Frontiers and Sustainable Economic Development

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Abstract

Agricultural land expansion, and natural resource exploitation by primary sector activities more generally, is a fundamental feature of economic development in poor economies Yet, developing countries that are highly dependent on exploiting their natural resource endowments tend to exhibit a relatively poor growth performance. To explain this phenomenon, the following paper proposes a *frontier expansion hypothesis*: the structural economic dependence of these economies on frontier land and resource expansion precipitates a "boom and bust" pattern of development that is not conducive to sustained high rates of long-run economic growth. Frontier-based development is symptomatic of a pattern of economy-wide resource exploitation that: a) generates little additional economic rents, and b) what rents are generated are not being reinvested in more productive and dynamic sectors, such as manufacturing. Given these problems, the key to sustainable economic development in poor economies will be improving the economic integration between frontier and other sectors of the economy, targeting policies to improved resource management in frontier areas and overcoming problems of corruption and rent-seeking in resource sectors.

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JEL classification: O13, O41, Q32, Q33.

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Introduction: Natural Capital and Sustainable Development

Most economic interpretations of sustainability take as their starting point the consensus reached by the World Commission on Environment and Development (WCED). The WCED (1987) defined sustainable development as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs".

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 1, 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. This concern is especially important for developing countries that

[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.

are dependent on the exploitation of natural capital for their current development efforts. As we discuss further below, this dependence of low and middle-income economies on natural resources is a key "stylized fact" for these economies, and should shape our perspective on the role of efficient and sustainable management of natural capital to foster long-run development.

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). 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 1). These two contrasting views are now generally referred to as *weak sustainability* versus *strong sustainability*.

The two sides in the debate between weak and strong sustainability are not easy to reconcile. 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. As we shall, such principles are important for determining the extent to which frontier land expansion and resource expansion in low and middle-income economies is contributing to sustainable development in these economies.

The next section outlines four key "stylized facts" concerning the pattern of resource use in developing economies. These facts indicate that agricultural land expansion, and natural resource exploitation by primary sector activities more generally, is a fundamental feature of

economic development in poor economies. The third section reviews various hypotheses that explain this phenomenon. The key explanation of this paper – the *frontier expansion hypothesis* – is further explained in subsequent sections. The main argument is that frontier-based development may lead to an initial "economic boom" for a developing economy, but the economic benefits are eventually dissipated. Empirical evidence supporting this hypothesis is also reviewed. Finally, the paper ends by discussing policy recommendations and reforms that could lead to better economic integration of frontier and other sectors in developing economies, that target improvements in rural resource management in frontier areas, and that might ameliorate problems of corruption and rent-seeking in resource sectors.

Natural Capital and Developing Economies: Four "Stylized Facts"

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. The key question now is: what do these current debates over the relationship between natural capital, growth and development imply for present-day low and middle-income countries in Africa, Asia and Latin America? However, before we can explore such implications further, we need to understand some of the key structural features, or "stylized facts", of natural resource use in these economies.

Stylized Fact One: The Majority of Low and Middle Income Countries Have Resource-Dependent Economies

Most low and middle-income economies today are highly dependent on the exploitation of their natural resource endowments. For these economies, primary product exports - and often one or two main commodities - account for nearly all export earnings.

Appendix 1 depicts the export concentration in primary commodities for 95 low and middle-income economies.[2] As indicated in the appendix, 72 of the countries – more than three

[2] As indicated in Appendix 1, the designation of "low and middle-income countries" in Africa, Latin America, Asia and Oceania, is based on the World Bank's definition. The World Bank lists a total of 142 such countries in these regions. However, many of the countries not included in Appendix 1 are small island states and nations (e.g., Antigua and Barbuda, Gaza Strip, Cook Islands, Kiribati) or countries for which export data are not readily available (Democratic Peoples Republic of Korea). The 95 economies listed in the table have GDP per capita in 1994 at 1987 constant purchase power parity $ of less than $10,500 with an average of $2,691 and a median of $1,604.

quarters - have 50% or more of their exports from primary products, and 35 countries – more than a third – have an export concentration in primary commodities of 90% or more.

Appendix 1 also indicates the share in total exports of the two main primary commodities for each country. For those low and middle-income countries with an export concentration in primary products of 50% or more, two commodities account for most of these exports and for a large share, if not the majority, of total exports. On average, for countries with a primary product export share of 50% or more, the two main commodities accounted for about 60% of total exports. For those countries with a primary product export share between 10-50%, the two main primary commodities still account for a significant proportion of total exports (i.e., at least 10%). On average, for countries with a primary product export concentration of 10-50%, the two main commodities accounted for over 25% of total exports.

Although since the 1960s, some low and middle-income countries have reduced their resource dependency, there are important regional differences. Figure 2 shows the average regional changes from 1965 to 1990/99 in primary product export concentration for Sub-Saharan Africa, North Africa and the Middle East, Latin America and the Caribbean, and Asia and Oceania. In 1965 low and middle-income economies in all four regions had on average 85-92% of their exports based on primary commodities, but regional trends have varied considerably over the next thirty years. In the 1990s, African countries still remained highly dependent on primary product exports (85%), and North African and Middle Eastern countries also maintained high resource dependence (73%). Latin American and Caribbean economies reduced their primary commodity export share much more, but still have a relatively high export share (67%). Only in Asia and Oceania has resource dependency fallen dramatically over the thirty-year period, to less than half of all exports (42%).

The World Bank has attempted to measure recently the extent to which the overall "wealth" of an economy consists of natural capital. For low and middle-income countries dependent on export revenues from primary commodities (other than petroleum), 20% of their national wealth comprises natural capital (World Bank 1997). These economies are typically located in the Caribbean, East and Southern Africa, the Middle East, South Asia and West Africa. As a comparison, natural capital accounts for only 5% of wealth for developed economies in North America, and 2% for developed economies in the Pacific and Western Europe. The most important source of natural capital in resource-dependent low and middle-

income countries is agricultural land, especially for economies without substantial petroleum reserves. For example, in the poorest countries, agricultural cropland comprises around 80% of the natural capital.

Stylized Fact Two: Resource Dependency in Low and Middle-Income Countries is Associated with Poor Economic Performance

Low and middle-income countries tend to be dependent on their natural resource endowments for economic growth and development because in poor economies natural capital may be the only source of capital readily available to them. Moreover, many countries are fortunate to have abundant natural resources to exploit, although as we have just seen, the most likely form of natural capital available to the poorest countries is likely to be land.

Given our discussion earlier on the importance of natural capital to sustainable development, one might conclude that greater resource abundance should improve economic performance. 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.

As we shall discuss further below, it has been difficult to determine from the empirical evidence whether greater *resource abundance*, in the terms of a larger natural resource endowment or stocks, is associated with lower long-run growth in developing economies. However, recent evidence does provide some evidence that *resource dependency* may be associated with poorer economic performance. [3] For example, many low and middle-income

[3] As will be discussed further below, much of the claims of a "resource curse" hypothesis – that resource-abundant economies grow less fast than resource-poor ones – is based on empirical estimations by Jeffrey Sachs and colleagues. However, these authors use primary products exports as a percentage of GDP as the measure of a country's "resource abundance". Strictly speaking, such a variable cannot be a true indicator of "resource abundance" *per se*, as it is not a measure of the total resource endowment or stocks of a country. Instead, throughout this paper, indicators such as primary products exports as a percentage of GDP or of total exports will be referred to as measures of a country's *resource dependency*, as in Appendix 1 and subsequent figures, as these indicators are really a measure of the degree to which an economy is dependent on natural resource-based exports. Hence, the second stylized fact is stated in terms of the correlation between resource dependency, and not abundance, with poor economic performance in low and middle-income countries.

economies that can be classified as highly resource dependent today, in terms of primary product export share as in Appendix 1, also currently display low or stagnant growth rates (Barbier 1999).

Cross-country analysis has confirmed that 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; Rodríguez and Sachs 1999). Economies with a high primary product export share of GDP in 1971 also tended to have low growth rates during the subsequent period 1971-89 (Sachs and Warner 1995). This finding is confirmed for the 1970-90 period, even when direct controls for the influence of geography, climate and growth in the previous decade are included (Sachs and Warner 2001). Table 1 replicates the results for the analysis that controls for growth in the 1960s.

There is also evidence that low and middle-income economies that are more resource-dependent tend to have lower levels of GDP per capita. Figure 3 indicates this relationship. The average export share of primary commodities in the total exports of low and middle-income countries over 1990/99 appears to be negatively correlated with the real GDP per capita of these countries in 1994.[4]

Finally, low and middle-income economies that are more resource-dependent tend to have higher poverty levels. Figure 4 illustrates this association. Resource dependency appears to be positively correlated with the proportion of the population living in poverty.

Stylized Fact Three: Development in Low and Middle-Income Economies is Associated with Resource Conversion

As noted above, in developing economies, especially those without oil and natural gas reserves, the most important source of natural wealth is agricultural land. In these economies, expansion of this agricultural land base is occurring rapidly through conversion of forests, wetlands and other natural habitat. In addition, many developing regions of the world are also

[4] As indicated, the relationship depicted in Figure 3 is for the low and middle-income developing economies listed in Appendix 1 and for the 1990s. Rodríguez and Sachs (1999) appear to obtain the contradictory finding that GDP per capita is positively associated with "resource abundance". However, the latter relationship is established by regressing the log of GDP per capita in 1970 on exports of natural resources, in percent of GDP, also in 1970. Clearly, the results of Rodríguez and Sachs are for a different era, just before the oil and commodity price boom of the 1970s and early 1980s. In addition, as the authors indicate, their data set includes predominantly mineral and energy exporting countries, and countries other than the low and middle-income economies listed in Appendix 1.

placing greater stress on their freshwater resources as a result of increasing population and demand.

López (1998) identifies most of Sub-Saharan Africa, parts of Asia and the tropical forests of South America as regions with "abundant land" and open-access resource conditions that are prone to agricultural expansion. Widespread land and resource conversion is also occurring in Central America, parts of Mexico and tropical South America and some East and South East Asian countries, mainly due to the high degree of integration of rural areas with the national and international economy as well as population pressures. Agricultural land expansion in many tropical regions is also spurred by the prevailing structural conditions in the agricultural sectors of many developing countries, such as low irrigation and fertilizer use as well as poor crop yields (FAO 1997).

Table 2 indicates the dependence of developing countries on agricultural land expansion for crop production. Over 1970-90 increased harvested area accounted for 31% of the additional crop production in these countries, and over 1990-2010 this contribution is expected to rise to 34%. However, some of the increase in harvested area is likely to come from cropping intensity (i.e. multi-cropping and multiple harvests on the same land area). Although improvements in cropping intensity and yields are expected to reduce the developing world's dependency on agricultural land expansion over 1990-2010, about 19% of the contribution to total crop production increases in poorer economies are likely to be derived from expansion of cultivated land. Cropland expansion is expected to be particularly prevalent in Sub-Saharan Africa, East Asia (excluding China) and Latin America (including the Caribbean).

