Leapfrogging Possibilities For Sustainable Consumption and Production in Africa
- An Overview -

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Executive Summary

The industrial sector in Africa in general is not well developed. Except for few countries like South Africa that boast well developed manufacturing industries, for most of the African countries the lions share of their economic turnover comes from agriculture. Given that 45% of the population is below poverty line, over-consumption is not yet a problem in Africa in general. This will not, however, be the case in the long term even with a business-as-usual trajectory. There is an opportunity in discussing consumption in terms of meeting universally accepted basic needs for the ever increasing population of Africa.

The prevailing pattern of production of products and service in Africa both in size and content is not capable of adding value to the level that is required to address social and economic needs of Africa within an ecologically sustainable framework. The big challenge in terms of consumption is to break the vicious cycle of poverty.

Africa faces two-pronged challenge constituting of a number of complex and interlinked aspects. The first one is the production and infrastructural challenge. This includes agricultural productivity, energy supply, urbanization, solid waste, and water supply and sanitation. The second one is health and environmental challenge covering diseases such as malaria, tuberculosis and HIV/Aids and environmental problems including climate change, desertification, and biodiversity depletion.

It is important to take the specific context of Africa into account in order to succeed in shifting to a sustainable consumption and production (SCP) system within the regional reality. SCP is all about contributing to environmental quality through efficient production and use of natural resources, minimization of wastes, and optimization of supply of products and services. It involves business, government, communities and households.

One interesting area in less developed areas such as many countries in Africa is the case of leapfrogging into sustainability without the need to pass through intermediate stages of development. Leapfrogging in Africa has a potential to help speed up the process of development using advanced systems. It can do so by avoiding intermediate steps taken in countries in the North. Carrying out leapfrogging in the right context can save on infrastructure development costs by creating a shortcut to clean, safe and efficient technologies. Africa can learn from the experience of more advanced countries regarding the how-to of providing the social benefits to a significant portion of its population while avoiding at the same time any negative environmental side effects. It can also enhance its opportunity to become competitive in applying advanced systems early on.

There are cases in Africa and worldwide where countries and villages have leapfrogged from scratch to efficient and modern technologies such as solar power. Many of the leapfrogging discussions and literatures on successful cases and suggestions for the future, specifically targeting Africa, focus on the ITC sector. In addition to this indispensable role of ICT in the economic and social development, there is an obvious
need to consider leapfrogging possibilities in other sectors such as agriculture, manufacturing and service sectors. Three clusters namely infrastructure planning and development; production and manufacturing; and service delivery, that are attractive from the perspective of SCP in Africa are related to meeting basic needs and have an important role in terms of pulling millions of Africans out of poverty.

The major opportunities for leapfrogging in Africa are the rich natural resource endowment of the continent; its currently low level of technological development; limited infrastructural expansion; and low-level corporate establishment. The challenges in realizing leapfrogging into SCP in Africa manifest at three points namely, pre-leap phase in the form of platform and framework (e.g. global economic structure); vehicles (e.g. low level of education); and during the post-leap phase (e.g. lock-in problems)

To enable leapfrogging in an SCP fashion in Africa, the required policies and actions can be categorized into four clusters namely, political and institutional cluster; infrastructural cluster; development context and cooperation cluster; and instrumental cluster. Government policies, education as well as institutional capacity building are included under the first cluster. The second cluster is about the technological infrastructure and associated decentralized systems. The development and cooperation cluster is where the soft parts of stakeholder participation, cooperation as well as partnership are highlighted. Aspects such as cultural context that are related to the prevailing condition on the ground in Africa are parts of the instrumental cluster. Leapfrogging to SCP is desirable and possible in Africa. It is important to highlight the role of legislative and policy level measures that can pave the way for leapfrogging. As in the case of the Brazilian ethanol case, for any kind of technological change that can be characterized as some form of leapfrogging to succeed, both strong government policies and good technological capabilities are needed in order to achieve widespread deployment of the technologies.

Leapfrogging is not and can not be a panacea for all problems and development challenges of Africa. It is, however, an alternative that has the potential to avoid future social, economic and environmental costs of conventional alternatives. Integrated and holistic policies and strategies should be developed and implemented to amplify its merits while minimizing its demerits. To this end, the role of development partners is important provided that they support contextualized leapfrogging solutions in a less prescriptive fashion.

