with physical and human capital, environmental resources should be viewed as important economic assets, which can be called *natural capital*. However, the services provided by natural capital are unique. They include the use of resources for material and energy inputs, the "assimilative capacity" to absorb waste, and the provision of ecological services. The latter services are particularly not well understood, and lie at the heart of the debate over the role of natural capital in sustainable development. That is, does the environment have a unique or "essential" role in sustaining human welfare, and if so, are special "compensation rules" required to ensure that future generations are not made worse off by natural capital depletion today? A further debate has emerged over whether environmental degradation in an economy may initially increase, but eventually declines, as per capita income increases. This hypothesis, called the environmental Kuznets curve (EKC) has led to a number of attempts to estimate empirically an "inverted U" shaped relationship between a variety of indicators of environmental pollution or resource depletion and the level of per capita income. Finally, recent economic theories and empirical evidence have questioned whether poorer economies that are endowed with abundant natural resources develop more rapidly than economies that are relatively resource poor. It is possible that resource abundant economies are not reinvesting the rents generated from natural resource exploitation into productive assets, or that resource booms actually divert economic resources from more productive and innovative sectors. The result is a "boom and bust" pattern of economic development. There is evidence of this phenomenon particularly with regard to economic development and land expansion, especially in Latin America.

Overall, although our understanding of the role of natural resources in economic development has improved markedly in recent decades, there is still much to learn. How natural resource depletion is affecting the ecological services provided by the environment is one concern. In the case of the poor economies, there is increasing evidence that their prospects for economic "take off" are being adversely affected by the lack of efficient and sustainable management of their natural resource base. Yet the "underpricing" and "undervaluing" of natural capital makes it difficult to design appropriate policies for ensuring that natural resource rents are reinvested in other productive assets of the economy.

**Keywords:** economic development, environmental Kuznets curve, natural capital, natural resources, resource-abundant economies, sustainable development.

**JEL classification**: O13, O41, Q32, Q33.

## Introduction

Compared to some other academic disciplines, economics is not known for being particularly tolerant of revisions to its "mainstream" core concepts or paradigms. Yet, today a major change is occurring in the economic view of the world, and it is likely to have profound implications for many years to come.

Surprisingly, however, contemporary economists appear to be largely unaware that their "worldview" is undergoing such an important change. Perhaps one reason is that, unlike previous major innovations in economic thinking, there is no one person responsible or associated with the new doctrine, such as a Karl Marx with "Marxism", a John Maynard Keynes with "Keynesian economics", a John Nash with a "Nash equilibrium", or a Milton Friedman with "monetarism". Perhaps another reason is that the change in economic thinking has been fairly gradual and unheralded. Just as it is hard to pinpoint a single individual, or even to a group of like-minded individuals, as being responsible for this changing worldview, it is difficult to find a particular body of work, journal articles or books that has instigated this change. Instead, in this instance economic thinking is evolving more as the result of outside influences and pressures, such as the need for economics to be "relevant" to contemporary policy issues and problems.

So what exactly is this gradual, largely unnoticed, yet possibly profound change in the economic worldview? Simply put, the age-old concept of the "economic system" has been irrevocably changed. No longer do we consider the economic process of producing goods and services and generating human welfare to be solely dependent on the accumulation of physical and human capital. That is, an increasing number of economists now accept that there is a third form of "capital" or "economic asset" that is also crucial to the functioning of the economic system of production, consumption and overall welfare. This distinct category consists of the natural and environmental resource endowment available to an economy, which is often referred to generally as *natural capital*.

The rest of this lecture is devoted to elaborating further on the "new thinking" concerning the relationship between natural resources and economic development, and in particular, on the key issues and debates that are emerging from this thinking. As a useful starting point, I will characterize briefly how physical, human and natural capital are now thought to contribute to the functioning of an economic system. What becomes immediately clear is that the services provided by natural capital are unique, and in the case of the ecological services and life-support functions of the environment, are not well understood. As a result, there has also been considerable debate over the role of natural capital in "sustainable" economic development. That is, does the environment have an "essential" role in sustaining human welfare, and if so, are special "compensation rules" required to ensure that future generations are not made worse off by natural capital depletion today? A further debate has emerged over whether environmental degradation in an economy may initially increase, but eventually declines, as per capita income increases. Empirical verification of this *environmental Kuznets curve* hypothesis has often been cited as evidence that economies will be able to overcome certain environmental problems through further economic growth and development. Finally, recent economic theories and empirical evidence have questioned whether poorer economies that are endowed with abundant natural resources develop more rapidly than economies that are relatively resource poor. It is often argued that resource-abundant economies are not reinvesting the rents generated from natural resource exploitation into productive assets, or that commodity price booms actually divert economic resources from more productive and innovative sectors.

In sum, our understanding of the role of natural resources in economic development has advanced considerably in recent years, although there is still much more to learn. In the rest of this lecture, I will try to convince you that what we do know about this role is sufficient to recognize that efficient and sustainable management of natural resources is a critical policy objective for the economic process. We can no longer exclude natural capital from any meaningful discussion of the factors determining economic development. Our concept of the "economic system" has indeed changed irrevocably.

**Natural Capital and the Economic System**

Figure 1 depicts the basic relationship between physical, human and natural capital and the economic system.

Human-made, or physical, capital ($K_P$), natural capital ($K_N$) and human capital ($K_H$) all contribute to human welfare through supporting the production of goods and services in the economic process. For example, $K_P$, consists of machinery, equipment, factory buildings, tools and other investment goods that are used in production; $K_N$ is used for material and energy inputs into production, acts as a "sink" for waste emissions from the economic process, and provides a variety of "ecological services" to sustain production, such as nutrient recycling, watershed protection and catchment functions, and climate regulation; and $K_H$ includes the human skills necessary for advanced production processes and for research and development activities that lead to technical innovation. However, all three forms of capital also contribute directly to human welfare independently of their contributions through the economic process. For instance, included in physical capital, $K_P$, is fine architecture and other physical components of cultural heritage; $K_N$ includes aesthetically pleasing natural landscapes, and provides a variety of ecological services that are essential for supporting life; and increases in $K_H$ also contribute more generally to increases in the overall stock of human knowledge.

One way of illustrating how unique are the various "goods and services" produced by natural capital is to examine the various economic values that arise through the functioning of a natural ecosystem. For example, most natural ecosystems generate multiple benefits, or values. Table 1 illustrates this with the example of an aquatic ecosystem. As shown in the table, the concept of *total economic value* (TEV) is one framework that economists have developed for categorizing the various multiple benefits arising from natural systems such as an aquatic ecosystem. Total economic value distinguishes between *use* values and *non-use* values, the latter referring to those current or future (potential) values associated with an environmental resource which rely merely on its continued existence and are unrelated to use. Typically, use values involve some human 'interaction' with the resource whereas non-use values do not.

Use values are also grouped according to whether they are *direct* or *indirect*. The former refers to both *consumptive* and *non-consumptive* uses that involve some form of direct physical interaction with the resources and services of the system: harvesting of fish and wild resources, transport and use for recreation and tourism. It is also increasingly being recognized that the livelihoods of populations in areas neighboring aquatic ecosystems may be affected by certain key *regulatory ecological functions* (e.g. storm/flood protection, water purification, habitat functions, etc.). The values derived from these functions are considered to be "indirect", as they occur through the support and protection of economic activities that have directly measurable values (e.g. property and land values, drinking supplies, commercial fishing, etc.). Many unique natural environments are considered to have substantial existence values, in that many individuals do not make use of these environments but nevertheless wish to see them preserved "in their own right". Other important non-use values are bequest and cultural/heritage values. The Everglades in Florida or the Great Barrier Reef off the coast of Australia are unique ecosystems that we may wish future generations to enjoy in a fairly "intact" state and that are also considered important components of national and cultural heritage.