Fischer and Heilig (1997) combined the results of the FAO (1995) study summarized in Table 2 with recent UN population projections to estimate the demand for additional cultivated land in developing countries in 2050. Their results are indicated in Table 3. All developing countries are expected to increase their demand for cultivated cropland considerably, leading to extensive conversion of forests and wetlands. Throughout the developing world, cultivated land area is expected to increase by over 47% by 2050, with about 66% of the new land coming from deforestation and wetland conversion.

Recent hydrological projections of the world's freshwater resources have pointed to an emerging global threat, the dwindling supply of freshwater relative to the growing demand for water worldwide (Falkenmark *et al.* 1998; Revenga *et al.*2000; Rosegrant *et al.* 2002;

Vörösmarty *et al.* 2000). According to various scenarios, water scarcity is expected to grow dramatically in some regions as competition for water increases between agricultural, urban and commercial sectors. The cause of this global water crisis is largely the result of population growth and economic development rather than on global climate change (Vörösmarty *et al.* 2000). The problem is expected to be particularly severe in low and middle-income countries, especially in selected river basins within those countries (Rosegrant *et al.* 2002).[5]

Table 4 indicates recent global projections over 1995 to 2025 for total water withdrawal and the share of withdrawal to renewable water supply.[6] Already, developing countries account for 71% of global water withdrawal. Water demand in these countries is expected to grow by 27% over 1995 to 2025. The ratio of water withdrawals to total freshwater resources per year is often referred to as relative water demand or the water "criticality ratio". Hydrologists typically consider criticality ratios for a country or a region between 0.2 and 0.4 to indicate medium to high water stress, whereas values greater than 0.4 reflect conditions of severe water limitation (Cosgrove and Rijsberman 2000; Vörösmarty *et al.* 2000). Although criticality ratios are projected to remain low across all developing countries, there are important regional exceptions. By 2025 Asia is expected to show signs of medium to high stress (see Table 4). West Asia/North Africa is currently facing severe water limitation, and this problem is expected to reach critical levels by 2025.

As shown in Table 5, the problem of water stress and scarcity is likely to be worse for key developing countries and regions. The two most populous countries of the world, China and India, together account for around 35% of global water withdrawal. Both countries are already displaying medium to high water stress, which is expected to worsen by 2025. However, the problem is worse still for specific river basin regions within each country. Some of these river basins have or will have in coming years criticality ratios exceeding 100%, suggesting chronic

[5] Hydrologists distinguish two concepts of water use: water withdrawal and water consumption (Gleick 2000, p. 41). Withdrawal refers to water removed or extracted from a freshwater source and used for human purposes (i.e. industrial, agricultural or domestic water use). However, some water withdrawal may be returned to the original source, albeit with changes in the quality and quantity of the water. In contrast, consumptive use is water withdrawn from a source and actually consumed or lost to seepage, contamination, or a "sink" where it cannot economically be reused. Thus water consumption is the proportion of water withdrawal that is "irretrievably lost" after human use. For example, in 1995 total global freshwater withdrawals amounted to 3,800 km^3, of which 2,100 km^3 was consumed.

[6] The projections in Tables 4 and 5 correspond to the "business as usual" baseline scenario in Rosegrant *et al.* (2002).

problems of extreme water scarcity. Other countries facing worsening water stress and scarcity include Pakistan, the Philippines, South Korea, Mexico, Egypt and virtually all other countries in West Asia/North Africa.

Increasing land conversion and stress on freshwater resources in developing countries may be symptomatic of a more general correlation between environmental deterioration and growth in these economies. A World Bank study noted that GDP growth and higher incomes in developing economies are associated with better sanitation and improved water supply, as well as investments in cleaner technologies (Thomas *et al.*2000). However, the same study tested for a correlation between growth and an overall environmental quality change index (EQI) across developing countries, where the EQI was constructed by attaching equal weights to changes in indicators of water quality, air quality and deforestation. For 56 developing economies, the study found a statistically significant negative correlation (r = -0.27) between EQI and growth rates over 1981-98. Countries with higher growth rates displayed deteriorating overall environmental quality.[7]

Stylized Fact Four: A Significant Share of the Population in Low and Middle-Income Economies Is Concentrated on Fragile Lands.

Between the years 2000 and 2030, the world's population is expected to increase by more than a third, from 6.06 billion to 8.27 billion (Population Division of the United Nations 2001). Virtually all of this population growth will occur in the less developed regions, and mainly in urban areas. Rural populations are expected to fall in more developed regions over 2000-2030, from 0.29 billion to 0.21 billion. Only a modest rise in rural populations will occur in less developed regions over the same period, from 2.90 billion to 3.08 billion.

However, these aggregate trends in world population obscure two important facts concerning rural populations in developing countries. First, rural population growth is much higher for those low and middle-income economies that are more resource dependent, and second a large share of the rural populations in these economies are concentrated on poor, or "fragile", lands.

[7] Controlling for per capita income in 1981 also yielded a correlation coefficient of –0.27 that was significantly significant at the 95% confidence level.

Figure 5 illustrates that rural population growth rates are positively correlated with the degree of resource dependency in low and middle-income economies. The trend line in the figure indicates that, on average, rural populations are expanding at 1% per year in developing economies that have a primary commodity export share of 70% or higher. In contrast, for those economies with a primary product export share of 25% or less, rural populations are stagnant or even declining.

The World Bank has launched a major study of the concentration of rural populations in developing economies on "fragile lands", which they define as "areas that present significant constraints for intensive agriculture and where the people's links to the land are critical for the sustainability of communities, pastures, forests, and other natural resources" (Word Bank 2003, p. 59). The main findings of the study are:

- Since 1950, the estimated population on fragile lands in developing economies has doubled.
- Currently one quarter of the people in developing countries – almost 1.3 billion – survive on fragile lands. More than 1.2 billion people on fragile lands are in the developing regions of Latin America, Africa and Asia.
- The developing country populations on fragile lands include 518 million living in arid regions with no access to irrigation systems, 430 million on soils unsuitable for agriculture, 216 million on land with steep slopes and more than 130 million in fragile forest systems.
- These populations living on fragile land in developing countries account for many of the people in extreme poverty, living on less than $1 per day.

The World Bank study also identified specific developing countries with significant shares of their populations on fragile lands, i.e. from 20-30% of their population, to 30-50%, to 50-70% to over 70% (World Bank 2003, Table 4.3). Seventy-two low and middle-income economies from Appendix 1 can be grouped into these four categories.

The results are indicated in Figure 6, which shows that resource-dependent low and middle-income economies contain large concentrations of their populations on fragile lands. Moreover, greater resource dependency is associated with a large percentage of population on fragile land. For example, as the concentration of populations on fragile lands in low and

middle-income economies increases from 20-30% to 30-50% to 50-70% to over 70%, the average share of primary products in exports rises from 62.9% to 72.8% to 87.6% to 98.3% respectively.

Explaining the Poor Economic Performance of Resource-Dependent Developing Economies

In sum, the four stylized facts discussed above suggest that agricultural land expansion, and natural resource exploitation by primary sector activities more generally, appears to be a fundamental feature of economic development in many of today's poorer economies. Yet, as the second stylized fact indicates, developing countries that are highly dependent on exploiting their natural resource endowments tend to exhibit a relatively poor growth performance. This poses an intriguing paradox. Why is it that, despite the importance of natural capital for sustainable economic development, increasing economic dependence on natural resource exploitation appears to be a hindrance to growth and development, particularly in today's low and middle-income economies?

One possible explanation is the *resource curse hypothesis*. According to this view, the limits of resource-based development stem from the poor potential for such development in inducing the economy-wide innovation necessary to sustain growth in a small open economy. This phenomenon is often linked to the "Dutch disease" effect arising from some exogenous influence, such as trade liberalization or a resource price boom. For example, 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, 1997 and 2001) 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.

A second explanation is the *open access exploitation hypothesis*. Brander and Taylor (1997 and 1998) note that over-exploitation of many renewable natural resources – particularly the conversion of forests to agricultural land – often occurs in developing countries because 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 the resource good resulting from trade openness leads to greater exploitation, which under conditions of open access produces declining welfare in the long run.[8]

An alternative explanation put forward in this paper is the *frontier expansion hypothesis*.[9] Later in this paper, we elaborate on this hypothesis in further detail. However, it is worth outlining the key features of the hypothesis here: The structural economic dependence of a small open developing economy on exploiting its natural resource endowment – in particular its dependence on frontier land and resource expansion – precipitates a "boom and bust" pattern of development that is simply not conducive to sustained and high rates of long-run economic growth. Although frontier-based economic development can lead to an initial "economic boom", it is invariably short-lived and the economic benefits are dissipated. The key to this phenomenon is that the small open economy faces a trade off between allocating the production from additional frontier resources either to increase domestic consumption and exports (in exchange for imported consumption), or alternatively for capital accumulation. If the additional frontier "reserves" are used mainly to expand consumption and exports, then there will be little additional capital accumulation, and thus no long-term take off into sustained growth once the frontier is closed. If during the frontier expansion phase the economy does manage to invest in capital accumulation as well as increased consumption and exports, then the initial boom period will

[8] 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. 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 country imposing "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."

[9] Note that the frontier expansion hypothesis and the open access exploitation hypothesis share some similarities. For example, Brander and Taylor (1997) show that a small, open and resource-abundant economy that produces a resource product through open access resource exploitation and a manufacturing good will also have a "boom and bust" pattern of development in the long run. 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 shows that improvements in the terms of trade increases the rate of open access resource extraction and real income to increase in the short-run, but inevitably permanent income falls in the long run.

coincide with increased growth. However, this growth path cannot be sustained. Once the frontier is "closed" and any reserves of land and natural resources available to an economy have been fully exploited or converted, some economic retrenchment is inevitable, and an economic bust will occur.

Frontier Expansion and Economic Development

Finding “new frontiers”, or “reserves”, of natural resources to exploit has been the basis of much of global economic development for the past five hundred years (Cipolla 1976; di Tella 1983; North and Thomas 1973; Toynbee 1976; Webb 1964). Such frontier-based economic development is characterized by a pattern of capital investment, technological innovation and social and economic institutions dependent on “opening up” new frontiers of natural resources once existing ones have been “closed” and exhausted (di Tella 1982; Findlay 1995; Findlay and Lundahl 1994).