1 Background

Globally challenges like climate change are demanding the reorganization of human activities using different paradigm shift. The ecological and resource crises faced by the world today call for the need to have a sustainable economic development that takes into account both social as well as ecological performances of development plans and strategies.
It is imperative to design and develop ecologically sustainable, economically viable, and socially desirable products and services that are necessary to satisfy basic needs. A systems perspective of production and consumption is of paramount importance. Improvements that have been done at the technical efficiency level related to production systems should be scrutinized to avoid the risk of a rebound effect situation where these improvements are offset by the ever increasing consumption. As a way of positively influencing the consumption component, the productive machinery should be decoupled from the activity of creating and generating new demands. Economically, continuous growth in the production realm should be based on creative mechanisms of producing affordable products and services and expanded marketing that reaches out to the low-income members of the society.

Overall, production systems and consumption patterns should be optimized leading to:
1) Low level of life cycle concentration of natural substances from the earth’s crust and man-made substances in the ecosphere
2) Low level of life cycle intervention on productivity, originality and diversity of subsystems of ecosystems
3) Increased quality of life by meeting basis needs in a sustainable way. This implies creating optimum number of new jobs for local communities per unit of resource use or per unit of profit generated by managing the trade-off between issues such as profit-making interest of companies, requirement of professionalism, labour-intensiveness, degree of value added, etc.
4) A situation where optimum proportion of primary raw material is processed for a value added export and domestic consumption paying attention to possible conflicting parameters such as access to technology, availability of hard currency, and the need for job creation.

One of the prerequisites for the optimization of the whole of production systems and consumption patterns is a change in the type of technological systems involved. For a well established system, the changes can assume an evolutionary mode where incremental improvements are made gradually. Owing to an already established technological and institutional setup, the incremental changes, more often, occur at the technical level in which some technological components are changed without significantly affecting the whole system.

The economies of most countries in the North, for example west European countries, have evolved over a long period of time from agricultural economy to an economy that featured the flourishing of craftsmen and artisans, then to an economy of industrial production and manufacturing and finally to an information and service-based economy.

The Asian Tigers which in 1950s had similar human development and economic profiles as in present day Sub-Saharan Africa leaped to their current status of playing the role of a globally powerful economic partner by addressing productivity through improving access and quality of education systems at all levels including compulsory elementary and secondary level education. The improvement in productivity enabled the pursuance of an export-driven economic model of development. High levels of savings both at
household and government level resulted from good economic policies that enjoyed educated workforce triggered a significant growth of investments in manufacturing technologies that helped sustain the growth in these countries.

In view of the ecological challenges the world is facing today, emulating the economic growth of the Asian Tigers or attaining the level of living standards of countries in the North should be done through promoting sustainable development that addresses both the production and consumption realm.

In this regard, the World Summit on Sustainable Development in its Johannesburg Plan of Implementation called for the development of a ten year framework programme (10YFP) to support regional and national initiatives to promote the shift towards sustainable consumption and production (SCP) patterns. A global effort called the Marrakech Process is underway in mainstreaming activities that promote progress on the implementation of SCP and the elaboration of regional and national strategies and the proposal for a global 10YFP on SCP.

Many development efforts have not delivered promised changes in Africa, albeit for different reasons. One example of such global effort that affects Africa and other regions of the world is the endorsement of the UN Millennium Development Goals (MDG) by over 180 member states at UN General Assembly in 2000. The target year for the MDGs is 2015. MDGs consist of eight goals, eighteen targets and forty eight indicators harbouring a number of previous declarations between 1970s and 90s. The first seven goals cover the development challenges of Africa including poverty and hunger, health problems, lower participation of girls in education as well as environmental management issues. Current assessments indicate that most African countries are falling short of meeting the MDGs. Looking at Human Development Index (HDI) calculated using three variables that are part of MDGs underlying parameters namely Life Expectancy, Education Level and Income, Africa is lagging behind other regions (Figure 1).
Africa has attracted the attention of the Marrakech Process assuming the status of being the only region for which a dedicated taskforce called Taskforce for Cooperation with Africa is established (see Section 3.2.1). Can Africa leapfrog in growing economically to the level of meeting basic needs of its population through promoting SCP without passing through the long period of evolution experienced by many countries in the North despite its current severe challenges such as poverty?

In regions of the world such as Africa where there is no well-established large scale technological system and associated institutional and cultural landscape, leapfrogging to a new set of technological system can be a better option.

1.1 Objective
The objective of this preliminary review report is to:

i) clarify the potential role of leapfrogging in promoting SCP in Africa;

ii) identify existing cases of leapfrogging in Africa and other relevant economies

iii) identify the most promising sectors for leapfrogging;

iv) analyze the key enabling conditions for leapfrogging to SCP in African countries

1.2 Methodology
This work was done based on a desktop literature review. Different types of literature including online sources were consulted. The choice of sources and materials and hence cases was done based on the relevance to African demographic reality and diversity of economic actors.

