CHAPTER 1

ENVIRONMENTAL SUSTAINABILITY, ECONOMIC GROWTH AND STRUCTURAL TRANSFORMATION: CONCEPTUAL ISSUES

There are important differences among economists, and also between economists and ecologists, regarding the relationship between economic growth and the environment, the meaning of sustainability, and the policies necessary to make growth consistent with environmental sustainability. Against this backdrop, this chapter examines some conceptual issues critical to understanding different approaches.

The chapter is organized in four parts. Section A summarizes some fundamental differences among scholars on what sustainability is, how it could be achieved, and the policies deemed necessary to make growth consistent with environmental sustainability. In this context, section B identifies some conceptual issues related to the notions of the green economy and green growth. A particular challenge is to operationalize the idea of a green economy in a development context. Section C builds on one of the approaches of section A to discuss how resource use and environmental impacts change during the course of economic development. This shows that for countries at low levels of development, there will necessarily be a trade-off between structural transformation, on the one hand, and environmental sustainability, on the other hand. Section D introduces the concept of *sustainable structural transformation* (SST) as an appropriate strategy for managing that trade-off and introducing a development-led approach to the green economy.

A. THE RELATIONSHIP BETWEEN THE ECONOMY AND THE ENVIRONMENT: ALTERNATIVE VIEWS

Traditionally, economists downplayed the importance of the natural environment for economic processes. They viewed the economic system in terms of the reciprocal circulation of income between producers and consumers, and focused on the problem of allocating resources efficiently between different uses to meet unlimited wants. Neoclassical environmental and resource economists consider the environment, along with the planet's resources, as a sub-part of the economic system. They have introduced natural capital into their analytical frameworks and examined problems of resource misallocation arising from the failure of markets to generate appropriate prices for natural resources. There is also increasing attention to natural capital within growth models (see, for example, Hallegatte *et al*., 2011). In general, mainstream economists have assumed that the expansion of the economy should allow societies to harness new technologies to conserve scarce resources, as well as to offset any adverse effects that increased economic activity might have on the environment (Grossman and Krueger, 1995). In other words, growth is conceptualized as a solution rather than as the cause of environmental problems. Moreover, the expansion of an economy can continue into the future following a balanced growth path without any apparent limits.

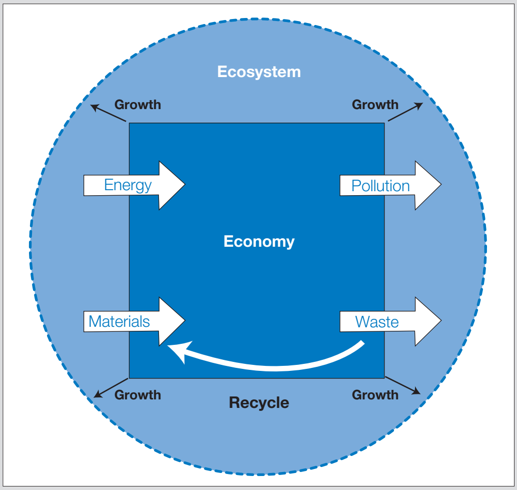
This view stems in part from the fact that neoclassical economists do not regard the scarcity of natural resources as a binding constraint. In their view, the scarcity of a natural resource should lead to an increase in its price and substitution away from that resource into other relatively less expensive factor inputs. The idea is that natural capital (such as renewable and non-renewable resources) and man-made or reproducible capital are substitutes, and so the depletion of natural capital should affect their supply price and induce substitution away from natural capital and into reproducible capital. Because of the assumption of substitutability between natural and reproducible capital, sustainability in mainstream economics requires *maintaining intact the value of a nation's total capital stock over time* (Heal, 2007). This notion of sustainability which is referred to as *weak sustainability* in the literature allows countries to compensate for the depletion of some kinds of capital by investing in other kinds of capital. It draws heavily from studies by Solow (1974) and Hartwick (1977), showing that a maximal level of consumption or welfare can be maintained over time if the rent from the use of exhaustible resources is reinvested in reproducible capital (the Hartwick rule). In this framework, what is important for sustainability is not the composition of a nation's capital, but the total value of its capital stock. Furthermore, it is assumed that there is a positive relationship between the total value of an economy's capital and long-run living standards — or there is a discounted value of welfare. Consequently, if a country wants to maintain its long-run living standards intact, it also has to maintain the total value of its capital stock intact.

Although the methodology adopted by mainstream economists in dealing with environmental issues is regarded as analytically rigorous and tractable, it suffers from several limitations. In particular, it treats the economy as if it is a self-contained system, with the planet, resources, animals and people existing as components of the economic system. This ignores the fact that in reality the economy is a part of the larger ecosystem, which is the source of natural resources used in an economy and is also a sink for the wastes produced in it. Vencatachalam (2007) argues that the narrowness of the neoclassical approach to environmental and ecological issues has made it difficult to understand and address environmental problems, such as global warming and the loss of biodiversity.

In contrast to environmental and resource economists, ecological economists view the economic system as a part of the larger ecosystem, which is the source of natural resources used in an economy and is also a sink for the wastes produced in it (Constanza, 1991; Daly 1996). That is, it receives inputs, such as energy and material resources, from the broader natural systems and produce wastes and pollution as outputs (see figure 1). These inputs and outputs from and to the ecosystem constitute what is known as the throughput of an economy.