**Natural Capital and Sustainable Development**

The importance of the total capital stock concept to sustainability is illustrated in Figure 2, which summarizes broadly the economic view of sustainable development. Most economic interpretations of sustainability take as their starting point the consensus reached by the World Commission on Environment and Development (the WCED, or Brundtland Commission). The WCED defined sustainable development as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED 1987).

Economists are generally comfortable with this broad interpretation of sustainability, as it is easily translatable into economic terms: an increase in well-being today should not have as its consequences a reduction in well-being tomorrow. [1] That is, future generations should be entitled to at least the same level of economic opportunities - and thus at least the same level of economic welfare - as currently available to present generations. Consequently, economic development today must ensure that future generations are left no worse off than present generations. Or, as some economists have succinctly put it, per capita welfare should not be declining over time (Pezzey 1989).

As noted in Figure 2, it is the *total* stock of capital employed by the economic system, including natural capital, that determines the full range of economic opportunities, and thus well-being, available to both present and future generations. Society must decide how best to "use" its total capital stock today to increase current economic activities and welfare, and how much it needs to "save" or even "accumulate" for tomorrow, and ultimately, for the well-being of future generations.

However, it is not simply the aggregate stock of capital in the economy that may matter but also its composition, in particular whether present generations are "using up" one form of capital to meet the needs of today. For example, much of the recent interest in sustainable development has risen out of concern that current economic development may be leading to rapid accumulation of physical and human capital, but at the expense of excessive depletion and degradation of natural capital. The major concern has been that, by depleting the world's stock of natural wealth irreversibly, the development path chosen today will have detrimental implications for the well-being of future generations. In other words, according to this view, current economic development is essentially unsustainable.

While it is generally accepted by most economists that economic development around the world is leading to the irreversible depletion of natural capital, there is widespread disagreement as to whether this necessarily implies that such development is inherently unsustainable. From an economic standpoint, the critical issue of debate is not whether natural capital is being irreversibly depleted, but whether we can compensate future generations for the current loss of natural capital, and if that is possible, how much is required to compensate future generations for this loss Mäler (1995).

However, economists concerned with this problem appear to be divided into two camps over the special role of natural capital in sustainable development. The main disagreement between these two perspectives is whether natural capital has a unique or "essential" role in sustaining human welfare, and thus whether special 'compensation rules' are required to ensure that future generations are not made worse off by natural capital depletion today (see Figure 2). These two contrasting views are now generally referred to as *weak sustainability* versus *strong sustainability*.[2]

According to the *weak sustainability* view, there is essentially no inherent difference between natural and other forms of capital, and hence the same "optimal depletion" rules ought to apply to both. As long as the natural capital that is being depleted is replaced with even more valuable physical and human capital, then the value of the aggregate stock - comprising human, physical and the remaining natural capital - is increasing over time.[3] Maintaining and enhancing the total stock of all capital alone is sufficient to attain sustainable development.

In contrast, proponents of the *strong sustainability* view argue that physical or human capital cannot substitute for all the environmental resources comprising the natural capital stock, or all of the ecological services performed by nature. Essentially, this view questions whether, on the one hand, human and physical capital, and on the other, natural capital, effectively comprise a single "homogeneous" total capital stock. Uncertainty over many environmental values, in particular the value that future generations may place on increasingly scarce natural resources and ecological services, further limits our ability to determine whether we can adequately compensate future generations for irreversible losses in essential natural capital today. Thus the strong sustainability view suggests that environmental resources and ecological services that are essential for human welfare and cannot be easily substituted by human and physical capital should be protected and not depleted. Maintaining or increasing the value of the total capital stock over time in turn requires keeping the non-substitutable and essential components of natural capital constant over time.

The two sides in the debate between weak and strong sustainability are not easy to reconcile. Recent extensions to the economic theory of sustainable development have not so much resolved this debate as sharpened its focus. It may take several generations before we know for sure which view of the role of natural capital in sustainable development is the correct one. Unfortunately, by then it may be too late to correct many of the costly mistakes of the past.

**Growth, Environment and the EKC**

A new area of enquiry has emerged in environmental economics that also has important implications for sustainable development. This recent literature is concerned with the analysis of *environmental Kuznets curves* (EKC), i.e. the hypothesis that there exists an "inverted U" shaped relationship between a variety of indicators of environmental pollution or resource depletion and the level of per capita income.[4] The implication of this hypothesis is that, as per capita income increases, environmental degradation rises initially but then eventually declines. Figure 3 shows a typical EKC estimated for sulfur dioxide ($SO_2$). Although estimations of such EKC relationships began in the early 1990s, interest in these studies is likely to continue for some time. There are several reasons for this.

First, the EKC is a falsifiable hypothesis that can and will continue to be tested through empirical investigation. Thus an increasing number of studies are attempting to determine whether the EKC hypothesis holds for various indicators of environmental degradation, both over time and across countries, regions, states, districts and even cities.

Second, the EKC hypothesis poses an important intellectual challenge. Explanations as to why environmental degradation should first increase then decline with income have focused on a number of underlying causes, including:

- the effects of structural economic change on the use of the environment for resource inputs and to assimilate waste;
- the effects of increasing income on the demand for environmental quality; and
- the types of environmental degradation and ecological processes.

It is not yet clear which of these factors, if any, explain why we might observe an EKC relationship. For example, many of the original explanations of the EKC hypothesis focused on changes in the composition of goods and services due to structural shifts in the economy, the efficiency of resource use, the composition of inputs, and technological innovation. However, increasingly it has been recognized that the effect of such changes on environment-income linkages are not "exogenous" processes – determined by factors outside the economy – but are influenced by policy choices (Andreoni and Levinson 2001; López 1994; Panayotou 1995 and 1997; Stern *et al.* 1996; World Bank 1992). Similarly, previous conjecture that environmental quality is simply a "luxury good", and thus the demand for improved environmental quality increases more than proportionately with income, is proving difficult to substantiate (Lieb 2002; McConnell 1997). Finally, it is possible that EKC studies are providing misleading information on environment-income linkages (Stern *et al.* 1996). As discussed earlier in this lecture, there is much that we do not know about key ecological processes and functions, as well as the valuable services that they provide. Even if we observe EKCs for certain indicators of pollution and resource depletion, it does not necessarily follow that the overall health and functioning of ecosystems will also improve as income increases.

Third, and perhaps most importantly, the EKC hypothesis has revived interest in the long-standing debate over the environmental implications of economic growth (Ansuategi *et al.*1998). One important interpretation of such estimated curves is that economies will eventually "grow out of" many environmental problems (Beckerman 1992). Taken to its extreme, this argument suggests that we do not have to regard the environment as anything special. As people get richer they will increase their demand for the environment and improve it, initially with public health legislation, then clean air, then conservation generally.

However, other commentators have been more cautious, noting that conclusive evidence of an EKC relationship applies only to a few pollutants, thus making it difficult to use this evidence to speculate more generally about growth-environment linkages (Arrow *et al.* 1995). Still others have pointed out that, even for those pollutants displaying EKC characteristics, aggregate global emissions are projected to rise over time, demonstrating that the existence of an EKC does not necessarily imply that, at the global level, any associated environmental damage is likely to disappear with economic growth (Selden and Song 1994; Stern *et al.* 1996). Policy makers are following this renewed debate with interest. From their perspective, the critical policy issue is whether economic growth should continue to be the main priority, with protection of the environment a secondary consideration to be addressed mainly in the future, or whether explicit policies to control environmental degradation at the local, national and global level are required urgently today.