However, recognition of the role of the frontier in development has only occurred over the past century, beginning with the first "frontier thesis" on American development as put forward by Frederick Jackson Turner.[10] Turner’s frontier thesis was further extended by Walter Prescott Webb to explain not just American but global economic development over the 1500-1900 period of world history.[11] In recent decades, historians, geographers and social scientists have continued to modify the Turner-Webb “frontier thesis” to describe processes of frontier-based development in many areas of the world, including Latin America, Russia, Canada, South Africa, Australia, and New Zealand (Hennessy 1978; Savage and Thompson 1979; Wieczynski 1976;Wolfskill and Palmer 1983). Although there is considerable debate over whether the

[10] In his now infamous 1893 address to the American Historical Association, *The Significance of the Frontier in American History*, Turner argued that "the existence of an area of free land, its continuous recession, and the advance of American settlement westward, explain American development" (Turner 1986, p. 1). Critical to this frontier expansion was the availability of “free” land and resources: “Obviously, the immigrant was attracted by the cheap lands of the frontier, and even the native farmer felt their influence strongly. Year by year the farmers who lived on soil whose returns were diminished by unrotated crops were offered the virgin soils of the frontier at nominal prices. Their growing families demanded more lands, and these were dear. The competition of the unexhausted, cheap, and easily tilled prairie lands compelled the farmer either to go west and continue the exhaustion of the soil on a new frontier, or to adopt intensive culture” (Turner 1986, pp. 21-2).

[11] Webb (1964) suggested that exploitation of the world’s “Great Frontier”, present-day North and South America, Australia, New Zealand and South Africa, was instrumental to the “economic boom” experienced in the “Metropolis”, or modern Europe: “This boom began when Columbus returned from his first voyage, rose slowly, and continued at an ever-accelerating pace until the frontier which fed it was no more. Assuming that the frontier closed in 1890 or 1900, it may be said that the boom lasted about four hundred years” (Webb 1964, p. 13).

original "thesis" envisioned by Turner and Webb is still relevant for all frontier regions, there is a general consensus over both the definition of a “frontier” and its significance in terms of economic development: a frontier area is assumed to be “a geographic region adjacent to the unsettled portions of the continent in which a low man-land ratio and unusually abundant, unexploited, natural resources provide an exceptional opportunity for social and economic betterment to the small-propertied individual” (Billington 1966, p. 25). Or, as di Tella (1982, p. 212) has put it more succinctly, throughout history “processes” of frontier-based development “were characterized by the initial existence of abundant land, mostly unoccupied, and by a substantial migration of capital and people.”

As noted by Findlay and Lundahl (1994, p. 70), the analysis of frontier-based development "has been used extensively by historians and geographers for a wide variety of times and places, but has been neglected by economists." The exceptions are the "staples thesis", which has argued that the development of many countries and regions has been led by the expansion of export sectors, and in particular, natural resource exports, and the "vent for surplus" theory, which suggested that trade was the means by which idle resources, and in particular natural resources in poor countries, were brought into productive use (Chambers and Gordon 1966; Myint 1958; Smith 1976; Southey 1978; Watkins 1963). Both theories are relevant to the economic analysis of frontier-based development, because they focus on the existence of excess resources – "land" and "natural resources" – that are not being fully exploited by a closed economy. The function of international trade is to allow these new sources of natural resources that previously had no economic value to be exploited, for increased exports and growth.

However, it is also fair to say that both the staples and vent-for-surplus theses have been mainly concerned with "surplus" natural resources as the basis for the origin of trade and export-led growth. For example, the staples theory was largely an attempt to explain the very substantial inflows of capital and labor into the "regions of recent settlement", i.e. Webb's "Great Frontier of Canada, the United States, Argentina and Australia, that occurred largely in the nineteenth and early twentieth centuries (Findlay and Lundahl 1994). Equally, Myint (1958) argued that the classical vent-for-surplus theory of trade is a much more plausible explanation of the start of trade in hitherto "isolated" country or region with a "sparse population in relation to its natural resources" such as "the underdeveloped countries of Southeast Asia, Latin America and Africa when they were opened up to international trade in the nineteenth century."

More recent theories have focused on characterizing the "endogenous" or "moving" frontier as the basis for attracting inflows of labor and capital into a region or economy (di Tella 1982; Findlay 1995; Findlay and Lundahl 1994; Hansen 1979). Such "surplus land" models essentially postulate a Ricardian land frontier, whereby additional land can be brought into cultivation through investment of labor and/or capital, provided that the resulting rents earned are competitive with the returns from alternative assets. Thus frontier expansion becomes an "endogenous" process within a general equilibrium system of an economy, sometimes incorporating trade and international capital flows, with the supply and price of land determined along with the supplies and prices of all other goods and factors. As a consequence, changes in relative commodity and factor prices, as well as exogenous factors such as technological change and "transport revolutions", induce adjustments in the supplies of the specific factors including expansion of the land frontier. As in the case of staples theory, these "endogenous frontier" models have been used mainly to explain the inflows of capital and labor into the "regions of recent settlement", i.e. Webb's "Great Frontier of Canada, the United States, Argentina and Australia, that occurred largely in the nineteenth and early twentieth centuries, and export-led colonial agricultural development in certain tropical countries.[12]

The *frontier expansion hypothesis* put forward in this paper follows in the same tradition of previous theories of frontier-based development, albeit with a crucial difference. Rather than focusing on historical applications where capital and labor inflows into regions and countries with surplus land have led to export booms and growth, here the emphasis is on the present-day process of frontier expansion in a typical low and lower middle income open economy with abundant resources but a rapidly growing population. In other words, frontier expansion in today's developing countries is generally associated with land conversion, and unlike historical cases where exploitation of "new' resources led to increased economic development and growth, the economic benefits of frontier land expansion today are largely short-lived.

[12] Hansen (1979) suggests that his Ricardian land surplus model is mainly applicable to the agricultural development "under old-style imperialism" (i.e. colonialism) whereby "subsistence agriculture by illiterate and uneducated native farmers takes place exclusively on vast expanses of marginal land, whereas intra-marginal land is occupied by colons – knowledgeable Europeans capable of picking up and applying technical progress." Findlay and Lundahl (1994) show how their basic "endogenous frontier" model can be modified closer to the "vent-for-surplus" theory to explain the process of rapid export expansion in key plantation and peasant export economies, such as smallholder rubber in Malaya and bananas and coffee in Costa Rica in the late nineteenth and early twentieth century, cocoa in Ghana in the early twentieth century and rice in Burma in the second half of the nineteenth century.

Why is Frontier Expansion Unsustainable?

The key to understanding to why frontier expansion is not leading to sustainable economic development in poor economies can be found in the four "stylized" facts of natural resource use in these economies.

For example, the first three stylized facts suggest that developing countries today are embarking on a pattern of resource-dependent development that culminates in frontier resource exploitation, particularly in the form of agricultural land expansion and chronic stress on freshwater resources, but the end results do not yield much in the way of sustained economic progress. In fact, stylized fact four indicates the "symptoms" of malaise associated with frontier-based development today: In many developing economies a significant proportion of extremely poor households are concentrated on fragile lands, and both rural population growth and the share of population on fragile lands seem to increase with the degree of resource dependency of a developing economy. That is, frontier land expansion appears to be serving mainly as an outlet for the rural poor in many developing countries.

But why should frontier land expansion be associated with "unsustainable" economic development in many low and middle-income countries today? As discussed in the previous section, frontier expansion in a small open economy can lead to a successful resource-based development. There are clearly historical precedents for such a development path.

For example, it has been argued that 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). Other examples of successful mineral-based development have been cited for today's economies (Davis 1995; Wright and Czelusta 2002). In the developing world, most prominent have been the mineral-led booms in the 1990s in Peru, Brazil and Chile, although Davis (1995) identifies up to 22 mineral-based developing economies who appear to have fared comparatively well compared to other developing countries.

Recent reviews of successful resource-based development, both past and present, have pointed to a number of key features critical to that success (David and Wright 1997; Wright and Czelusta 2002).

First, the given natural resource endowment of a country must be continuously expanded through a process of *country-specific knowledge in the resource extraction sector*. As argued by Wright and Czelusta (2002, pp. 29 and 31): "From the standpoint of development policy, a crucial aspect of the process is the role of country-specific knowledge. Although the deep scientific bases for progress are undoubtedly global, it is in the nature of geology that location-specific knowledge continues to be important….the experience of the 1970s stands in marked contrast to the 1990s, when mineral production steadily expanded primarily as a result of purposeful exploration and ongoing advances in the technologies of search, extraction, refining, and utilization; in other words by a process of learning."

Second, there must be *strong linkages between the resource and other, more dynamic economic sectors (i.e., manufacturing)*. "Not only was the USA the world's leading mineral economy in the very historical period during which the country became the world leader in manufacturing (roughly from 1890 to 1910); but linkages and complementarities to the resource sector were vital in the broader story of American economic success….Nearly all major US manufactured goods were closely linked to the resource economy in one way or another: petroleum products, primary copper, meat packing and poultry, steel works and rolling mills, coal mining, vegetable oils, grain mill products, sawmill products, and so on" (Wright and Czelusta 2002, pp. 3-5).

Third, there must be *substantial knowledge spillovers* arising from the extraction and industrial use of resources in the economy. For example, David and Wright (1997) suggest that the rise of the American minerals economy can be attributed to the infrastructure of public scientific knowledge, mining education and the "ethos of exploration". This in turn created knowledge spillovers across firms and "the components of successful modern-regimes of knowledge-based economic growth. In essential respects, the minerals economy was an integral part of the emerging knowledge-based economy of the twentieth century….increasing returns were manifest at the national level, with important consequences for American industrialization and world economic leadership" (David and Wright 1997, pp. 240-241).[13]

[13] Wright and Czelusta (2002, p. 17) cite the specific example of the development of the US petrochemical industry to illustrate the economic importance of knowledge spillovers: "Progress in petrochemicals is an example of new technology built on resource-based heritage. It may also be considered a return to scale at the industry level, because the search for by-products was an outgrowth of the vast American enterprise of petroleum refining."

However, there are two important caveats attached to the above conditions for successful resource-based development.

First, all of the past and present examples of such development are clearly based largely on minerals-based development. There is little evidence to date that a small open economy dependent on frontier agricultural land expansion is likely to foster the above conditions for successful resource-based development. In fact, there is some evidence that agricultural-based development based on land expansion may be negatively correlated with economic growth and development (Stijns 2001).