This shift in vision has important consequences. Whilst environmental and resource economists within the neoclassical tradition focus on allocation issues, ecological economists emphasize the overall scale of the economy as a key policy issue. At the global level, as the economy grows bigger and bigger, it reduces the capacity of the ecosystem to perform its source and sink functions more and more. From this perspective, there are global limits to economic growth in the sense that, once the global economy passes a certain size, the benefits of consuming produced goods and services are outweighed by the costs in terms of destruction of ecosystem services on which the economy is based. This issue is not relevant when the material weight of the economic system on the ecological system is relatively small, but it becomes relevant in a "full world"[2], where the size of the global

Figure 1. The economy as a subsystem of the Earth system



Source: Based on Goodland and Daly (1996).

economy undermines the natural bases for economic processes and prosperity. Most ecological economists believe that we are now living in a full world.

Ecological economists are likewise sceptical about the substitutability between natural capital and man-made capital, as implied by the notion of weak sustainability. Consequently, they share the view that sustainability requires society maintaining intact its natural capital to ensure that future generations have the same production and consumption possibilities that are available to the current generation. This is the notion of *strong sustainability* in the literature on environmental and ecological economics (Daly 1990; 1996). It should be noted that, although proponents of strong sustainability emphasize the preservation of the stock of natural capital, some also assume that there is substitutability within natural capital, but not between natural and man-made capital. Other proponents, however, argue that there is the need to preserve the physical stocks of critical natural capital, because they provide life-support services and the loss of natural capital is irreversible. Furthermore, there is uncertainty about the impact of natural resource depletion and so society should adopt a cautious approach to the use of natural capital. Daly (1990) has identified four basic principles that economies could follow to ensure that natural capital is maintained at a sustainable level, namely: (a) the health of ecosystems and their life support services should be maintained; (b) renewable resources should be extracted at a rate that is not more than their rate of regeneration; (c) non-renewable resources should be consumed at a rate that is not more than the rate at which they can be replaced through discovery of renewable substitutes; and (d) waste disposal should be done at a rate not higher than the rate of absorption by the environment.

While ecological economists recognize the existence of limits to economic growth at a global scale, they also argue that developing countries still need to expand their economies. Levels of human well-being are very low, and people have legitimate aspirations to higher living standards which can only be achieved through high levels of economic growth maintained over a few generations. What this implies is that global distributional issues are at the heart of the concern to ensure environmental sustainability along with prosperity for all. This approach draws attention to major global inequities in terms of the distribution of both contributions to, and the costs of, environmental pressures. The work of ecological economists is also showing that international trade is acting as a powerful mechanism through which environmental constraints in one country are being circumvented, and environmental costs outsourced from countries of consumption to countries of production.

B. CONCEPTUAL ISSUES CONCERNING THE GREEN ECONOMY AND GREEN GROWTH

It is against the background of these alternative views of the relationship between the environment and the economy that the new policy concepts of the "green economy" and "green growth" have been introduced. There is no consensus on the meaning of these terms. But, rhetorically, being "green" connotes being good to the environment. UNEP (UNEP, 2011b) defines a green economy as one which is "low-carbon, resource-efficient and socially inclusive", or to put it in other words, a green economy is "one that results in improved human well-being and social equity while significantly reducing environmental risks and ecological scarcities". The Organization for Economic Cooperation and Development (OECD, 2011) states that "green growth means fostering economic growth and development while ensuring that natural assets continue to provide resources and environmental services on which our well-being relies".

The major point of introducing these concepts has been to sharpen the focus on the relationship between the economy and the environment within a policy discourse, where the concept of sustainable development has been in long use. Neither UNEP nor OECD sees these concepts as replacements for the idea of sustainable development. According to OECD (2011), green growth is "a subset" of the idea of sustainable development, "narrower in scope, entailing an operational policy agenda that can help achieve concrete, measurable progress at the interface between economy and environment"; whilst UNEP (2011b) sees the usefulness of the concept of a green economy stemming from "a growing recognition that achieving sustainability rests almost entirely on getting the economy right".

However, there is also a significant difference between these new concepts and the old concept of sustainable development. In general terms, sustainable development has been defined as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs". But such development rests on three pillars — economic growth, social equity and environmental sustainability — and it was explicitly recognized that in achieving sustainable development there would be potential trade-offs amongst them. In contrast, the concepts of green economy and green growth place greater emphasis on the potential synergies between economic growth and environmental sustainability. These synergies definitionally constitute what a green economy is in the UNEP Green Economy Report ((UNEP, 2011b). With regard to green growth, three basic positions have been identified in the literature (see Huberty *et al.*, 2011). The first, and weakest, argues that greening the economy does not inhibit economic growth and employment creation; the second argues that there are significant new opportunities for growth and jobs in green sectors; and the third, and strongest, argues that new environmental technologies and renewable energy systems will provide the basic sources of economic growth in the coming long-wave of economic growth.

The idea that economic growth and environmental sustainability are complementary objectives is certainly attractive. However, there is a danger that political enthusiasm undermines policy rigour. Huberty et al. (2011) go as far as to say that "to date, discussions of 'green growth' have been more religion than reality", adding that "the easiest arguments about green growth are not satisfactory". Dercon (2011) notes that "much of the discussion on green growth remains relatively vacuous in terms of specifics for poor settings", and says that the understanding of the interaction between green growth strategies and investments and poverty is particularly weak. He asks: "Is all green growth good for the poor, or do certain green growth strategies lead to unwelcome processes and even 'green poverty', creating societies that are greener but with higher poverty?" (p. 2). From another perspective, Hoffmann (2011) argues that current approaches to the green economy are simply insufficient to meet the challenge of reducing global emissions and thus mitigating climate change.