To date, the empirical evidence suggests that EKC relationships are more likely to hold for certain types of environmental damage, e.g. pollutants with more short-term and local impacts, versus those with more global, indirect and long-term impacts such as carbon dioxide and other greenhouse gases (Arrow *et al.* 1995; Barbier 1997; Cole *et al.* 1997; Selden and Song 1994). In terms of types of "localized" environmental damage, the EKC hypothesis seems mainly to be valid for air pollution, in particular sulfur dioxide ($SO_2$) and to a lesser extent solid particulate matter (SPM). The evidence for other localized forms of environmental damage, such as water pollution, deforestation, urban waste and toxic metals, is more mixed (Barbier 1997; Cole *et al.* 1997). Moreover, environment-income relationships appear to vary across individual countries. For example, a study for Malaysia found SPM to be increasing with income (Vincent 1997), whereas a study for the United States indicated that SPM and other major air pollutants decline with increasing levels of income (Carson *et al.* 1997).

However, even when an EKC relationship is estimated, often the turning point on the curve, where environmental degradation starts to decline with per capita income, proves to be very high relative to the current per capita GDP levels of most countries of the world (Barbier 1997). For example, in one recent analysis, none of the estimated EKC turning points for various environmental indicators are below the minimum income level of the sample of countries analyzed, and the turning points for nitrates, carbon dioxide, energy consumption and traffic volumes are well above the maximum income of the countries in the data set (Cole *et al.* 1997). In the case of those EKC estimates for tropical deforestation that are robust, the per capita income levels of most developing countries are also well to the left of the estimated turning point peaks (Cropper and Griffiths 1994; Barbier and Burgess 2001; Koop and Tole 1989).

Overall, such results suggest that most countries have not yet reached levels of per capita income for which environmental improvement is likely to occur. The implications are a worsening global problem of environmental degradation as the world economy and populations expand, even for those environmental indicators that display EKCs (Selden and Song 1994; Stern *et al.* 1996). This can be seen clearly in Figure 4. This figure shows the future trend in global sulfur dioxide emissions based on the estimated EKC for $SO_2$ depicted in Figure 3 and employing aggregation of individual country projections of population and economic growth over 1990 to 2025. The resulting projections show a rise in global sulfur dioxide emissions throughout this period. For example, total global emissions of $SO_2$ rise from 383 million metric tons in 1990 to 1,181 million metric tons in 2025, or from 73 to 142 kg per capita (Stern *et al.* 1996).[5]

Where the EKC relationship does appear to hold, especially for certain air pollutants with localized or short-term effects, there is evidence that the eventual reduction in emissions associated with higher per capita income levels may be attributable to the "abatement effect" that arises as countries become richer (Andreoni and Levinson; López 1994; Panayotou 1997). Also, both the willingness and the ability of political jurisdictions to engage in and enforce improved environmental regulations, to increase public spending on environmental research and development, or even to engage in multilateral agreements to reduce emissions may also increase with per capita income levels (Carson *et al.* 1997; de Bruyn 1997; Komen *et al.* 1997).[6] However, it is a great leap of faith to conclude from these results that economic growth on its own will foster environmental improvement automatically. As Panayotou (1997) has concluded, "when all effects are considered, the relationship between growth and the environment turns out to be much more complex with wide scope for active policy intervention to bring about more desirable (and in the presence of market failures) more efficient economic and environmental outcomes."

This conclusion may be particularly relevant for low income and rapidly industrializing developing countries, whose current per capita income levels are well below the turning points of most estimated EKCs. In the absence of national and multilateral policy interventions, environmental degradation will continue in these countries as per capita income increases, at least over the medium term. In this regard, the observation of Vincent (1997) from his analysis of Malaysia is very apt: "The lack of evidence of EKCs in Malaysia does not prove that EKCs do not exist anywhere. It does indicate, however, that policy makers in developing countries should not assume that economic growth will automatically solve air and water pollution problems."

In sum, the implications of the EKC literature for sustainable development are fairly straightforward. Regardless of whether one is an adherent of the weak sustainability or strong sustainability view, estimated EKC relationships on their own do not help us determine what actual policies are required in the economy to manage its total capital stock, including its stock of natural capital. Although recent EKC studies appear to have revived the wider "growth versus the environment" debate, these studies offer very little support for the view that economic growth alone is the solution to all environmental problems. Rather, it is clear from the EKC literature that specific policies to protect the environment are necessary to reduce environmental damages that are imposing real welfare losses. As Arrow *et al.* (1995) have succinctly put it: "Economic growth is not a panacea for environmental quality; indeed it is not even the main issue."

**Natural Resource Abundance and Economic Growth**

So far, we have examined how management of environmental and natural resources, i.e. the *natural capital stock*, of a country is important for achieving sustainable economic development. We have also reviewed the recent findings of the EKC literature to make the case that the causal relationship is from improved environmental management to enhanced economic development and welfare, and not the other way around.

It is therefore tempting to conclude that, if natural capital is so important to sustainable development, then more of a good thing must be even better. That is, economies that have a greater endowment of natural resources must surely have a much better chance of attaining higher economic growth rates and prosperity than relatively resource-poor economies. This must be particularly true with respect to low and middle-income countries, whose economies are generally more dependent on exploiting their natural capital stock in the transition to developing industrial and service sectors and the "take off" into higher and more balanced rates of long-run growth.

However, if per capita income is to be sustained or increased in these economies, especially with population increases, then any depreciation of natural resources must be offset by investment in other productive assets. This implies managing natural resources so as to maximize resource rents and channeling those rents into productive investments elsewhere in the economy. Although it would seem that the windfall profits generated by resource price booms would be beneficial to this process, as we will discuss further below, this may not be the case for resource-abundant developing countries.

In fact, recent evidence suggests that resource-abundant countries, especially developing economies, may not be benefiting economically from this apparent comparative advantage. Many low-income and lower middle-income economies that can be classified as highly resource dependent today also currently display low or stagnant growth rates (Barbier 1999). Cross-country analysis has confirmed that resource-abundant countries - i.e. countries with a high ratio of natural resource exports to GDP - have tended to grow less rapidly than countries that are relatively resource poor (Sachs and Warner 1997). Economies with a high ratio of natural resource exports to GDP in 1971 also tended to have low growth rates during the subsequent period 1971-89 (Sachs and Warner 1995).

Such evidence might be considered surprising, given the commonly held view that abundant natural resources ought to be the basis for economic expansion for those countries fortunate to have such a rich endowment. For example, the origins of rapid industrial and economic expansion in the US over 1879-1940 were strongly linked to the exploitation of abundant non-reproducible natural resources, particularly energy and mineral resources (Romer 1996; Wright 1990). In particular, during 1880-1920, the intensity of US manufacturing exports in terms of non-reproducible resources grew both absolutely and relative to the resource-intensity of imports. However, there is also evidence that were other factors that made this historical situation in the US unique. For example, Wright (1990) maintains that, over this era:

- the United States was not only the world's largest mineral producing nation but also one of the world's largest countries and markets;
- high international transport costs and tariff barriers for manufactured goods compared to highly efficient and low cost domestic transportation meant that the United States was a vast free trade area for internal commerce and industrial expansion that benefited from "economic distance" from the rest of the world; and
- because of the quantities of resources that were available combined with the large internal markets for goods, increasing investment in basic technologies for extracting and processing natural resources was highly profitable.

As Wright (1990, pp. 665 and 661) suggests: "the abundance of mineral resources, in other words, was itself an outgrowth of America's technological progress," and in turn, "American producer and consumer goods were often specifically designed for a resource-abundant environment".