Second, the existence of policy and market failures in the resource sector, such as rent-seeking behavior and corruption or open-access resource exploitation, will mitigate against successful resource-based development. Unfortunately, it is well documented that resource sectors in many developing countries are prone to problems of rent-seeking and corruption, thus ensuring that natural resource assets, including land, are not being managed efficiently or sustainably (Ascher 1999; Tornell and Lane 2001; Torvik 2002).[14] Several studies have noted the rent-dissipation effect of poorly defined property rights, including the breakdown of traditional common property rights regimes, in developing countries (Alston *et al.* 1999; Baland and Plateau 1996; Bromley 1989 and 1991; Deacon 1999; Ostrom 1990). Brander and Taylor (1997 and 1998) note that over-exploitation of many renewable natural resources – particularly the conversion of forests to agricultural land – occurs frequently 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 over the long run.

In many developing economies, inequalities in wealth between rural households also have an important impact on land degradation and deforestation processes, which may explain why so many poorer households find themselves confined to marginal lands (Barbier 1999). Such problems are exacerbated by government policies that favor wealthier households in markets for key resources, such as land.

[14] There is also an obvious link between rent-seeking activities in frontier areas and the lack of government enforcement of efficient regulation of these activities For example, Ascher (1999, p.268) points out: "The weak capacity of the government to enforce natural-resource regulations and guard against illegal exploitation is an obvious factor in many of the cases reviewed. In every case of land and forest use, illegal extraction and failure to abide by conservation regulations reduce the costs to the resource exploiter and induce overexploitation, while failing to make the exploiter internalize the costs of resource depletion and pollution."

First, poorer households are often unable to compete with wealthier households in land markets for existing agricultural land. The result is two segmented land markets: the wealthier rural households dominate the markets for better quality arable land, whereas the poorer and landless households either trade in less productive land or migrate to marginal lands.

Second, although poorer households may be the initial occupiers of converted forestland they are rarely able to sustain their ownership. As the frontier develops economically and property rights are established, the increase in economic opportunities and potential rents makes ownership of the land more attractive to wealthier households. Because of their better access to capital and credit markets, they can easily bid current owners off the land, who in turn may migrate to other frontier forest regions or marginal lands.

For example, in Colombia distortions in the land market prevent small farmers from attaining access to existing fertile land (Heath and Binswanger 1996). That is, as the market value of farmland is only partly based on its agricultural production potential, the market price of arable land in Colombia generally exceeds the capitalized value of farm profits. As a result, poorer smallholders and of course landless workers cannot afford to purchase land out of farm profits, nor do they have the non-farm collateral to finance such purchases in the credit market. In contrast, large land holdings serve as a hedge against inflation for wealthier households, and land is a preferred form of collateral in credit markets. Hence the speculative and non-farming benefits of large land holdings further bid up the price of land, thus ensuring that only wealthier households can afford to purchase land, even though much of the land may be unproductively farmed or even idled.

Similar to Colombia, land titling, tax and credit policies in Brazil generally reinforce the dominance of wealthier households in credit markets and the speculative investment in land as tax shelters (Alston *et al.* 1999; Mahar and Schneider 1994). Because poorer households on the frontier do not benefit from such policies, their ability to compete in formal land markets is further diminished. This reinforces the "sell out" effect of transferring frontier land ownership from poorer initial settlers to wealthier and typically urban-based arrivals, forcing the poorer households to drift further into the frontier, or enter into land use conflicts with wealthier landowners (Alston *et al.* 1999; Schneider 1994).

A fairly straightforward way of empirically verifying whether frontier-based development is associated with poor economic performance 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, α_{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:

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

Note that $b_0 > 0$, $b_1 < 0$, $b_2 > 0$, $b_3 < 0$ and $|b_1| > b_2$ would imply that i) countries with increased long run agricultural land area would have lower levels of per capita income than countries with decreased agricultural land area and ii) 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 again represented by gross domestic product (GDP) per capita in constant purchasing power parity (1987 $). The indicator α_{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.[15]

The results of the analysis for all tropical countries and for low and lower middle income countries (i.e. real per capita GDP less than $3,500 over 1961-94) are shown in Table 6. For both regressions, the estimated coefficients are highly significant and also have the expected signs and relative magnitudes.[16] 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 7.

[15] The data used in this analysis is form the World Bank's *World Development Indicators*, and are available from the author upon request.

[16] 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.

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.

It is revealing to compare the projections in Figure 7 with the actual land use situation in 1994 for developing countries. For all countries in 1994, the average land expansion index was 1.18, and for lower income countries it was 1.17. Of the 35 countries in 1994 with per capita incomes less than $3,500, only six have not experienced some agricultural land expansion compared to the 1961 base year.[17] Only eleven lower income countries are in the 1.3 to 1.9 range of agricultural land expansion, where continued expansion is associated with slightly higher levels of GDP per capita.[18] One country (Fiji) has already passed the turning point of 1.9 where further agricultural land expansion corresponds with lower levels of GDP per capita. Thus it is fair to say that, for the vast majority of lower income countries, further agricultural land expansion is likely to be associated with lower levels of GDP per capita.

The Frontier Expansion Hypothesis

Having provided evidence that frontier-based development is not leading to sustainable economic development in poor economies, we now must try to explain why. Here, we can only sketch out the main features of this *frontier expansion hypothesis*.[19]

[17] The six countries are Grenada (with a long run agricultural land change index of 0.684), Jamaica (0.893), Bolivia (0.961), Bangladesh (0.981), Mauritania (0.998) and the Maldives (1.000).

[18] The eleven countries are Sri Lanka (with a long run agricultural land change index of 1.348), Burundi (1.397), Rwanda (1.403), Papua New Guinea (1.432), Nicaragua (1.454), Uganda (1.478), the Philippines (1.511), Vanuatu (1.610), Paraguay (1.663), Belize (1.671) and Guatemala (1.705).

[19] In a separate paper, "Frontier Expansion and Economic Development", available at the author's website, http://uwacadweb.uwyo.edu/Barbier, a formal model illustrating the frontier expansion hypothesis is developed.

First, it must be noted that frontier land expansion and resource exploitation is associated with poor economic performance in resource-dependent developing countries but not necessarily a cause of it. That is, frontier-based development is symptomatic of a pattern of economy-wide resource exploitation that: a) generates little additional economic rents, and b) what rents are generated are not being reinvested in more productive and dynamic sectors, such as manufacturing.

Second, one important reason that frontier land expansion is unlikely to generate much rents is that, as such expansion results largely from conversion of forest, wetlands and other natural habitat, it is likely to yield mainly "marginal" or "fragile" land exhibiting low productivity as well as significant constraints for intensive agriculture (World Bank 2003). This in turn implies that very little effort is invested, either by poor farmers working this land or government agricultural research and extension activities, in developing *country-specific knowledge* in improving the productivity and sustainable exploitation of frontier land and resources.

Third, in contrast to past and present examples of successful minerals-based development, there are unlikely to be *strong linkages between more dynamic economic sectors (i.e., manufacturing)* and the economic activities responsible for frontier land expansion (Wright and Czelusta 2002). This in turn limits the opportunities for *substantial knowledge spillovers* arising from the exploitation and conversion of frontier resources, including land. Thus frontier-based economic activities are unlikely to be integrated with the rest of the economy. There are two reasons for this. First, as noted above, frontier land expansion appears to be serving mainly as an outlet for the rural poor in many developing countries, which suggests that much of the output is either for subsistence or local markets. Second, by definition, frontier areas are likely to be located far away from urban and industrial centers.

Fourth, as discussed in the previous section, policy and market failures, such as rent-seeking behavior and corruption or open-access resource exploitation, are prevalent in the resource sectors of many developing economies. Frontier land expansion and resource exploitation is especially associated with open access. In addition, many large-scale resource-extractive activities, such as timber harvesting, mining, ranching and commercial plantations, are often responsible for initially opening up previously inaccessible frontier areas (Barbier 1997). Investors in these activities are attracted to frontier areas because of the lack of government

controls and property rights in these remote areas mean that resource rents are easily captured, and thus frontier resource-extractive activities are particularly prone to rent-seeking behavior (Ascher 1999).

All of these factors combine to ensure that frontier-based economic development is unlikely to lead to high rates of sustained economic growth. In essence, all frontier resources, including land in forests and wetlands, are "reserves" that can be exploited potentially for economic rents. However, as we have seen, conversion of frontier land "reserves" produces mainly fragile agricultural land that is largely an outlet for absorbing poor households. Such frontier land expansion does not generate substantial rents, and any resulting agricultural output will increase mainly consumption of non-tradable goods (food for subsistence or local markets). Frontier resource-extractive activities may yield more significant rents, but the rent-seeking behavior associated with these activities will mean that these rents will be re-invested into further exploitation of frontier resources. This process will continue until the economically accessible frontier resource "reserves" are exhausted and all rents are dissipated.

The lack of integration of frontier-based economic activities with the rest of the economy also decreases the likelihood that any rents generated by these activities will be reinvested in more productive and dynamic sectors, such as manufacturing. In essence, the frontier sector operates as a separate "enclave" in the developing economy. As already noted, frontier-based land expansion will result mainly in small-scale agricultural production that increases domestic, non-traded consumption. In contrast, more large-scale, frontier resource-extractive activities, such as mining, timber extraction, ranching and plantations, may generate increased resource-based exports. Such exports are more likely to result in either imported consumption or imported capital goods that are employed predominantly in the frontier resource-extractive industries. There are two reasons for this outcome. First, large-scale resource-extractive activities tend to benefit wealthier households in the economy, who have a higher propensity to consume imported goods. Second, as explained above, the re-investment of resource rents into further exploitation of frontier extractive reserves will require specific investments in imported capital goods for this purpose, such as mining machinery, milling equipment, road-building and construction tools, etc.

It follows that, although frontier-based economic development can lead to an initial "economic boom", it is invariably short-lived and the economic benefits are quickly dissipated. If the additional frontier "reserves" are used mainly to expand domestic consumption and exports

(in exchange for imported consumption), then there will be little additional capital accumulation outside of the frontier resource-extractive sector. This implies that any economic boom will continue only as long as the frontier resource reserves last. Once resource rents are dissipated and the frontier is effectively closed, there will be no long-term take off into sustained growth for the economy as a whole.

If during the frontier expansion phase some rents are invested in capital accumulation in other sectors of the economy as well, then the initial boom period will coincide with increased growth. However, this growth path cannot be sustained. The additional capital accumulation is unlikely to overcome the poor linkages between other economic sectors (i.e., manufacturing) and frontier-based economic activities, and is therefore unlikely to yield substantial economy-wide knowledge spillovers. As a result, any additional growth generated by this capital accumulation will last only as long as frontier expansion continues. Once the frontier is "closed" and any reserves of land and natural resources available to an economy have been fully exploited or converted, some economic retrenchment is inevitable, and an economic bust will occur.

In sum, the structural economic dependence of a small open low or lower middle income economy on frontier land and resource expansion precipitates a "boom and bust" pattern of development that is simply not conducive to sustained and high rates of long-run economic growth. Resource dependency, frontier-land expansion and populations concentrated on fragile lands are all indications that a developing economy is not exploiting its natural capital efficiently and sustainably.