More research is definitely needed. But one review of the literature on green growth in the context of developed countries has concluded that "green growth arguments should be treated with cautious optimism" (Huberty *et al.*, 2011). The research shows that combining growth with emissions reductions is possible at low cost. But, in general, "none of the current prescriptions for green growth guarantee success" (Huberty *et al.*, 2011). In particular, the creation of green jobs and new green sectors in many cases may simply offset the destruction of brown jobs in declining sectors. Moreover, new opportunities for economic growth in developed countries based on the development of green sectors have particularly relied on exports and may not be replicable. In the context of developing countries, research is even scarcer. But Dercon (2011) carefully examines how internalizing environmental costs may change patterns of growth and concludes that "it is not very plausible that green growth will offer the rapid route out of poverty as it appears to promise, or even as rapid an exit with more conventional growth strategies" (Dercon, 2011).

Relating the concepts of green economy and green growth to processes of economic development is as yet a major weakness within the literature. IBON International (2011) states that “by focusing on ‘getting the economy right’, proponents of the green economy and green growth end up getting development wrong”. Khor (2011) is particularly sensitive to this issue. He cautions against a one-dimensional usage of the green economy concept, which promotes it in a purely environmental manner without fully considering the development dimension and equity issues, particularly at the international level, and against a one-size-fits-all approach, in which countries at different levels and stages of development, and in particular the priorities and conditions of developing countries, are not taken into account. He also argues that the meaning, use and usefulness of the notion of the green economy for policymakers in developing countries, and also in international negotiations, will depend on clarification of a number of difficult questions, notably (a) whether the attainment of a green economy constrains other objectives (growth, poverty eradication, job creation); (b) how to identify and deal with trade-offs; (c) what is the combination between these aspects at different stages of development as well as stages in the state of the environment; (d) what is the role of the State in building a green economy, its compatibility with free market and the role of the private sector; and (e) how to build an economy that is more environmentally friendly and how to handle the transition from the present to a greener economy.

It is clear that operationalizing the concept of the green economy in the context of sustainable development and poverty eradication in a way which is relevant to developing countries is a work in progress. More attention needs to be given to the nature of the relationship between the economy and the environment, the way in which such relationship evolves during the process of economic development, and the implications of that evolving relationship for the policy challenge of promoting development and poverty reduction in countries at different levels and stages of development.

C. THE DYNAMICS OF DEVELOPMENT, RESOURCE USE AND ENVIRONMENTAL IMPACTS

This section seeks to build a developmental approach to the relationship between the economy and the environment. It takes as its starting point the idea that the economy is best viewed as a subsystem of the Earth-system and then considers how, within this vision, resource use and environmental impacts change during the economic development process. This provides the basis for a strategic approach to sustainable development, which builds on the imperative of structural transformation for accelerated economic growth and poverty reduction.

It summarizes three major views of the dynamics of development, resource use and environmental impacts, namely:

- The IPAT equation;
- The Environmental Kuznets Curve (EKC) hypothesis; and
- Socioecological metabolism and structural change.

These views constitute a valuable framework to comprehend where countries at different levels of development stand in relation to their current and future use of natural resources and levels of environmental impact. They provide a basis for starting to think about a development-led approach to the green economy.

1. The IPAT equation

Economists have long tried to identify the factors that determine the degree of environmental impact registered throughout the different stages of the development process. One of these attempts is represented by the IPAT equation, formulated by Ehrlich and Holdren (1971) and Commoner (1972). In basic terms, it suggests that an environmental impact (I) depends on the levels of population (P), affluence (A) and technology (T).

$$\text{Environmental impact} = \text{Population} \times \text{Affluence} \times \text{Technology}$$

The equation is useful to express the extent to which each component contributes to an unsustainable situation, but it can also be interpreted as a way to assess an economy's pathway towards sustainability. By analysing each of its components, the identity implies that growing population rates lead to larger pressures on the environment. On the other hand, higher levels of affluence, which is generally measured in consumption per capita terms, entail a larger demand for natural resources and energy, as well as a rising generation of wastes and pollution. Finally, the level of technology, understood as the different ways in which societies use their productive resources, can have a significant effect on the degree of environmental impact, either reducing it or enlarging it. For example, the internal combustion technology has importantly contributed to the development of industrialized economies by using fossil fuels, but it has also significantly increased the levels of pollution in the atmosphere. Conversely, renewable energy technologies (RET) can crucially contribute to reduce atmospheric pollution and prevent the depletion of non-renewable resources.

The IPAT equation is very simple and has been modified several times since its inception (Chertow, 2001). A common approach is to describe each of the factors with more detail.

$$\text{Impact} = \text{Population} \times \frac{\text{GDP}}{\text{Population}} \times \left(\frac{\text{Resource Use}}{\text{GDP}} + \frac{\text{Pollution/Waste}}{\text{GDP}} \right)$$

This form of the equation expresses affluence as GDP per capita, as had already been mentioned. However, the technology factor is now decomposed into two separate components, which relate to the throughput of an economy. On the one hand, resource intensity (i.e. resource use per unit of production) shows how efficiently the inputs are used; while, on the other hand, pollution or waste intensity (i.e. pollution/waste per unit of production) exhibits the degree of "cleanliness" of a certain technology in relation to the outputs. In this sense, improvements in environmental quality can be attained by minimizing resource intensity, as well as pollution intensity.

Important policy implications arise from the IPAT equation. In particular, the need to develop more efficient technologies is vital. Members of the Factor 10 Club (1994) believe that existing resource and pollution intensities must improve by a factor of 10 during the next three to five decades so as to significantly lower the environmental impacts, especially when it comes to the generation of greenhouse gases (GHG). Others, like von Weizsäcker *et al.* (1997), propose a factor 4 approach, according to which the global population could double its wealth, while halving the amount of used resources. This basically involves multiplying the affluence (A) component by two in the IPAT equation and reducing technological-induced (T) impacts by half. Nonetheless, whichever factor is chosen (whether 10, 4 or another number), the magnitude of the required tasks to transform the structure of the global economy involves enormous efforts.