However, it is doubtful that the unique circumstances over 1879-1940 that allowed the United States to achieve "congruence" between intensive resource use and basic processing and manufacturing technologies, and thus attain rapid economic expansion, are applicable to resource-abundant developing economies today. For one, after 1940, this unique "congruence" had clearly ended for the United States, largely due to changes in the international economy, even though the US still had abundant resources. As Wright (1990, p 665) points out: "the country has not become 'resource poor' relative to others, but the unification of world commodity markets (through transportation cost reductions and elimination of trade barriers) has largely cut the link between domestic resources and domestic industries….To a degree, natural resources have become commodities rather than part of the 'factor endowment' of individual countries." As some researchers have pointed out, the changed international conditions during the post-war era may have also affected the role of primary-product export promotion as the "engine of growth" for developing economies. During this era, the main source of economic growth in developing countries has not been primary-product based exports but labor-intensive manufactured exports (Findlay 1996; Findlay and Wellisz 1993).[7]

Not only are the conditions for "congruence" between resource abundance, technological progress and industrial expansion lacking in most developing economies today, but it is also possible that increased economic dependence on resource exploitation may be detrimental to innovation and growth. For example, recent explanations of the limitations of resource-based development have focused on the poor potential for such development in inducing the economy-wide innovation necessary to sustain growth in a small open economy. Matsuyama (1992) has shown that trade liberalization in a land-intensive economy could actually slow economic growth by inducing the economy to shift resources away from manufacturing (which produces learning-induced growth) towards agriculture (which does not). Sachs and Warner (1995) also argue that the relative structural importance of tradable manufacturing versus natural resource sectors in an economy is critical to its growth performance, i.e. when a mineral or oil-based economy experiences a resource boom, the manufacturing sector tends to shrink and the non-traded goods sector tends to expand. This phenomenon is often referred to in the literature as the "Dutch disease" effect.[8]

Sachs and Warner (1999) have recently examined evidence over the period 1960-94 for eleven major Latin American economies to test the hypothesis that any natural resource booms occurring in these countries may have had a positive impact on their growth performance.[9] First, the authors note that the main structural feature of these economies is that they have remained by and large exporters of primary commodities or manufactured products based on these commodities. Second, they suggest that a significant resource boom occurred in only four of the eleven countries (Bolivia, Ecuador, Mexico and Venezuela), and mixed evidence of a boom in another three (Chile, Colombia and Peru). However, Sachs and Warner conclude that in only one of these seven countries (Ecuador) did a resource boom have a positive and lasting effect on GDP per capita. In two countries (Chile and Colombia) there appears to be no effect of a resource boom on economic development, and in the remaining four cases (Bolivia, Mexico, Peru and Venezuela), the resource boom actually produced a negative impact on GDP per capita. On balance, resource booms appear to frustrate economic growth in Latin America, most likely through a Dutch disease effect.

If natural resource booms are not important catalysts for economic development in poorer countries, then perhaps the process of resource exploitation occurring in these economies is not as economically beneficial as it could be. That is, the structural economic dependence of a small open low or lower middle income economy on exploiting its natural resource endowment may not be leading to sustained and high rates of economic growth. This may be occurring because natural resource assets, including land, are not being managed so as to maximize rents and/or whatever rents are being generated in the economy are not being channeled into productive investments elsewhere in the economy.

Brander and Taylor (1997 and 1998) provide some theoretical support for this perspective. They note that over-exploitation of many renewable natural resources – particularly the conversion of forests to agricultural land – occurs in developing countries if property rights over a resource stock are hard to define, difficult to enforce or costly to administer. They demonstrate that opening up trade for a resource-abundant economy with an open access renewable resource may actually reduce welfare in that economy. As the resource-abundant country has a comparative advantage in producing the resource good, the increased demand for this good resulting from trade openness leads to greater resource exploitation, which under conditions of open access leads to declining welfare in the long run. Brander and Taylor conclude that, as the problem lies with the "open access" nature of exploitation in the resource-abundant economy, then the first-best policy would be for the developing country to switch to more efficient resource management policy through simply establishing property rights.[10] However, as they acknowledge, there are many policy and institutional distortions that currently work against such solutions in developing countries. Consequently, Brander and Taylor (1997, p. 550) argue in favor of "second best approaches", such as the imposition of "a modified 'Hartwick's rule' (see Hartwick 1977) under which an exporting country that experienced temporary gains from selling a resource good on world markets might re-invest those proceeds in an alternative asset."

Current policies in resource-abundant developing economies appear not to be ensuring that any resource rents earned are re-invested efficiently into other productive assets in the economy (Pearce and Barbier 2000). Such an outcome may be reinforced by corruption, bureaucratic inefficiency and misguided policies that benefit special interests that gain from short-term resource exploitation (Ascher 1999; Barbier and Damania 2000; Deacon 1994). If this is the case, then irrespective of what may happen to a country's terms of trade or commodity prices, any initial "economic boom" associated with land conversion or increased resource exploitation is invariably short-lived as the extra rents generated are eventually dissipated. Once the land expansion and increased exploitation of new resource "reserves" comes to an end, or poorer quality land and resources are brought into production, then some economic retrenchment is inevitable. What we should therefore observe is that economic development in a resource-dependent small open economy displays an inherently "boom and bust" pattern.

Again, Brander and Taylor (1997) show that a small, open and resource-abundant economy that produces both a resource and a manufacturing good in the long run will have such a pattern of development. That is, the economy will experience early gains from trade, followed by a period of declining utility. With the specific case of Latin America in mind, in which raw materials are often inputs into semi-processed or processed exports, López (1989) also develops a two-good model of a resource-rich open economy in which the open access renewable resource serves as an input into an "enclave" export processing sector. López demonstrates that improvements in the terms of trade increases the rate of open access resource extraction and causes real income to rise in the short-run, but inevitably permanent income falls in the long run.

As mentioned above, the classic case of open access resource exploitation in many developing countries is conversion of forest to agriculture (Barbier and Burgess 2001). If agricultural land expansion in these small open economies is associated with a "boom and bust" pattern of economic development, then there are two possible consequences. First, economies that have increased their agricultural land base significantly over the long run are likely to have lower levels of GDP per capita then economies that have tended to reduce their dependence on agricultural land expansion. For the latter countries, a shrinking agricultural land base may be evidence that tradable manufacturing and other dynamic sectors have become structurally more important in the economy relative to natural resource sectors and that agriculture itself has become a more capital-intensive, productive and innovative sector.[11] Second, for those countries that are dependent on agricultural land expansion, further increases in agricultural area will tend to produce only modest increases in GDP per capita. Beyond a certain point, additional increases in land expansion will be associated with lower GDP per capita, because of the "boom and bust" pattern of resource-dependent development described above.

A fairly straightforward way of empirically verifying the above phenomenon is to estimate a relationship between GDP per capita and some measure of long-run agricultural expansion. For example, if the latter indicator was some index, $\alpha_{it}$, then the above hypotheses suggest that there may be a cubic relationship between per capita income, $Y_{it}$, and this indicator of long run agricultural land change:

$$Y_{it} = b_0 + b_1\alpha_{it} + b_2\alpha_{it}^2 + b_3\alpha_{it}^3 \quad . \qquad (1)$$

In the above equation $b_0 > 0$, $b_1 < 0$, $b_2 > 0$, $b_3 < 0$ and $| b_1| > b_2$ would imply that countries with increased long run agricultural land area would have lower levels of per capita income than countries with decreased agricultural land area, and per capita income would tend to fluctuate with long run agricultural land expansion.