Final Remarks

Clearly, if resource-dependent development in poor economies is associated with frontier land expansion and resource exploitation, then the critical issue for these economies is how to improve the sustainability of such development. Based on our previous discussion, the key to sustainable economic development will be improving the economic integration between frontier and other sectors of the economy, targeting policies to improved resource management in frontier areas and overcoming problems of corruption and rent-seeking in resource sectors.

Better integration between frontier-based activities and more dynamic economic sectors means a greater commitment to promoting “agro-industrialization” generally. As argued by Reardon and Barrett (2000), such a strategy comprises three related sets of changes: a) growth of

commercial, off-farm agro-processing, distribution and input provision activities; b) institutional and organizational change in relations between farms and firms both upstream and downstream, such as marked increased in vertical integration and contract-based procurement; and c) related changes in product composition, technologies, and sectoral and market structure. Such an integrated approach to agro-industrialization is essential for developing *country-specific knowledge* in improving the productivity and sustainable exploitation of land resources, *strong forward and backward linkages* between more dynamic economic sectors (i.e., manufacturing) and agricultural activities, and finally, the opportunities for *substantial knowledge spillovers* from the farm to firm level.

However, frontier-based agricultural activities will be largely left out of the development of such agro-industrial capacity in low and middle-income economies unless specific policy reforms are aimed at improving resource management and productivity of frontier lands, and targeted especially at poor rural households farming these lands. Nevertheless, recent economic analyses are beginning to indicate what kind of policy reforms may be necessary to improve the incentives for better land management in the frontier areas and marginal farmlands of developing countries. The good news is that overall agricultural sector policy reforms that reduce price distortions, promote efficient operation of rural financial markets, and make property rights enforceable should support these incentives (Barbier 1997). In some countries, there may be a 'win-win' situation between general macroeconomic and sectoral reforms and improved land management. For example, in the Philippines it was found that reducing import tariffs and export taxes may also reduce the rate of upland degradation (Coxhead and Jayasuriya 1995). Similarly, in Indonesia reducing fertilizer, pesticide and other subsidies for irrigated rice could be compatible with improved investment and credit strategies for the uplands of Java (Pearce *et al.* 1990).

However, other economy-wide and sectoral reforms may have unknown - and possibly negative - aggregate impacts on land and resource use strategies of rural households. It may therefore be necessary to complement these reforms with specific, targeted policies to generate direct incentives for improved rural resource management. The main purpose of such policies should be to increase the economic returns of existing as opposed to frontier lands; improve the access of poorer rural households to credit and land markets; and alleviate any remaining policy biases in these markets that favor relatively wealthy farmers and individuals (Barbier 1997). In

some cases, specific non-price transfers in the form of targeted subsidies could reduce significantly the incentives for land degradation and forest conversion in developing countries. This is particularly true for expenditures that aimed to improve access by the rural poor to credit, research and extension, investments to disseminate conservation, information and technologies to smallholders, and investments in small-scale irrigation and other productivity improvements on existing smallholder land. For example, in Mexico there is some evidence that a land improvement investment program for existing rainfed farmers, particularly in States and regions prone to high deforestation rates, could provide direct and indirect incentives for controlling deforestation by increasing the comparative returns to farming existing smallholdings as well as the demand for rural labor (Barbier 2002; Barbier and Burgess 1996).

Targeting public investments and expenditures to the agricultural sector to provide effective credit markets and services to reach poor rural households, while continuing to eliminate subsidies and credit rationing that benefit mainly wealthier households, may be important in achieving a more efficient pattern of land use - and a less extensive one - in many developing countries. An important inducement for many poor smallholders to invest in improved land management is to establish proper land titling and ownership claims on the land they currently occupy. To improve land tenure services in areas where frontier expansion is occurring it may be necessary to develop more formal policies for smallholder settlement, such as a policy to allocate preferentially public land with fully demarcated ownership and tenure rights to smallholders.

In addition, policies that have increased processes of land degradation and deforestation as an unintended side effect should be mitigated. For example, expansion of the road network in frontier areas has been identified as a major factor in opening up forestlands and thus making these lands artificially cheap and abundantly available. Tax policies that encourage the holding of agricultural land as a speculative asset not only artificially inflate the price of existing arable land but promote much idling of potentially productive land.

Finally, in many developing countries policy reform will have to be complemented by investments in key infrastructural services. Several have been mentioned already - availability of rural credit, conservation and general extension services, land tenure and titling services, and irrigation and other land improvement investments for existing smallholder land. However, other services may also be important. For example, in most rural areas there needs to be a general

development of adequate post-harvest and marketing facilities targeted to smallholder production, in order to ensure that such production participates in an overall agro-industrial development strategy. In frontier areas, there is a need not only to increase credit and extension services to initial settlers but also more basic services such as improved community, education and health care services.

Perhaps one of the greatest challenges for policy reform in developing countries will be to reduce the propensity for corruption and rent-seeking in resource-based sectors. The institutional "failures" that promote such practices appear to be deep-seated and endemic, and will be difficult to change. Nevertheless, as argued by Ascher (1999, p. 299) there is some hope for reform even in this difficult area: "The fact that some government officials may intend to sacrifice resource-exploitation soundness for other objectives does not mean that they will necessarily have their way, even if they are chiefs of state. Prior arrangements, public outcry, and adverse reactions by international institutions can raise the political or economic costs too high. Other officials may be in a position to block their actions, especially if the structures of natural-resource policymaking reveal policy failures for what they are."

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Appendix 1

Export Concentration in Primary Commodities for Low and Middle Income Developing Economies

	Export Share 1990/99 a/	Export Share 1980/81 b/	Export Share 1965 b/	Main Export Commodities c/ 1		2	
	90%-100%						
Yemen A.R.	100	49	100	Fisheries	31.3%	Petroleum	14.1%
Botswana	100 c/	NA	NA	Diamonds	92.7%	Beef	5.3%
Angola	99	NA	82	Petroleum	77.1%	Coffee	2.6%
Nigeria	99	99	97	Petroleum	94.2%	Cocoa	2.5%
Mali	99	83	97	Cotton	41.9%	Groundnuts	0.8%
Ethiopia	99 d/	99	99	Coffee	66.6%	Sugar	1.1%
Iran	99 c/	NA	96	Petroleum	98.1%	Fisheries	0.2%
Rwanda	99 c/	99	100	Coffee	68.8%	Tea	8.4%
Eq. Guinea	99 c/	91	NA	Cocoa	53.5%	Timber	38.0%
Sao Tome & Pr.	99 d/	100	NA	Cocoa	95.5% d/	Copra	1.8%
Yemen PDR	99 d/	NA	94				
Burkina Faso	98 d/	85	95	Cotton	27.3%	Livestock	26.8% d/
Zambia	98 c/	99	100	Copper	93.3%	Zinc	1.8%
Liberia	98 c/	98	97	Iron Ore	60.4%	Rubber	20.4%
Sudan	97	99	99	Cotton	30.0%	Oilseed Cake	1.6%
Niger	97	98	95	Ores/Metals	67.0%e/	Food	29.0%e/
Uganda	97	100	100	Coffee	95.8%	Cotton	1.6%
Mauritania	97 d/	99	99	Fisheries	41.9%	Iron Ore	37.0%
Algeria	96	99	96	Petroleum	34.9%	Phosphate	0.2%
Benin	96	96	95	Cotton	26.0%	Cocoa	16.0%
Malawi	95	93	99	Tobacco	53.5%	Tea	15.4%
Libya	95	99	100	Petroleum	90.5%		
Iraq	95 c/	NA	99	Petroleum	94.4%	Tobacco	0.1%
Somalia	95 d/	99	86	Bananas	18.6%	Fisheries	3.5%
Ecuador	94	93	98	Petroleum	43.6%	Fisheries	15.8%
Gambia, The	94	NA	NA	Groundnuts	17.2%	Groundnut Oil	12.0%
Guyana	94 c/	NA	NA	Bauxite	39.5%	Sugar	35.7%
Congo, Dem. Rep. (Zaire)	93 d/	94	92	Copper	35.9%	Coffee	14.3%
Nicaragua	92	92	94	Coffee	40.9%	Cotton	21.2%
Comoros	92 d/	86	NA	Cloves	41.7% d/	Vanilla	33.3% d/
Cameroon	91	97	94	Petroleum	48.1%	Coffee	13.1%
Congo, Rep.	91 c/	94	37	Petroleum	83.2%	Timber	5.7%
Saudi Arabia	90	99	99	Petroleum	88.5%e/	Food	1.0%e/
Papua N.G.	90	100	90	Copper	31.0%	Coffee	15.2%
Lao PDR	90 d/	100	94	Timber	51.7% d/	Electricity	19.0%

Export Concentration in Primary Commodities for Low and Middle Income Developing Economies (cont.)

	Export Share 1990/99 a/	Export Share 1980/81 b/	Export Share 1965 b/	Main Export Commodities c/ 1		2	
	80%-89%						
Burundi	89 c/	96	95	Coffee	83.5%	Tea	4.2%
Venezuela	89	NA	98	Petroleum	55.7%	Aluminum	3.7%
Myanmar	89	81	99	Timber	40.3%	Rice	28.1%
Chad	89 d/	96	97	Cotton	33.2%	Oilseed	0.2%
Oman	88	96	NA	Petroleum	90.0%	Fisheries	0.7%
Cote d'Ivoire	88 d/	90	95	Cocoa	30.5%	Coffee	18.5%
Paraguay	87	NA	92	Cotton	16.4%	Soybeans	14.9%
Gabon	87 c/	NA	NA	Petroleum	70.5%	Manganese	8.1%
Guinea-Bissau	87 d/	71	NA	Fisheries	13.9%	Groundnuts	10.4%
Togo	86	85	97	Phosphate	31.7%	Cotton	11.8%
Ghana	86	98	98	Cocoa	49.2%	Aluminum	11.3%
Chile	85	90	96	Copper	42.9%	Fisheries	11.6%
Tanzania	84	86	87	Coffee	44.1%	Cotton	11.3%
Panama	81	91	98	Fisheries	31.3%	Bananas	22.5%
Honduras	80	89	96	Bananas	35.4%	Coffee	28.0%
Peru	80	83	99	Copper	17.3%	Zinc	12.3%
Guinea	80	NA	NA	Bauxite	72.8%	Aluminum	19.4%
Cuba	80 c/	NA	NA	Sugar	74.9%	Fisheries	2.3%
	70%-79%						
Mozambique	79 c/	NA	NA	Fisheries	55.7%	Sugar	7.1%
Bolivia	78	100	95	Tin	18.6%	Zinc	3.4%
Syrian Arab Republic	77	NA	90	Petroleum	40.1%	Cotton	7.9%
Maldives	77 d/	70	NA	Fish	57.1% d/		
Kenya	74	88	94	Coffee	31.7%	Tea	22.2%
Colombia	72	72	93	Coffee	46.7%	Bananas	4.1%
Zimbabwe	71	63	85	Tobacco	19.7%	Cotton	6.7%
Guatemala	71	71	86	Coffee	39.2%	Bananas	6.5%
	60%-69%						
Argentina	69	84	94	Oilseed	9.5%	Wheat	8.7%
Trinidad and Tobago	68	86	93	Petroleum	41.7%	Sugar	1.3%
Madagascar	67	92	94	Coffee	36.8%	Fisheries	8.8%
Uruguay	61	70	95	Beef	12.0%	Wool	8.5%
Senegal	60	81	97	Fisheries	39.9%	Phosphate	8.5%

Export Concentration in Primary Commodities for Low and Middle Income Developing Economies (cont.)