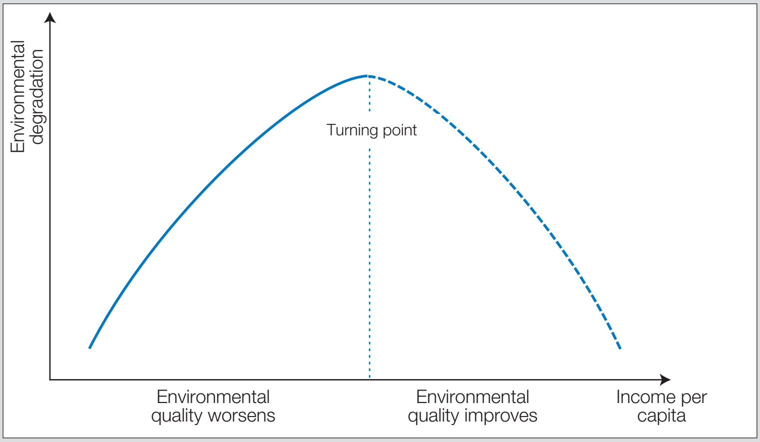
An important issue here is that, while rich industrialized countries might have the ability to generate technological innovations, many developing countries, and specifically most African countries, do not possess these capabilities. Many of them currently have access only to traditional technologies, which often are considered "dirty" or at least not efficient enough to offset the influence of the other factors in the equation. The plausibility for these countries to generate new technical innovations domestically and thus push the technological frontier is low, due to their lack of physical and human capital. Furthermore, it is important to keep in mind that the T-factor not only refers to technical innovations, but also to the institutional settings and the relationship between the different actors of a society. As recognized in the original Rio conference, changes in both technology and social organization are critical for sustainable development. This means that these countries face a complex situation, in which changes must take place at many different levels.

In relation to population, the IPAT has a harsh implication. As the number of people on the planet increases, the demand for resources will augment, generating severe consequences on the environment. However, the issue of curbing population growth depends on other developmental factors, such as reducing poverty and increasing women's rights, specifically in relation to access to education.

2. The Environmental Kuznets Curve (EKC)

Some researchers believe that the key to resolving environmental problems is the affluence factor. They argue that as economies grow and per capita income rises, environmental degradation increases but, after a certain threshold level of income, environmental quality improves. This relationship between growth and the environment is known as the EKC hypothesis (IBRD, 1992; Grossman and Krueger, 1993 and 1995). The EKC can be read following a similar logic to that applied to the original inverted-U curve formulated by Simon Kuznets (1955), which deals with income inequality and income per capita. In this fashion, the form of the EKC can be explained as a result of the process of structural change associated with economic development. In the early stages of development, there is a deterioration of environmental quality as the share of agriculture falls and the share of industry rises (see figure 2). This happens as a consequence of increasing physical capital intensive activities, rather than human capital intensive. Mass production, income per capita, and consumer expenditure grow gradually. As a society achieves a higher level of income, the share of industry starts declining and that of services increases, resulting in an expected improvement in environmental quality. At this "turning point", environmental indicators should start to display improvements. A related explanation is based on the sources of growth. For example, Copeland and Taylor (2004) argue that if capital accumulation is the source of growth in the early stage of development and if human capital acquisition is the source of growth in the advanced stage of development, then environmental quality will deteriorate at low

Figure 2. Stylized representation of the EKC hypothesis



Source: UNCTAD secretariat.

income levels and improve at very high income levels. In addition, there are other explanations for the EKC which rely on the assumption that environmental quality is a normal good whose demand increases with income. The idea being that, as income grows, environmental concerns increase, resulting in more environmental protection and better environmental quality. Yet another explanation for the EKC is that, as economies become richer, people tend to be more educated and have less children, leading to lower population growth rates. A decrease in population growth means less pressure on natural resources and hence less environmental degradation. The shape of the EKC can also be ascribed to the idea that poor countries do not have the means and capacity to adopt clean technologies and so, in the early stages of development, environmental quality tends to be low. However, as countries become richer and adopt clean technologies, environmental quality improves. This links the discussion back again to the T-factor in the IPAT equation.

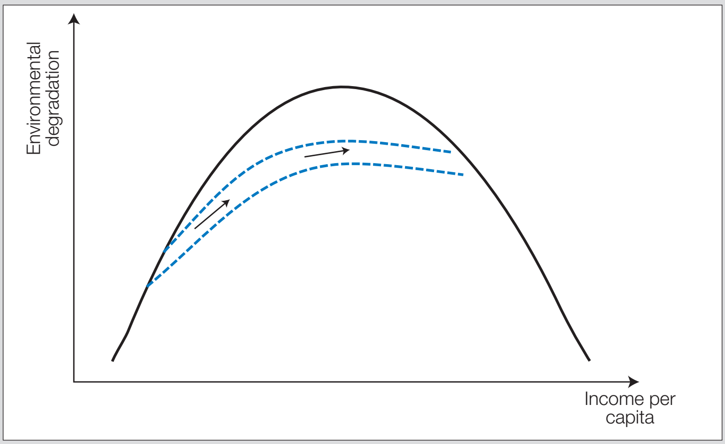
Empirical evidence has been used to assess the validity of the hypothesis. However, the empirical studies that have been carried out so far have yielded mixed results with regard to the existence of an automatic turning-point in environmental pressures. Van Alstine and Neumayer (2008) provide a critical review of the empirical literature on the EKC, arguing that the evidence is mixed. In particular, they show that the results of empirical tests of the EKC fall into three groups, depending on the indicator of environmental quality used. The first set, using indicators such as adequate sanitation and clean water, generally finds that environmental quality improves as income rises. The policy implication is that growth is good for the environment and so there is no need for environmental regulation. The second set of results, using indicators such as sulphur oxides and the rate of tropical deforestation, finds that environmental quality first deteriorates and then improves as income passes a certain threshold. This is consistent with the predictions of the EKC, and it implies that environmental quality depends on the level of development. It also implies that countries can grow out of their environmental problems over time (Beckerman, 1992). But the question arises as to the income level at which environmental quality begins to decline, whether it is automatic or due to government policy and whether any irreversible damage is done before the turning point. The final set of results, using indicators such as per capita carbon dioxide (CO_2) emissions and municipal waste, finds that there is no turning point; as income per capita rises, environmental pressures continue to rise.