The above relationship was estimated through employing a panel analysis of tropical developing countries over 1961-94. Per capita income, $Y_{it}$, is represented by gross domestic product (GDP) per capita in constant purchasing power parity (1987 $). The indicator $\alpha_{it}$ is an agricultural land long run change index, created by dividing the current (i.e. in year *t*) agricultural land area of a country by its land area in 1961.[12]

The results of the analysis for all tropical countries and for low and lower middle income countries (i.e. those economies with real per capita GDP less than $3,500 over 1961-94) are shown in Table 2. For both regressions, the estimated coefficients are highly significant and also have the expected signs and relative magnitudes.[13] Thus the estimations provide some empirical evidence that agricultural land expansion in developing countries conforms to a "boom and bust" pattern of economic development. This is seen more clearly when the regressions are used to project respective relationships between long run agricultural land expansion and GDP per capita, which are displayed in Figure 5.

As indicated in the figure, an increase in agricultural land expansion in the long run is clearly associated with a lower level of per capita income than decreasing agricultural land area. For all tropical countries, the turning point is a long run agricultural change index of 1.2. For lower income countries the turning point is 1.3. Although continued agricultural land expansion beyond these points does lead to a slight increase in GDP per capita, this impact is short-lived. For all tropical countries, per capita income starts to fall once the land area index reaches 2.3; for lower income countries this occurs sooner at an index of 1.9. Note as well that for lower income countries, there is very little increase in GDP per capita associated with expansion of land over the 1.3 to 1.9 range.

To conclude, even though a developing economy is endowed with abundant natural resources, the country may not necessarily be exploiting this natural wealth efficiently and generating productive investments. Or, as Wright (1990, p. 666) suggests: "there is no iron law associating natural resource abundance with national industrial strength." It is clear that the open access conditions and ill-defined property rights under which many resources, and especially land, are exploited in developing economies is partly to blame. It is also the case that in many countries natural resource assets, including land, are not being managed so as to maximize rents and/or whatever rents are being generated in the economy are not being re-invested productively elsewhere, especially in tradable manufacturing and other dynamic sectors.

**Final Remarks**

Although our understanding of the role of natural resources in economic development has improved markedly in recent decades, there is still much to learn. Nevertheless, as I have argued in this lecture, the view that environmental and natural resources should be treated as important economic assets, which can be called natural capital, is becoming more accepted. Armed with this concept, economists are now able to show the conditions under which depletion of this natural capital stock may or may not lead to more sustainable economic development.

However, the services provided by natural capital are unique and, in the case of the ecological and life-support functions of the environment, are not well understood. Improving our knowledge in this area is a critical task. It is also one in which economists must learn to work more closely with scientists from other disciplines, particularly biologists, ecologists and other natural scientists. Such inter-disciplinary efforts are especially relevant for a host of complex environmental management problems facing the world today, such as biodiversity loss, climate change, and the spread of biological invasions and infectious diseases (Barbier *et al.* 1994).

Better understanding of these complex environmental problems and of the value of ecological services may also help eventually to resolve the "weak" versus "strong" sustainability debate in economics. As I have noted in this lecture, the heart of this debate concerns whether the environment has an "essential" role in sustaining human welfare, and if so, whether special "compensation rules" are necessary in order to ensure that future generations are not made worse off by natural capital depletion today. These issues are unlikely to be resolved in the near future, and I have not attempted to do so here. Nevertheless, it is clear that the *very minimum* criterion for attaining sustainable economic development is ensuring that an economy satisfies *weak sustainability* conditions. That is, as long as the natural capital that is being depleted is replaced with even more valuable physical and human capital, then *the value of the aggregate stock* - comprising human, physical and the remaining natural capital – should be increasing over time. This in turn requires that the development path of an economy is governed by principles somewhat akin to Hartwick's rule (Hartwick 1977). First, environmental and natural resources must be managed efficiently so that the welfare losses from environmental damages are minimized and any resource rents earned after "internalizing" environmental externalities are maximized. Second, the rents arising from the depletion of natural capital must be invested into other productive economic assets.

The conclusion that efficient environmental resource management is the minimum condition necessary for sustainable economic development may surprise those who believe that the causality might run in the other direction. Proponents of the latter view argue that the environmental Kuznets curve literature provides evidence that environmental problems are likely to lessen as economies grow and develop. However, as I have sought to clarify in this lecture, the EKC literature does not support such a conclusion. Rather, many EKC studies suggest that specific policies to protect the environment are necessary for sustaining economic welfare, both currently and in the future. How key environmental indicators change with rises in per capita income is an important issue, but what is of more fundamental concern is how different policies can affect this relationship. Specifically, we need to determine what environmental policies are required to ensure that the needs of the present are met without compromising the economic opportunities to meet the needs of the future. With regard to these bigger policy issues, estimating EKC relationships for various indicators of environmental degradation is instructive of likely trends under current policies, but is perhaps less helpful in indicating what additional policies and instruments should be implemented.

Finally, this lecture has also considered a recent paradox concerning the role of natural resources in economic development: if natural capital is important for sustainable development, why is the economic performance of many resource-abundant developing countries lagging behind that of comparatively resource-poor economies? The answer to this paradox seems to be fairly straightforward. Simply because a developing economy is endowed with abundant natural resources, it does not necessarily follow that the country will exploit this natural wealth efficiently and reinvest resource rents in other productive investments. Ill-defined and lack of enforcement of property rights that create "open access" conditions for exploiting land and other natural resources in developing countries are part of the problem. In addition, rather than ensuring that any resource rents earned are re-invested efficiently into other productive assets, current policies in resource-abundant developing economies appear to work against this outcome. Corruption, bureaucratic inefficiency and polices biased in favor of special interests that gain from excessive resource extraction or conversion also exacerbate these policy failures. The result is that land expansion and increased exploitation of new resource "reserves" in many resource-dependent developing economies are not fostering a "takeoff" into sustainable development but rather a "boom and bust" pattern of economic growth and development.

In conclusion, the importance of natural resources to economic development is now well-established. How a country manages its natural capital stock is critical for achieving sustainable economic development. Moreover, misinterpretations of the EKC literature aside, the causal relationship is clearly from improved environmental management to enhanced economic development and welfare, and not the other way around. On the other hand, poor policies and the inefficient mismanagement of natural resources can also be detrimental to growth and development. Of course, it will always be difficult to determine what exactly is lost when we deplete natural resources and degrade the environment. But at the very least, economic policies should be in place to ensure that welfare-damaging environmental externalities are corrected, the rents generated from the depletion of natural capital are maximized, and that these rents are reinvested into dynamic and innovative sectors in the rest of the economy.