	Export Share 1990/99 a/	Export Share 1980/81 b/	Export Share 1965 b/	Main Export Commodities c/ 1		2	
	50%-59%						
Egypt	58	92	80	Petroleum	39.3%	Cotton	7.4%
Sierra Leone	58 c/	57	39	Bauxite	18.0%	Cocoa	16.3%
El Salvador	57	63	83	Coffee	63.6%	Sugar	3.0%
Central African Republic	57 c/	74	46	Coffee	26.0%	Timber	18.0%
Indonesia	54	96	96	Petroleum	31.1%	Rubber	4.7%
Morocco	50	72	95	Phosphate	16.9%	Fisheries	11.9%
	40%-49%						
Costa Rica	49	68	84	Coffee	31.4%	Bananas	20.0%
Jordan	47	57	81	Phosphate	22.1%	Wheat	0.3%
Brazil	46	59	92	Coffee	8.5%	Iron Ore	6.6%
Malaysia	33	80	94	Petroleum	12.5%e/	Food	10.0%e/
Sri Lanka	33	79	99	Tea	28.7%	Rubber	7.3%
	30%-39%						
South Africa	37	26	68	Ores/metals	16.0%e/	Petroleum	8.5%
Mexico	36	73	84	Petroleum	49.6%	Coffee	3.3%
Thailand	30	68	95	Fisheries	10.7%	Rice	9.0%
Jamaica	30	40	69	Aluminum	34.5%	Bauxite	16.5%
	20%-29%						
Mauritius	29	69	100	Sugar	38.7%	Fisheries	1.5%
Tunisia	26	56	82	Petroleum	32.5%	Fisheries	3.1%
India	25	47	51	Tea	4.6%	Iron Ore	4.2%
Vietnam	24 c/	NA	NA	Fisheries	10.3%	Rubber	4.0%
Dominican Rep.	21	81	98	Sugar	20.6%	Nickel	15.4%
Philippines	20	49	95	Coconut Oil	7.0%	Copper	5.1%
	10%-19%						
China	19	43	NA	Petroleum	12.5%	Cotton	1.7%
Pakistan	18	36	64	Cotton	12.1%	Rice	8.4%
Bangladesh	16	39	NA	Fisheries	12.5%	Jute	12.5%
Haiti	15	NA	NA	Coffee	15.5%	Cocoa	1.8%
Nepal	11	48	NA	Rice	3.6%	Oilseed	1.6%

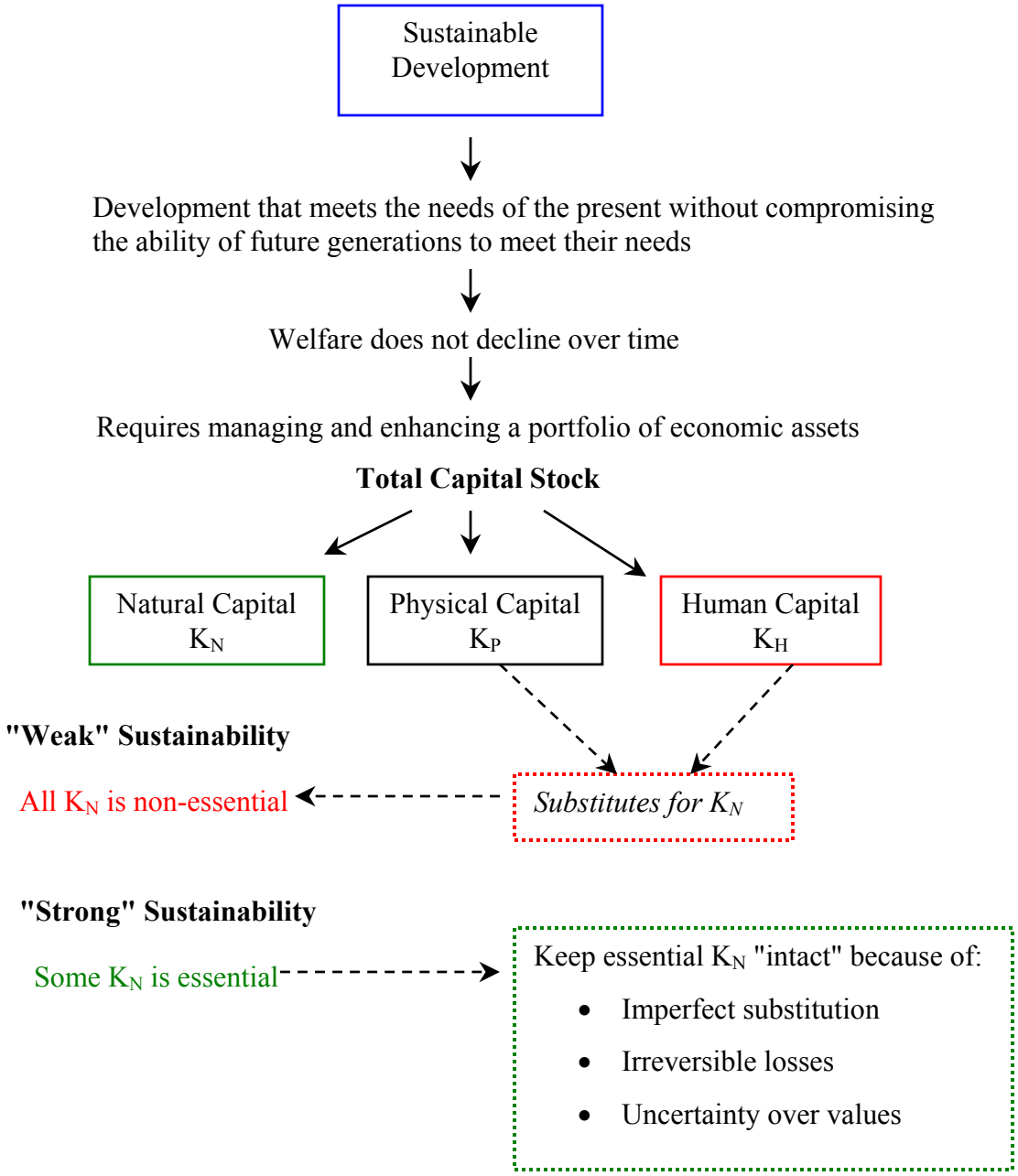
Export Concentration in Primary Commodities for Low and Middle Income Developing Economies (cont.)

	Export Share 1990/99 a/	Export Share 1980/81 b/	Export Share 1965 b/	Main Export Commodities c/ 1		2	
	0%-9%						
Korea, Rep.	7	9	40	Fisheries	3.1%	Sugar	0.2%
Lesotho	5 c/	NA	NA	Wool	4.8%		
Lebanon	2 c/	NA	66	Tobacco	1.3%	Wool	0.2%

Total No. of Countries	***95***
Avg Export Share of All Countries	***71***
Median Export Share of All Countries	***84***
Countries with Export Share > 90%	***35***
Countries with Export Share > 50%	***71***

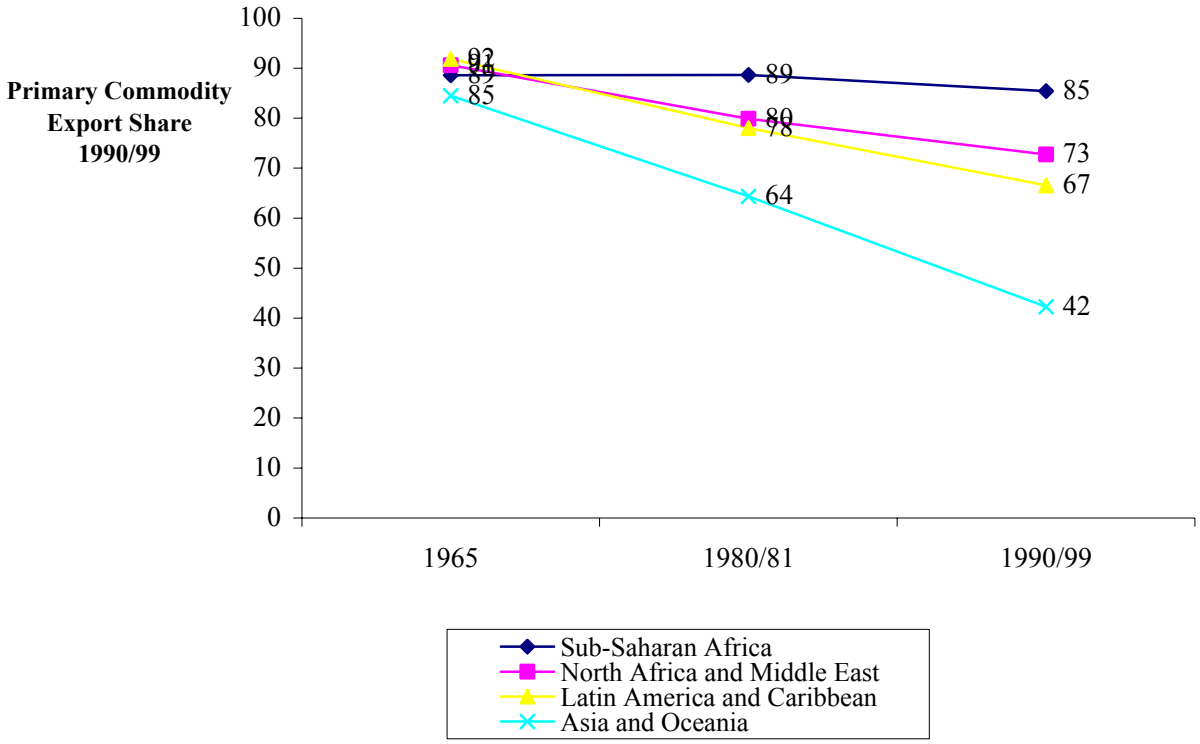
Notes: Low and middle-income countries in Africa, Latin America, Asia and Oceania, based on World Bank definition (countries with GDP per capita in 1994 at 1987 constant purchase power parity $ of less than $10,500 and an average of $2,691).
a/ Based on United Nations Conference Trade and Development (UNCTAD), *Handbook of International Trade and Development Statistics, 2001* unless otherwise stated.
b/ Based on various editions of the following World Bank documents: *World Development Report, Trends in Developing Economies, Commodity Trade and Price Trends* and *African Economic and Financial Data*.
c/ Based on World Bank, *Commodity Trade and Price Trends, 1989-91 Edition.*
d/ Based on World Bank, *Commodity Trade and Price Trends, 1989-91 Edition*
e/ Based on World Bank Development Indicators.