One reason adduced for the sensitivity of the empirical results to the measure of environmental quality used is that some indicators such as sulphur oxide and nitrogen oxide are relatively easy to eliminate, while $CO_2$and solid waste are more complicated to get rid of. Another explanation is that indicators that are "local public goods" (for example, clean water and adequate sanitation) tend to rise with income, while those that are "global public goods" (for example, CO_2 emissions) worsen as income rises.

A further complication in interpreting the EKC arises because of the implications of international trade. One group of researchers has suggested that as countries become richer, they start importing larger volumes of natural resources from other regions (Bringezu *et al.*, 2004; Ayres and van den Bergh, 2005; Rothman, 1998). Hence, the environmental burden is shifted away from their own territories towards those of other countries through international trade. This means that, if trade effects were taken into account, the EKC hypothesis would lose its validity, indicating that environmental quality does not decrease with increasing levels of income.

The mixed findings in the empirical literature present a challenge for policymakers because they have different policy implications. But in general, governments should not rely on pursuing economic growth as a measure of improving environmental conditions, especially when it comes to long-term and global problems, such as CO_2 emissions. An array of other actions, such as regulatory interventions or developing technological innovations, is important. For rich countries, what is imperative is that they must reduce their ecological footprint in absolute terms. That is to say, they should act to bring about the turning point. In the case of developing countries, it might be possible to avoid the resource-intensive and polluting development trajectory of their industrialised counterparts. They might “leapfrog”, or in other words “tunnel through” the EKC, accelerating their development processes by skipping inferior and less efficient stages and moving directly to more advanced ones (see figure 3). However, the ability to leapfrog and tunnel through the EKC in this way will depend upon effective technology transfer between richer and poorer countries, as well as increasing the ability of the latter to adapt and utilize these technologies.

Figure 3. Tunnelling through the EKC



Source: UNCTAD secretariat.

3. Socioecological metabolism and structural change

Although the affluence factor undoubtedly plays an important role, basing the transition towards a sustainable pathway solely on it may prove to be an overly simplistic approach. Several scholars consider that additional determinants exert a significant influence, and some of these can be rooted in the way the relationship between economies and the ecological system changes with the economic transformations associated with industrialization.

Socioecological metabolism is a term that has been steadily emerging in the sustainability literature, and specifically in the area of industrial ecology, to understand this relationship (Fischer-Kowalski and Haberl, 2007). *Metabolism* is a concept that originated in the biological sciences, and it essentially refers to the processes by which living organisms take nutrients from the environment, break them into smaller pieces so as to assimilate them, and then discard what is not required. In a way, this description is similar to the concept of throughput. Consequently, one can also conceive that societies carry out a metabolic process, by acquiring energy and extracting natural resources from the ecosystems, then processing them in order to be consumed, and finally generating wastes and other by-products, such as pollutant gases. The scale of this throughput is determined by the specific stage of development that an economy is going through. Societies have historically followed a trajectory that has clearly marked their changing interrelationship with the ecological sphere.

The primitive hunter–gatherer societies performed a basic metabolism, in which the scale of their throughput remained most of the time within the environment's carrying capacity. By not growing or farming their own food requirements, these societies just extracted from the natural realm the required amount of resources they required for subsistence, depending mostly on the sun's energy and biomass. They could only deplete the resources if their rate of consumption exceeded the ecosystem's natural regeneration rate. Meanwhile, the amount of wastes derived from their metabolic process was easily absorbed again by the ecosystem. However, over time, this socioecological regime evolved. The emergence of agriculture relied on the accumulation of knowledge about the natural world (e.g. climate patterns, soil and plants characteristics, etc.) and the development of new techniques. In this way, societies underwent a transition towards a new regime, in which they started "colonizing" nature and appropriating a larger amount of resources (Krausmann *et al.*, 2008). In other words, societies started to transform the natural ecosystems into man-made systems designed to maximize their productivity and social and economic usefulness. Animals and plants were domesticated, leading to an artificial selection of the genetic code. Moreover, populations started to expand, increasing the scale of their throughput and consequently exerting a larger pressure on the ecosystems. The main source of energy still remained solar-based, and these societies were completely reliant on the energy conversion provided by biomass sources. Their environmental impact varied according to the region, but environmental degradation and resource depletion started to emerge as problems in some areas. What is important to mention in this respect is that, although agrarian economies started to evolve thousands of years ago, this regime still exists today. Millions of people continue to subsist in agrarian economies, and specifically in Africa.

With industrialization, a new regime emerged, based on a revolutionary technological change and the use of non-renewable sources of energy. Fossil fuels and new production techniques allowed societies to “extend” their metabolism and overcome some of the problems associated with the agrarian societies, such as scarcity and its strong dependence on solar-based energy and climate. This facilitated an unprecedented productivity increase, driven by a significant expansion of population and per-capita material and energy consumption. Industrialization has allowed some countries to achieve higher levels of economic growth and elevate the standards of living of millions of people over the last century. However, at the same time, this transition has implied an even more severe pressure on ecosystems. The scale of throughput registered historical levels. The rate of resource extraction has surpassed the natural regeneration rates, resulting in depletion of natural capital, and the amount of wastes is larger than the amount that can be absorbed by the planet’s sink mechanisms (Haberl *et al.*, 2011).