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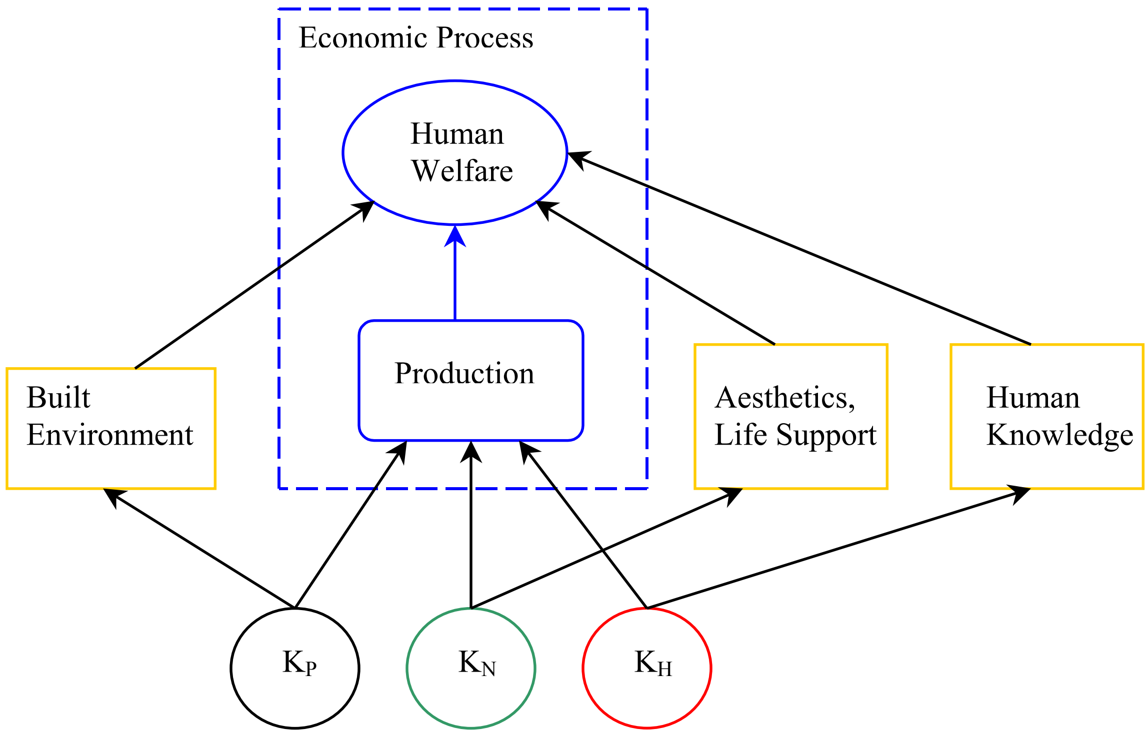
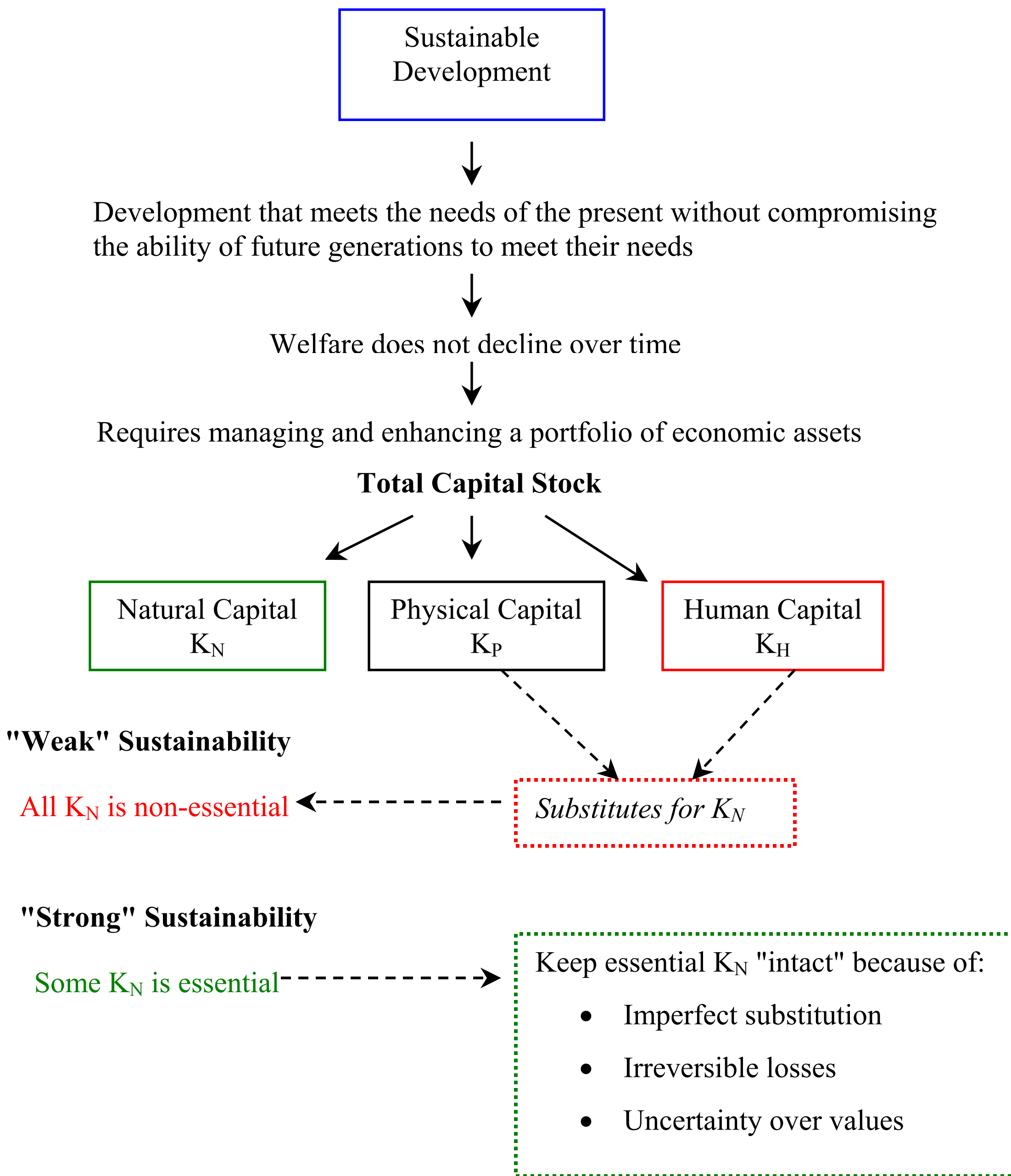
**Figure 1. Human, Physical and Natural Capital and the Economic System**



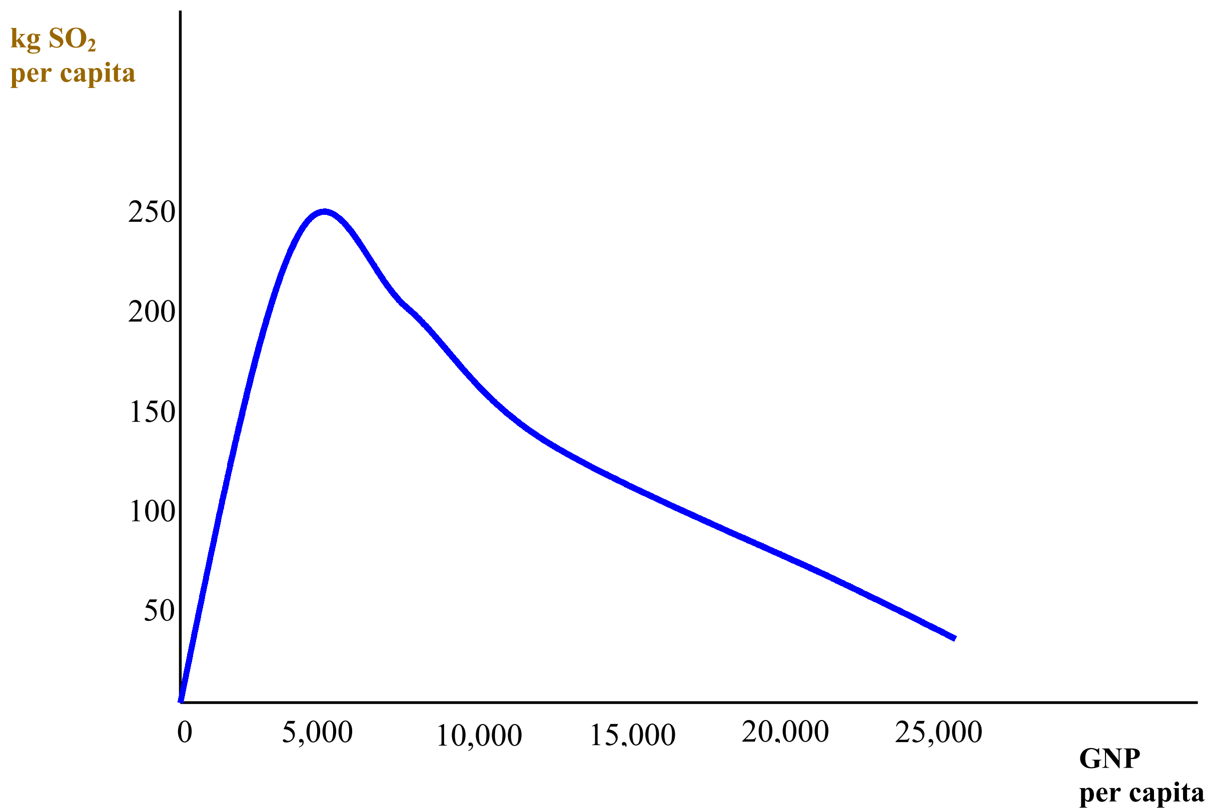

Source: Adapted from Pearce and Barbier (2000).