Figure 1. Sustainable Economic Development



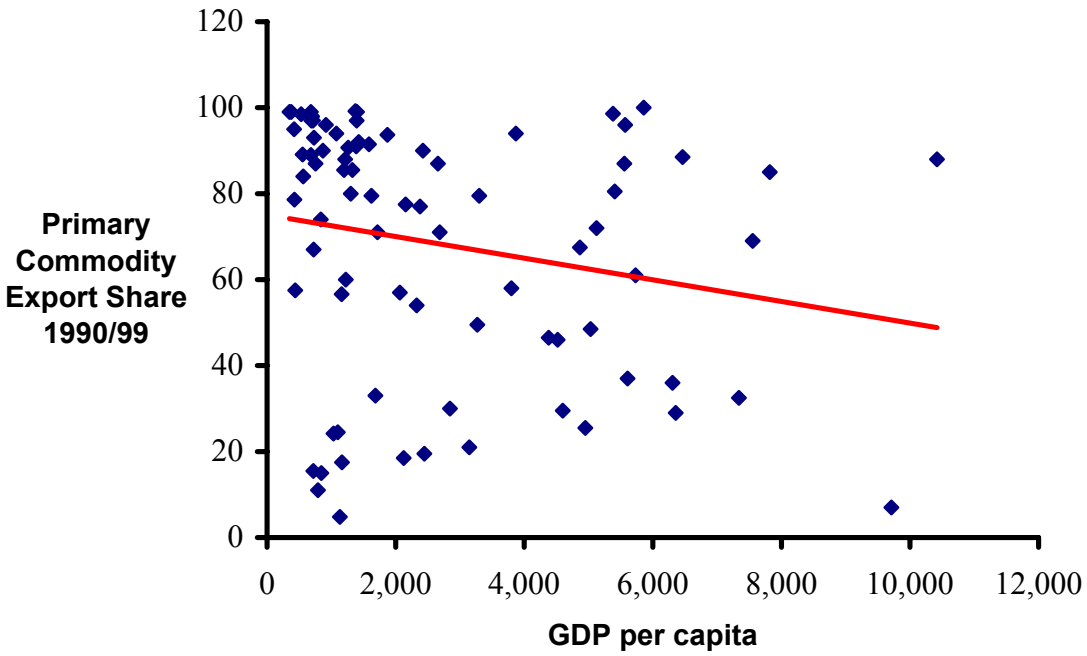
Source: Adapted from Pearce and Barbier (2000).

Figure 2. Regional Trends in Resource Dependency



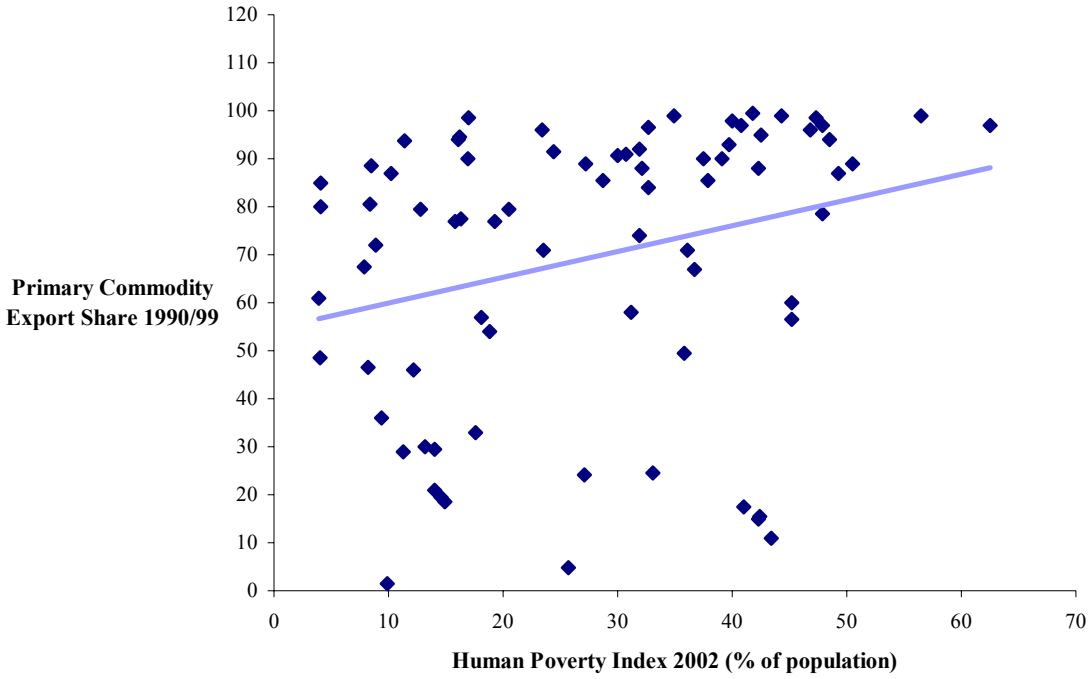
Source: See Appendix 1.

Figure 3. Resource Dependency and GDP per Capita in Low and Middle-Income Economies



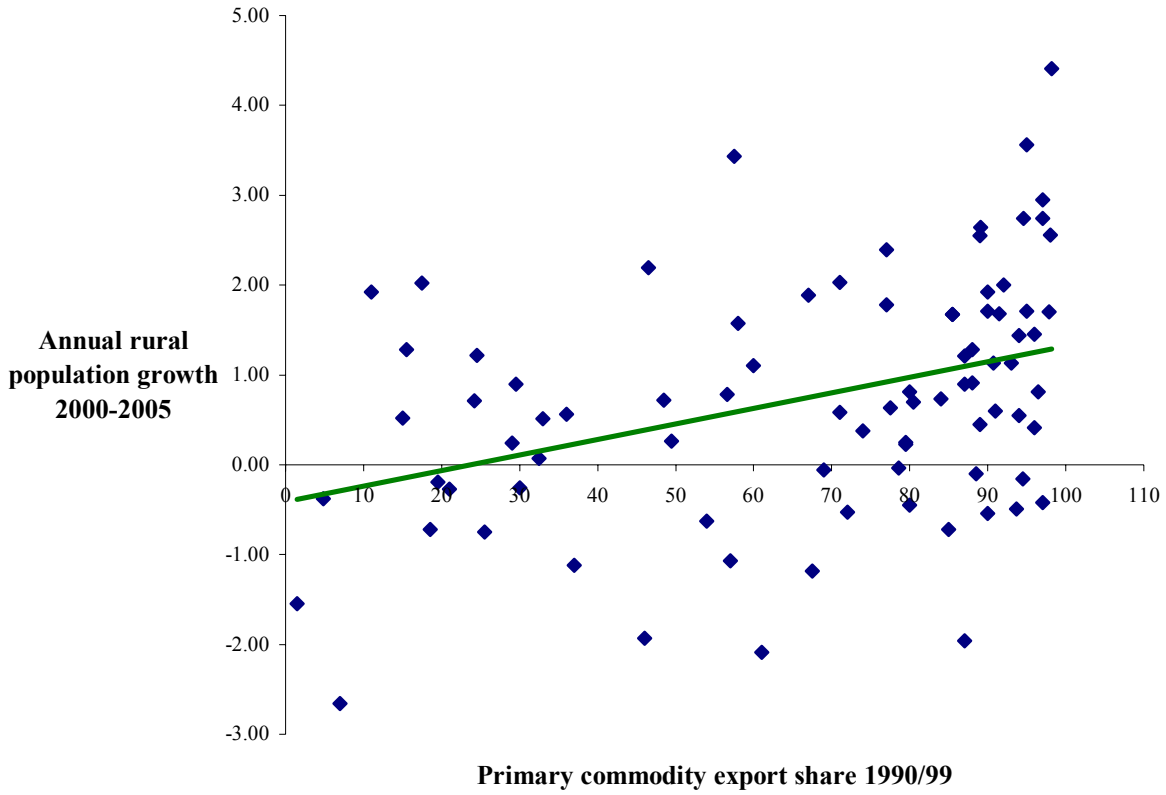
Notes: Primary commodity export share is the average export share 1990/99 for low and middle-income countries in Appendix 1.
GDP per capita in 1994 at 1987 constant purchase power parity $, from World Bank Development Indicators.
Correlation coefficient, r = -0.205. Number of observations = 82.

Figure 4. Resource Dependency and Poverty in Low and Middle-Income Economies



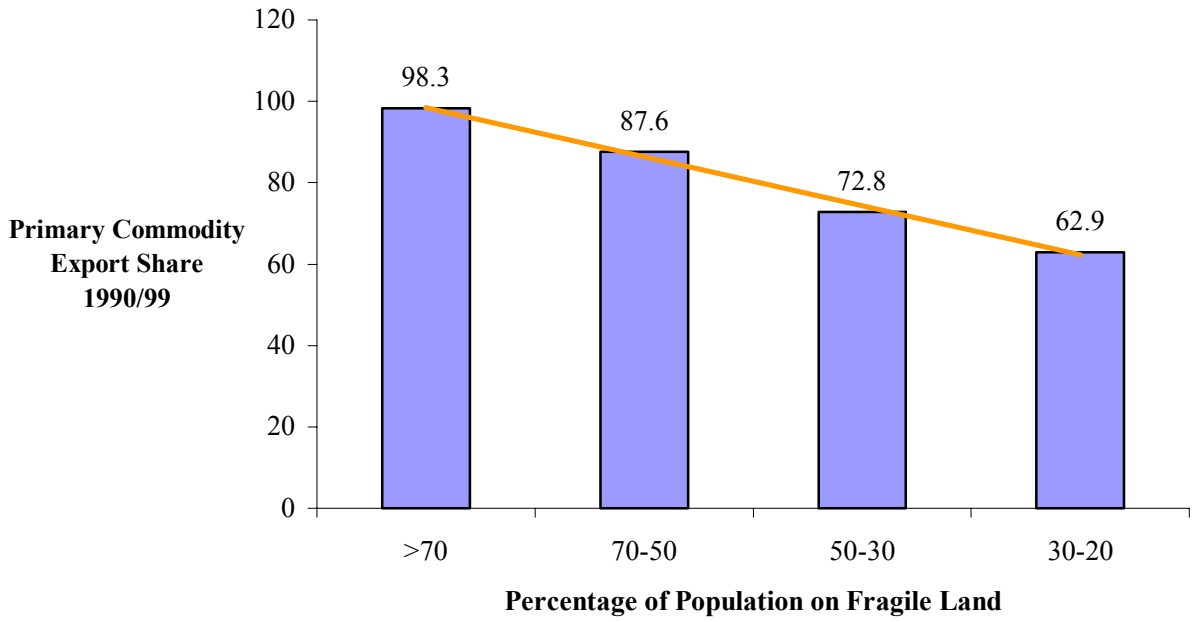
Notes: Primary commodity export share is the average export share 1990/99 for low and middle-income countries in Appendix 1.
Human Poverty Index 2002 from the United Nations Development Program, *Human Development Report 2002*.
Correlation coefficient, $r = 0.275$. Number of observations = 77.