The importance of the socioecological metabolism approach is that it takes into account resource use and environmental impacts, and illustrates how they change during the process of structural transformation. Table 1 shows some indicators that illustrate the transition between an agricultural and an industrial regime. These are presented in the third and fourth columns. Energy and material use per-capita increase significantly. The use of biomass as an energy source accounts for 10 per cent to 30 per cent of the total energy mix, while fossil fuels provide up to 80 per cent of the energy requirements. It is relevant to take these figures into account, since the transition from an agrarian to an industrial regime is still currently taking place in many economies. The three last columns present data for least developed countries (LDCs), developing countries (including LDCs) and developed countries. The metabolic profile of LDCs corresponds to that of a typical agrarian regime. Total energy and material use per capita and per unit of area are low, while they rely on traditional forms of biomass as their primary source of energy. Developing countries, on the other hand, present higher figures. However, on average, they seem to be closer to an agrarian profile, than to an industrial one, which indicates that they have still not managed to complete the transition. Their total energy and material use is still far from reaching the levels registered in the industrial regime. In

Table 1. Metabolic profiles of the agrarian and industrial regimes

	Unit	Agrarian society	Industrial society	LDCs	Developing	Developed*
Population density	cap/km^2	<40	100–300	40	76	116
Total energy use per capita	GJ/cap/year	50–70	150–400	33	64	205
Total energy use per unit area	GJ/ha/year	20–30	200–600	13	49	216
Biomass (share of energy use)	per cent	95–100	10–30	92	50	23
Fossil fuels	per cent	0–5	60–80	8	50	77
Use of materials per capita	ton/cap/year	2–5	15–25	4.2	6.8	16
Use of materials per unit area	ton/ha/year	1–2	20–50	1.3	4.8	18

Source: Fischer-Kowalski (2011) and Haberl *et al.* (2011).
Notes: * Based on European Union (EU) 15.
cap = capita; GJ = gigajoule; ha = hectare; km^2 = square kilometre

contrast, the figures corresponding to developed nations — which are based on the EU15 members — show a considerable use of energy and resources and a very strong dependency on fossil fuels.

The metabolic profiles of different types of economies are also profoundly influenced by trade. As countries begin to industrialise, their material and energy requirements augment significantly, and a diverse range of different types of materials are needed and utilised. Hence, these countries start relying not only on domestic sources, but also in foreign stocks of natural capital to fulfil their material requirements (Bringezu *et al.*, 2004). In general, there is an escalating dependency of domestic industries in industrialized countries on imports of natural resources, particularly regarding fossil fuels and metal ores (European Commission, 2006). In this way, industrialized countries shift the environmental burden away from their own territories through trade, and externalize it to other regions (Schütz *et al.*, 2003; Giljum *et al.*, 2008). Concomitantly, resource-exporting countries, which may be predominantly agricultural- or mineral-based, exhibit elevated material extraction rates and resource use. High levels of environmental pressure can, in such cases, be coupled with low levels of consumption.

The findings of the research based on socioecological metabolism are important as they show that structural transformation is going to exacerbate resource and in particular energy use. The challenge for developing countries in this context is how to reconcile the imperatives of structural transformation for improving human well-being with the imperatives of environmental sustainability, at both national and global levels.

D. THE CONCEPT OF SUSTAINABLE STRUCTURAL TRANSFORMATION

The challenge of achieving sustainable development is different in countries at different levels of development. For countries at low levels of development which are commodity-based and in which low-productivity agriculture is still the predominant source of livelihood, the challenge involves resolving a specific dilemma. On the one hand, structural transformation is necessary for achieving substantial and broad-based improvements in human well-being. On the other hand, structural transformation, together with rising affluence and growing population, will necessarily intensify environmental pressures, through the increasing demand for natural resources, including both material and energy inputs used in production, the increasing magnitude of waste and pollution, and the increasing relative reliance on non-renewable resources.

In this situation, the sustainable development dilemma facing governments is to promote structural transformation and increase human well-being without increasing the environmental pressure in an unsustainable manner. This *Report* argues that this dilemma can be resolved through a strategy of sustainable structural transformation (SST). This is a development strategy which promotes structural transformation but which adopts deliberate, concerted and proactive measures to improve resource efficiency and mitigate environmental impacts of the growth process. In short, they should promote sustainable structural transformation, which will be defined here as structural transformation accompanied by the relative decoupling of resource use and environmental impact from the economic growth process.

1. The meaning of structural transformation

The term “structural transformation” has been used regularly in the economic literature over several decades. However, different meanings have been given to this concept (Silva and Teixeira, 2008; Syrquin, 2010; Lin, 2011 and 2012). It will be used in this *Report* to refer to a process in which the relative importance of different sectors and activities within a national economy changes, in terms of both composition and factor utilization, with a relative decline of low-productivity agriculture and low value added extractive activities and a relative rise of manufacturing and high-productivity services. This process also involves upgrading within sectors as production becomes more skill-, technology- and capital-intensive. Moreover, the sectoral shifts also tend to increase the predominance of sectors and activities with a higher growth potential, both in terms of income elasticity of demand, the presence of increasing returns to scale and the potential of technological progress. The development of manufacturing activities has historically been at the heart of processes of structural transformation and, as argued in the *Economic Development in Africa Report 2011* (UNCTAD and UNIDO, 2011), will be critical to the success of such processes in Africa.