**Figure 2. Sustainable Economic Development**




Source: Adapted from Pearce and Barbier (2000).

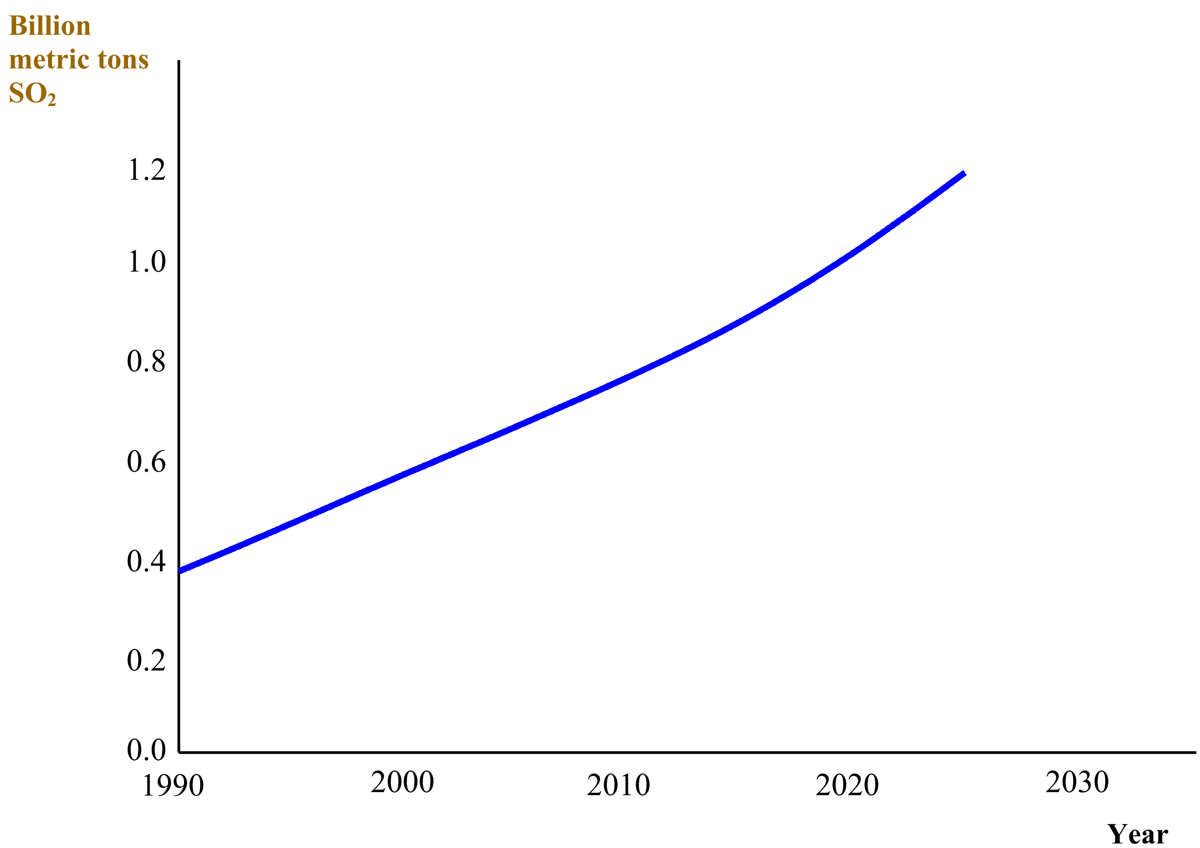
**Figure 3. An Environmental Kuznets Curve for Sulfur Dioxide**




The above curve is the environmental Kuznets curve for sulfur dioxide ($SO_2$) estimated across rich and poor countries of the world by Panayotou (1995). The "peak" or "turning point" level of per capita income where $SO_2$ levels start to fall is around $5,000.

Source: Adapted from Panayotou (1995).

**Figure 4. Projected Trends for Global $SO_2$ Emissions**




Source: Stern *et al.* (1996).

**Figure 5. Projected Trends in Agricultural Land Expansion Per Capita Income for Tropical Developing Countries**

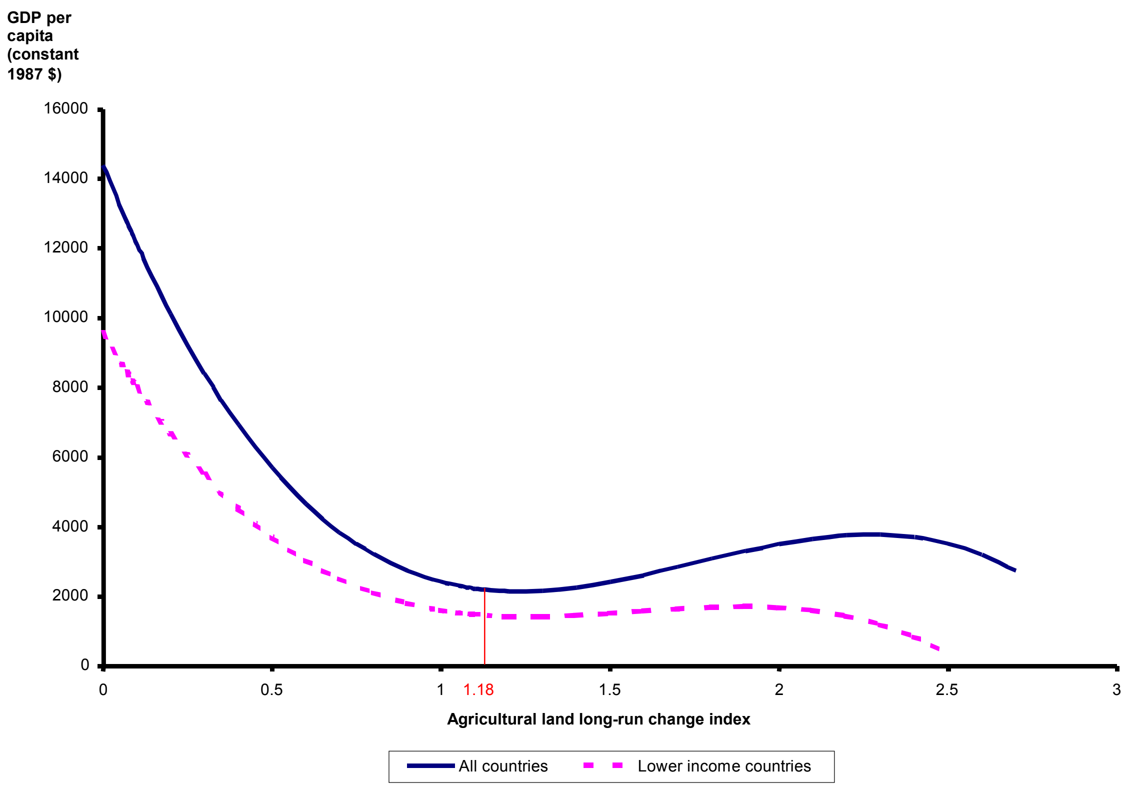


**Table 1. Classification of Total Economic Values for Aquatic Ecosystems**

| USE VALUES | | NON-USE VALUES |
|---|---|---|
| **Direct Use Values** | **Indirect Use Values** | **Existence Values**<br>**Bequest Values** |
| • fish<br>• aquaculture<br>• transport<br>• wild resources<br>• potable water<br>• recreation<br>• genetic material<br>• scientific/educational | • nutrient retention/cycling<br>• flood control<br>• storm protection<br>• external ecosystem support<br>• shoreline/river bank stabilization | • biodiversity<br>• culture, heritage |

Source: Adapted from Barbier (1994).