An overall consideration was done as to the different target groups of the report ranging from technical experts and academicians as well as governmental and industrial policy makers.

\[1\text{UNEP (2002a)}\]
PART I - CONTEXTUAL DESCRIPTION

2 Synopsis of status of production and consumption in Africa

The success of any effort of problem-solving is often associated with the matching of the proposed solution to the context. For the same reason, understanding the production and consumption status in Africa as well as the challenges in changing the current situation is vital. This chapter deals with creating the context of production and consumption in Africa mainly from the perspective of challenges faced such as agricultural productivity, energy supply, solid waste management, health problems, and environmental challenges including climate change.

2.1 Production of products and economic structure

The industrial sector in Africa in general is not well developed. Except for few countries like South Africa that boast well developed manufacturing industries, for most of the African countries the lion’s share of their economic turnover comes from agriculture. Agricultural activity contributes at least 40% of exports, 30% of GDP, up to 30% of foreign exchange revenues, and 70% of employment in Sub-Saharan Africa.\(^2\)

Even for the case of agriculture, mechanized agriculture is used to a limited extent. Around 60% of the economic output of Africa comes from the five largest economies of the region, namely, South Africa, Egypt, Nigeria, Algeria, and Morocco. Angola has recently overtaken Morocco. Mining is a major sector in some African countries. For example, it accounts for a third of Botswana’s GDP.

2.2 Consumption and Poverty

Given that 45% of the population is below poverty line, over-consumption is not yet a problem in Africa in general. This will not, however, be the case in the long term even with a business-as-usual trajectory. That is where the social leapfrogging becomes relevant. There is an opportunity in discussing consumption in terms of meeting universally accepted basic needs for its ever increasing population (Figure 2). The challenge here is to do it without pursuing a moving-target of created artificial needs. Technical and institutional networks that provide consumers with the right information to make sustainable choices should be developed.

\(^2\)Segal and Stollery (2007)
2.3 Challenges in production and consumption

Areas of challenge associated with the activities of production and consumption within the African context of focusing on the grand objective of meeting basic needs are briefly presented as follows in the form of two clusters namely, production and infrastructural challenges as well as health and environmental challenges.

2.3.1 Production and infrastructural challenges

2.3.1.1 Agricultural productivity

Despite the role of agriculture is a major sector in many African countries with a significant share in terms of labour force, national GDPs and export revenues, it suffers from low-level of productivity.

Plots of land owned by farmers in many countries in Africa are not able to support the entitled households due to this low productivity. The agro-industrial sector is still at a low level of development that it is yet unable to act as driver for the agricultural sector. Exports of agricultural produces from Africa that make up a major source of foreign currency in many countries have a very low added value that the real gains are far below than the potential. Table 1 depicts the different indicators of the agriculture sector in Africa in comparison with other regions of the world.

---

3 UNEP (2002b)
Table 1: Agricultural Indicators by Region

<table>
<thead>
<tr>
<th>Region</th>
<th>Africa</th>
<th>Sub-Saharan Africa</th>
<th>Near East and North Africa</th>
<th>South Asia</th>
<th>East Asia and Pacific</th>
<th>Latin America and Caribbean</th>
<th>Middle income countries</th>
<th>High income countries</th>
<th>World</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proportion of arable land irrigated</td>
<td>7.0</td>
<td>3.8</td>
<td>28.7</td>
<td>39.3</td>
<td>31.9</td>
<td>11.6</td>
<td>19.9</td>
<td>11.9</td>
<td>20.0</td>
</tr>
<tr>
<td>Added value per worker in 1999 ($/year)</td>
<td>416</td>
<td>285</td>
<td>1,859</td>
<td>412</td>
<td>461</td>
<td>3,028</td>
<td>335</td>
<td>17,956</td>
<td>645</td>
</tr>
<tr>
<td>Per capita cereal production 1997/99 (kg/year)</td>
<td>147</td>
<td>128</td>
<td>128</td>
<td>224</td>
<td>336</td>
<td>259</td>
<td>339</td>
<td>746</td>
<td>349</td>
</tr>
<tr>
<td>Cereal yield 1997/99 (kg/ha)</td>
<td>1,225</td>
<td>986</td>
<td>1,963</td>
<td>2,308</td>
<td>4,278</td>
<td>2,795</td>
<td>2,390</td>
<td>4,002</td>
<td>2,067</td>
</tr>
<tr>
<td>Livestock productivity 1997/99 (kg/ha)</td>
<td>164</td>
<td>128</td>
<td>147</td>
<td>121</td>
<td>150</td>
<td>198</td>
<td>191</td>
<td>248</td>
<td>193</td>
</tr>
<tr>
<td>Fertilizer use 1997/99 (kg/ha)</td>
<td>22</td>
<td>9</td>
<td>69</td>
<td>109</td>
<td>241</td>
<td>85</td>
<td>111</td>
<td>125</td>
<td>100</td>
</tr>
</tbody>
</table>

Due to the cultivation of new additional land, the total food production has shown increase over the years while the per capita production has declined due to population rise over the same period (Figure 3).