Structural transformation occurs through factor accumulation, factor re-allocation and innovation, which refers to the introduction of products and processes which are new to a national economy. In dynamic economies undergoing structural transformation, there is a continual process of creative destruction, as some activities wither away whilst others mushroom. In general, structural transformation is also associated with changes in the form of integration into the global economy, in terms of both export and import composition, and also the increasing urbanization of the population.

2. Decoupling as a basis for sustainable structural transformation

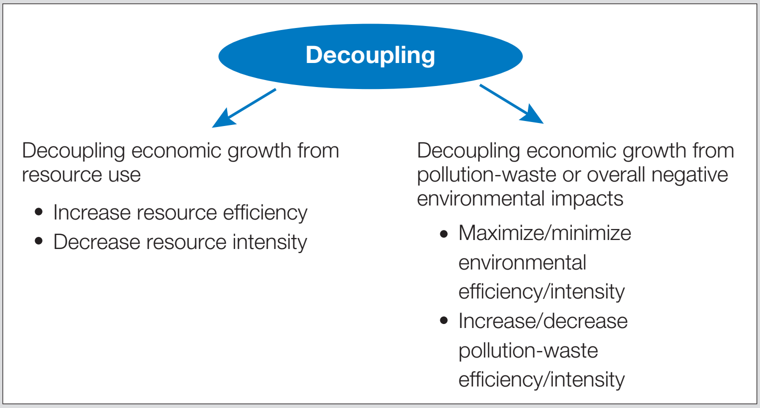
For developing countries, and especially for Africa, the priority is to achieve higher rates of economic growth by structural transformation. However, the transition to higher levels of development involves increasing the level of material throughput significantly. The policy challenge is therefore to transform the economic structure, while increasing human well-being and minimizing resource and pollution intensities. In other words, there is the need to attain *high-quality growth* by decoupling the increases in the level of material throughput — and consequently the pressure from the environment — from improvements in human well-being.

The term "decoupling" is used in the technical sense in which it is now being propagated in international policy debates on sustainability. The notion of decoupling was originally put forward by the Organization for Economic Cooperation and Development (OECD) in its policy paper, Environmental Strategy for the First Decade of the 21st Century (OECD, 2001), where it was first simply defined as breaking the links between environmental bads and economic goods. But in 2002, the World Summit on Sustainable Development (WSSD), hosted in South Africa, explicitly recognized the need to delink economic growth and environmental degradation — through improving efficiency and sustainability in the use of resources and production and reducing resource degradation, pollution and waste — as a key element of sustainable consumption and production (OECD, 2001: para. 15).

UNEP (2011a) has further developed the concept by distinguishing two separate components of decoupling: resource decoupling and impact decoupling. Resource decoupling can be achieved by increasing resource productivity or efficiency (GDP/resource use) or, conversely, by decreasing resource intensity (resource use/GDP). Impact decoupling might either refer to the pollution/waste intensity element of the technology factor in the IPAT equation or to the overall level of environmental impact. From an impact perspective, decoupling can be attained by mitigating the overall environmental impact per unit of production or by maximizing the level of production per unit of environmental impact. Figure 4 illustrates these options.

It is important to stress at this point that the concept of decoupling does not mean that production is somehow undertaken without using environmental inputs or creating waste. This is, strictly speaking, impossible. Resource decoupling (or increasing resource productivity) involves some "dematerialization" of extractive and

Figure 4. Components of decoupling



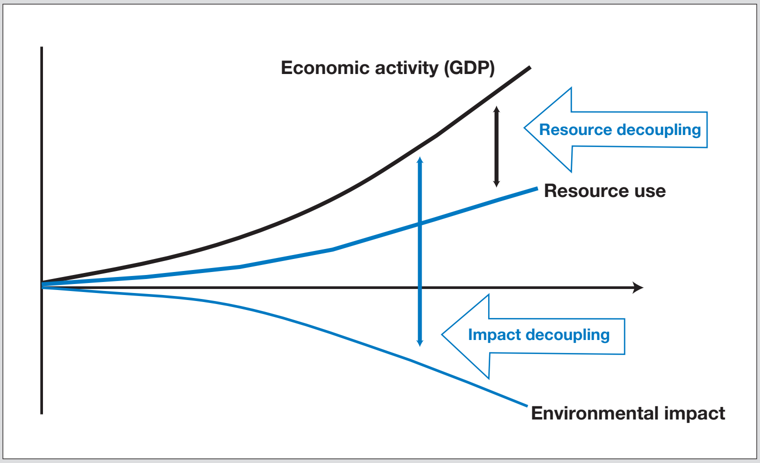
Source: UNCTAD secretariat.

productive processes, which means using less energy, water, land and minerals for a given amount of output. Impact decoupling (or increased eco-efficiency) requires that there are also less negative environmental impacts attached. These impacts can arise during the extraction of natural resources, during production in the form of pollution and emissions, during the use phase of commodities and in post-consumption stages in the form of wastes. With impact decoupling, not only the rate of use of natural resources is reduced, but environmental impacts (e.g. land degradation, water pollution, carbon emissions, etc.) are also mitigated (see figure 5). This form of decoupling may be achieved, for example, by reducing the carbon intensity of production in the case of CO_2 emissions.

Decoupling can further be classified in relative or absolute terms. Relative decoupling occurs when "the growth rate of the environmentally relevant parameter (resources used or some measure of environmental impact) is lower than the growth rate of a relevant economic indicator (for example, GDP)" (UNEP, 2011a). On the other hand, absolute decoupling takes place when resource use declines and the environmental impact of production and consumption decreases, even though the economy keeps growing.