**Table 2. Panel Analysis of Per Capita Income and Long Run Agricultural Expansion for Tropical Developing Countries, 1961-94**

| **Dependent Variable:** GDP per capita (PPP, constant 1987 $)[a] **Parameter Estimates:**[b] | | |
|---|---|---|
| **Explanatory Variables** | **All Countries** (N = 1135) | **Lower Income Countries**[c] (N = 867) |
| Constant | 14393.37 | 9560.07 |
| | (23.69)** | (7.03)** |
| Long run agricultural land area change index ($\alpha_{it}$)[d] | -24293.31 | -16645.71 |
| | (-19.04)** | (-5.30)** |
| $\alpha_{it}^2$ | 15217.53 | 11013.18 |
| | (11.18)** | (4.58)** |
| $\alpha_{it}^3$ | -2896.32 | -2330.33 |
| | (-6.59)** | (-3.87)** |
| F-test for pooled model | 168.01** | 126.05** |
| Breusch-Pagan (LM) test | 6576.23** | 3614.50** |
| Hausman test | 6.85 | 44.02** |
| Adjusted $R^2$ | 0.368 | 0.937 |
| **Preferred model** | **One way random effects** | **Two way fixed effects** |

Notes: [a] Mean for all tropical developing countries over 1961-94 is $2,593, and for lower income countries $1,539. PPP is purchase power parity.
[b] t-ratios are indicated in parentheses.
[c] Countries with GDP per capita (PPP, constant 1987 $) less than $3,500 over 1961-94.
[d] Mean for all countries over 1961-94 is 1.150, and for lower income countries 1.149.
** Significant at 1% level, * significant at 5% level.

## Notes

[1] Although as Bishop (1993) has pointed out, the objective of "sustainability" is different from that of the standard economic objective of "efficiency." That is, there are potentially an infinite number of development paths for an economy, only some of which are sustainable. Efficiency therefore does not guarantee sustainability, as some efficient paths are not sustainable. At the same time, there is no reason why an economy could not be both efficient and sustainable.

[2] For further discussion of this distinction between weak and strong sustainability see Howarth and Norgaard (1995); Pearce, Markandya and Barbier (1989); Pearce and Barbier (2000); Toman, Pezzey and Krautkraemer (1995) and Turner (1993).

[3] Note, however, that rapid population growth may imply that the value of the per capita aggregate capital stock is declining even if the total value stays the same. Moreover, even if the per capita value of the asset base were maintained, it may not imply non-declining welfare of the majority of people. These considerations also hold for the 'strong sustainability' arguments discussed below.

[4]The concept of an environmental Kuznets curve (EKC) relationship draws its inspiration from the income distribution theory developed by Kuznets (1955), who hypothesized that there is an 'inverted U' relationship between an indicator of income inequality and the level of income. However, the exact origins of the EKC hypothesis are somewhat ambiguous, and appear to be the product of numerous studies conducted simultaneously in the early 1990s. Most sources point to the analysis by Grossman and Kreuger (1995) of air quality measures in a cross-section of countries for different years, which was part of a wider investigation into whether the claims that the economic growth accompanying the North American Free Trade Agreement might foster greater environmental degradation. Similarly, the study by Shafik (1994) was originally a background paper for the World Bank's enquiry into growth and environment relationships for the *World Development 1992* (World Bank 1992). Finally, Panayotou (1995) offers perhaps the earliest and most detailed explanation of a possible "Kuznets type U-shape relationship between the rate of environmental degradation and the level of economic development" in analysis conducted for the World Employment Programme of the International Labour Office in 1992.

[5] Selden and Song (1994) conduct similar projections for the four air pollutants for which they estimate an EKC relationship, $SO_2$, SPM, nitrogen dioxides ($NO_x$) and carbon monoxide (CO). Their results show world emissions increasing for all four pollutants through 2025, and for SPM and $NO_x$, emissions rise through 2050.

[6] On the other hand, corruption and bureaucratic inefficiency may also explain why EKCs "break down" for certain countries. See López and Mitra (2000).

[7] From their case study analysis of five open developing economies, Findlay and Wellisz (1993) conclude that over the post-war era it was economies with relatively no resources, such as Hong Kong, Singapore and Malta, that were among the earliest and most successful exporters of labor-intensive manufactures. In contrast, resource-rich Jamaica and the Philippines have done relatively poorly, whereas Indonesia and Malaysia have done comparatively better by balancing primary exports with rapid expansion of labor-intensive manufactures.

[8] Originally, the "Dutch disease" phenomenon was associated with the macroeconomic implications of an economy's over-dependence on a single, traded natural resource sector (e.g. oil), which emphasized the enclave character of the sector as the predominant source of foreign exchange availability (e.g. see Neary and van Wijnbergen 1986). As the consequence of a resource price boom (e.g. oil price shock), expansion of the resource-based sector would be accompanied by a change in the real exchange rate, and the rest of the economy would decline relatively. The more recent treatments of the "Dutch disease" phenomenon, such as by Matsuyama (1992) and Sachs and Warner (1995) discussed here, focus less on the economic implications of a resource boom via real exchange rate movements but via internal economic distortions caused by the shift of resources from a more innovative sector (e.g. manufacturing) to a less innovative sector (e.g. agriculture, minerals). This latter representation of the "Dutch disease" is more appropriate for characterizing a small open economy, in which real exchange rate determination is not considered.

[9] The countries are Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Mexico, Paraguay, Peru, Uruguay and Venezuela.

[10] In a recent analysis of land expansion in Mexico, Barbier (2002) demonstrates that institutional constraints, such as the *ejido* common-property land management regime, may have slowed down the pace of land conversion and deforestation in pre-NAFTA Mexico. However, increased trade liberalization under NAFTA combined with the widespread relaxing of the land management rules of the *ejido* regime could accelerate land clearing in Mexico.

[11] In the small open economy model of Brander and Taylor (1997), if the country specializes in the manufacturing good in the long run, it gains unambiguously from trade.

[12] The data used in this analysis is form the World Bank's *World Development Indicators.*

[13] Although only the preferred models are indicated in Table 1, the panel analysis was performed comparing OLS against one-way and two-way random and fixed effects models. Alternative versions of these models also employed White's robust correction of the covariance matrix to overcome unspecified heteroskedasticity. However, heteroskedasticity proved not to be a significant problem in both regressions. In the regression for all tropical developing countries, the F-test for the pooled model and Breusch-Pagan LM test were highly significant, suggesting rejection of the OLS model due to the presence of individual effects. The Hausman test was significant only at the 10% level, suggesting that random effects specification is preferred to the fixed effects model. The one-way model tended to outperform the two-way effects model. In the regression for lower income countries, the F-test for the pooled model, the LM test and the Hausman test were all highly significant, suggesting that the fixed effects model is preferred. The two-way model tended to outperform the one-way effects model.