Figure 5. Resource Dependency and Rural Population Growth in Low and Middle-Income Economies



Notes: Primary commodity export share is the average export share 1990/99 for low and middle-income countries in Appendix 1.
Annual rural population growth 2000-2005 from Population Division of the United Nations Secretariat, World Urbanization Prospects: The 2001 Revision.
Correlation coefficient, $r = 0.465$. Number of observations = 94.

Figure 6. Resource Dependency and Share of Population on Fragile Lands in Low and Middle Income Economies



Notes: Primary commodity export share is the average export share 1990/99 for low and middle-income countries in Appendix 1.
Share of population on fragile land is from World Bank, *World Development Report 2003*, Table 4.3. Fragile land is defined in the report as "areas that present significant constraints for intensive agriculture and where the people's links to the land are critical for the sustainability of communities, pastures, forests, and other natural resources" (p. 59).
Number of observations = 72, of which 2 (> 70%), 8 (70-50%), 33 (30-50%) and 29 (20-30%).

Figure 7. Agricultural Land Expansion and GDP per Capita in Tropical Countries, 1961-94

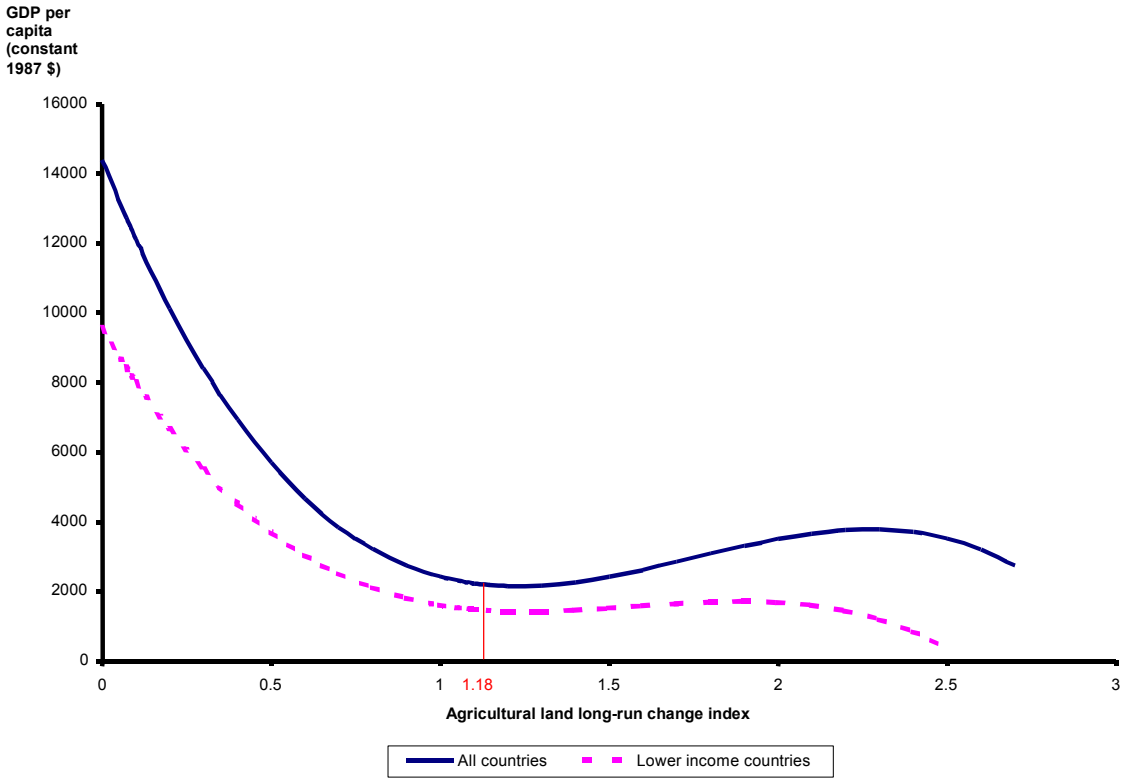


Table 1. Economic Growth and Resource Dependency, 1970-90

Dependent variable: Real GDP growth per capita, 1970-90	
Explanatory variables	**Coefficient (t-statistic)**
Log GDP per capita 1970	-1.8
	(8.87)
Primary product share	-9.9
(Exports of natural resources, % GDP, 1970)	(6.50)
Trade openness	1.3
	(3.2)
Log investment	0.8
	(2.4)
Rule of law	0.4
	(3.8)
Terms of trade change	0.1
	(2.1)
Growth 1960-1969	0.02
	(0.2)
R^2	76%
Sample size	69

Source: Sachs and Warner (2001).

Table 2. Trends in Crop Production and Harvest Area in Developing Regions

	Crop Production				Harvested Land		
	1970-90 Contribution (%) of increases in:		1990-2010 Contribution (%) of increases in:		1990-2010 Contribution(%) of increases in:		1990-2010 Percentage of crop production from new land
Region	**Yields**	**Harvested area**	**Yields**	**Harvested area**	**Arable land**	**Cropping intensity**	
Sub-Saharan Africa	53	47	53	47	64	36	30
Near East and North Africa	73	27	71	29	31	69	8
East Asia[a]	59	41	61	39	82	18	34
South Asia	82	18	82	18	22	78	4
Latin America[b]	52	48	53	47	60	40	29
All developing countries	69	31	66	34	62	38	19

Notes: [a] Excludes China.
[b] Includes the Caribbean.

Source: FAO (1995).

Table 3. Demand for Cultivated Land in 2050 in Developing Regions

Region	Cultivated crop land in 1990 (1000 ha)	% of production increase from new land	Additional cultivated land required in 2050 (1000 ha)	% of new lands from forest and wetland conversion
Africa	252,583	29	241,703	61
Asia[a]	456,225	10	85,782	73
Latin America[b]	189,885	28	96,710	70
All developing countries	899,795	21	424,194	66

Notes: [a] Excludes China.
[b] Includes the Caribbean.

Source: Fischer and Heilig (1997).

Table 4. Water Withdrawal by Volume and by Share of Total Renewable Supplies

Region/Country	Total Water Withdrawal (km^3)			Total Withdrawal as a Percentage of Renewable Water Supply (%)		
	1995	**2010**	**2025**	**1995**	**2010**	**2025**
Asia	2,165	2,414	2,649	17	19	20
Latin America	298	354	410	2	2	3
Sub-Saharan Africa	128	166	214	2	3	4
West Asia/North Africa	236	266	297	69	81	90
Developing Countries	2,762	3,134	3,507	8	9	10
Developed Countries	1,144	1,223	1,265	9	9	10
World	**3,906**	**4,356**	**4,772**	**8**	**9**	**10**

Source: Rosegrant *et al.* (2002), Table 4.1.

Table 5. Developing Countries and Regions with Critical Water Ratios

Region/Country	Total Water Withdrawal (km^3)			Total Withdrawal as a Percentage of Renewable Water Supply (%)		
	1995	2010	2025	1995	2010	2025
Huaihe	77.9	93.7	108.3	83	100	115
Haihe	59.2	62.1	62.9	140	147	149
Huanghe	64.0	71.1	79.5	89	99	111
Changjian	212.6	238.5	259.1	23	26	29
Songliao	51.5	59.2	67.6	26	30	34
Inland	89.5	98.9	111.2	299	330	371
Southwest	8.3	9.7	12.3	1	1	2
ZhuJiang	77.1	84.9	96.9	19	21	24
Southeast	38.8	41.4	47.7	27	29	33
China total	**678.8**	**4,356**	**845.5**	**26**	**29**	**33**
Sahyadri Gats	14.9	18.7	20.8	14	17	19
Eastern Gats	10.5	13.7	11.6	67	87	74
Cauvery	11.8	12.8	13.1	82	89	91
Godavari	30.2	33.3	38.8	27	30	35
Krishna	46.2	51.4	57.5	51	57	63
Indian-Coastal-Drain	34.8	46.9	43.6	108	145	135
Chotanagpur	7.2	10.9	14.3	17	26	34
Brahmari	25.5	27.2	31.0	24	22	26
Luni River Basin	41.9	43.1	50.8	148	140	166
Mahi-Tapti-Narmada	31.4	34.3	36.3	36	39	42
Brahmaputra	5.5	7.2	9.2	1	1	1
Indus	159.1	178.7	198.6	72	81	90
Ganges	255.3	271.9	289.3	50	54	57
India total	**674.4**	**750.0**	**814.8**	**30**	**33**	**35**
Pakistan	**267.3**	**291.2**	**309.3**	**90**	**98**	**105**
Philippines	**47.0**	**58.2**	**70.0**	**24**	**29**	**35**
South Korea	**25.8**	**34.9**	**35.9**	**56**	**75**	**78**
Mexico	**78.6**	**86.2**	**94.2**	**24**	**26**	**29**
Egypt	**54.3**	**60.4**	**65.6**	**89**	**99**	**108**
Other West Asia/North Africa[a/]	**143.2**	**156.0**	**171.5**	**116**	**125**	**139**

Notes: a/ Excluding Turkey.
Source: Adapted from Rosegrant *et al.* (2002), Table B.3.

Table 6. Panel Analysis of Per Capita Income and Long Run Agricultural Expansion, 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 (23.69)**	9560.07 (7.03)**
Long run agricultural land area change index (α_{it})[d]	-24293.31 (-19.04)**	-16645.71 (-5.30)**
α_{it}^2	15217.53 (11.18)**	11013.18 (4.58)**
α_{it}^3	-2896.32 (-6.59)**	-2330.33 (-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 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.