Figure 5 illustrates a case where there is actually relative decoupling in resource use, but absolute decoupling in environmental impacts. This might be quite a rare

Figure 5. A stylized representation of resource decoupling and impact decoupling



Source: Based on UNEP (2011a), figure 1.1.

conjunction in practice, as the level of resource use is associated at an aggregate level with environmental pressure (van der Voet *et al.*, 2005). But it is possible and would occur, for example, if the reduction in the rate of resource use was associated with a shift in the mix of the resources utilized and the level of material throughput, away from priority materials and products which have particularly heavy environmental pressures. This might, for instance, include processes involving fossil fuel combustion, or activities which involve a significant loss of biodiversity, overexploitation of resources or a collapse of fish stocks (UNEP, 2010b).

3. Sustainable structural transformation as a development strategy

SST is defined here as structural transformation accompanied by the relative decoupling of resource use and environmental impact from the growth process. Understood in this sense, the notion of SST leads to an expanded vision of a traditional strategy of structural transformation. Without the environmental sustainability dimension, strategies of structural transformation are particularly concerned with increasing labour productivity, through rising capital accumulation, an acceleration of technological innovation, introduction of new economic activities, increasing economic linkages, development of markets, division of labour, and an increasing formalization of the economic activity. Strategies of SST, by contrast, would seek to do all this, but they are also concerned with increasing the productivity of natural resource use and mitigating negative environmental impacts of rising production and consumption.

As with structural transformation, SST occurs through factor accumulation, including investment in natural capital, factor re-allocation and also organizational and technological innovation. A central aspect of the process is structural change in which new economic activities emerge and others wither away. In SST, one aspect of this process is the emergence of new dynamic green activities and an increase in the relative importance of green sectors, such as organic agriculture, renewable energy and ecotourism, within a national economy. Ocampo (2011), who, just like this *Report*, notes that green growth should be best understood as a process of structural change, focuses precisely on this aspect and stresses the importance of facilitating the emergence of new green industries related to new green technologies. However, SST is understood in a broader sense here as it is not simply related to the emergence of specific green sectors but rather to the greening of the economy through relative decoupling. Improvements in resource productivity are pivotal to the whole process of SST.

The importance of resource productivity can be illustrated by simply separating the different components of the challenge of achieving a new development path with greater human well-being and lesser environmental impact. Essentially, as the following equation expresses it, there are three basic challenges involved. The first challenge (expressed by the first ratio) is to have a form of economic growth which delivers more human well-being (WB) for every extra unit of GDP. The second challenge (expressed in the second ratio) is to have more GDP growth for every unit of resource use (RU); that is, to improve resource productivity. The third challenge (expressed in the third ratio) is to mitigate the environmental pressure by increasing the resource use associated with each unit of environmental impact (EI).

$$\frac{\text{WB}}{\text{Unit of EI}} = \frac{\text{WB}}{\text{GDP}} \times \frac{\text{GDP}}{\text{RU}} \times \frac{\text{RU}}{\text{Unit of EI}}$$

This is quite a simple formulation as it ignores, for example, the direct contribution of the environment to human well-being. However, it underlines the central importance of resource productivity as the link between human well-being and environmental pressures. It also identifies the different policy challenges involved in improving the overall quality of economic growth.

Essentially, a strategy of structural transformation can be expected to improve the quality of growth in the first sense. That is to say, when successful, it should result in a type of growth which leads to greater and more broad-based improvements in human well-being. Decoupling policies would seek to improve the environmental sustainability aspect of the growth process through addressing resource productivity and environmental impacts. The SST strategy, in addition, aims to improve the quality of growth in both the human well-being and environmental sustainability dimensions by enhancing the well-being aspect of economic growth and increasing resource productivity in a way which mitigates environmental impacts.

It should be stressed that improving resource productivity is not a magic bullet for resolving environmental problems in all contexts. Indeed, various researchers have pointed to the so-called “rebound effect”, in which improved resource efficiency lowers costs which, in turn, leads to increased resource use (Binswanger, 2001; Hertwich, 2005). Thus, improving resource productivity is not likely in itself to enable absolute decoupling. However, it can certainly support policies of relative decoupling, which seek to ensure that resource use and environmental pressures grow less rapidly than before as the economy grows.

In general, the concept of SST can be understood as a way to operationalize the concept of a green economy in the context of sustainable development and poverty eradication. The concept adds value because it provides a dynamic understanding of the efforts which are involved in greening the economy, and it places such efforts within a development perspective. It also provides a framework through which environmental issues can be articulated in the design of national development strategies. This avoids the danger of a one-dimensional approach in which environmental priorities are disconnected from development priorities.

The concept of SST can also bring new analytical and policy insights because it recognizes the central role of structural change in long-term economic growth processes. This goes beyond approaches to green growth which model growth in terms of an aggregate production function and ignore the dynamic forces associated with the emergence of new activities and the decline of others. As Ocampo (2011) argues, thinking of green growth as a process of structural change can provide a very fruitful basis for the formulation of developing countries' sustainable development strategies. The concept of SST enables this. It can also be applied and adapted to address the specific challenges facing developing countries at different stages in the process of structural transformation. Thus, a strategy of SST in economies which are dependent on agriculture and commodity exports and intend to promote economic diversification will be different from strategies in middle-income economies, which have managed to sustain growth for a number of years based on labour-intensive manufactures or services, but seek to upgrade towards more knowledge-, skill- and capital-intensive activities. In this way, the concept of SST can be used in a way which avoids the dangers of a one-size-fits-all approach.

Later chapters of this *Report* seek to apply the concept of SST to the challenge of achieving sustainable development in Africa. But first it is necessary to switch from conceptual issues and to get a better grasp of where Africa now stands in terms of resource use and efficiency. This is the subject of the next chapter.