![Figure 3: Total and per capita food production for Africa (Index: 1989-91=100)](chart)

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4 FAO (2003)

5 FAO (2003)
Part of the explanation for low agricultural productivity in Africa is the depletion of soil nutrients as well as lack of access to modern energy such as petroleum fuels that can be used to increase the productivity of the agricultural sector.

2.3.1.2 Energy supply
Africa is the least illuminated continent as figuratively shown in the famous “the earth in the night” picture taken from space. Africa consumes only 5.5% of the world energy despite its share of 13% of the world's total population. Access to modern energy such as electricity is still very low by any standard despite the high potential hydropower, solar and wind power in most of the countries in the continent. The per capita energy consumption of 5.82 MWh is far lower than the world average of 14 MWh per capita.

The issue is both access and quality of even the existing energy sources. A significant part of Africa is still using biomass, albeit through a traditional way, as a major source of energy for cooking and heating in the rural parts of Africa.

Energy consumption in Africa is largely dominated by combustible renewable resources (biomass, animal wastes, municipal and industrial wastes) with 47% of total (Figure 4). Biomass accounts for more than 80% in some countries such as Burundi (91%), Rwanda and Central Africa Republic (90%), Mozambique (89%), Burkina Faso (87%), Benin (86%), Madagascar and Niger (85%).

![Figure 4: Primary Energy Supply by Fuel in Africa in 2002 (Total 539.85 MTOE)](image)

The energy use in Africa’s agriculture in 1990 and projected for 2010 is depicted in Table 2 for three scenarios namely reference of business as usual, moderate improvement and accelerated growth.

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6 UNECA (2006)
7 ibid
8 ibid
9 UNECA(2006)
The Reference scenario assumes continuation of past trends in energy use in Africa's agriculture with an average growth rate of about 2% per annum. The scenario, therefore, depicts the current minimal utilisation of energy in the agricultural sector which results in relatively stagnant agricultural growth rates, modest increments in yields and thus continued food imports.

The Moderate Improvement scenario depicts a situation of substantial increases in agricultural energy use resulting in moderate growth rates, but lower than the population growth rate. Africa's agricultural growth is estimated at about 3% per year.

The Accelerated Growth scenario reflects agricultural systems that are highly mechanised. The energy intensive nature of the agriculture results in agricultural growth rates of about 4% per year, which are above the population growth rates. It appears from the analysis that Africa will need to double energy use in the agricultural sector in order to achieve self sufficiency in food production. This means that the rate of growth of food production should be equal or more than population growth rate.

Table 2: Projected energy requirements for agriculture in Africa (TJ)

<table>
<thead>
<tr>
<th>Sector</th>
<th>1990</th>
<th>2010</th>
<th>Reference</th>
<th>Moderate Improvement</th>
<th>Accelerated Growth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture</td>
<td>558 053</td>
<td>829 237</td>
<td>1 007 906</td>
<td>1 222 763</td>
<td></td>
</tr>
<tr>
<td>Ag-Transport</td>
<td>407 327</td>
<td>417 215</td>
<td>482 459</td>
<td>605 266</td>
<td></td>
</tr>
<tr>
<td>Ag-Industry</td>
<td>782 628</td>
<td>1 714 834</td>
<td>2 076 545</td>
<td>2 509 994</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>1 748 008</td>
<td>2 961 286</td>
<td>3 566 910</td>
<td>4 338 023</td>
<td></td>
</tr>
</tbody>
</table>

2.3.1.3 Urbanization

Urbanization is a challenge from the perspective of the construction of long-lasting structures of buildings and associated infrastructures. A rapid expansion of cities together with an ever-increasing migration from rural to urban centres is being witnessed in many countries in Africa. Other issues of concern with regard to urbanization are insecurity, unemployment, insufficient or non-existent energy and water supply, and severe wastewater and solid waste problems. Due to the missing of comprehensive planning that considers housing and mobility issues at the same time, some parts of the newly developed cities are difficult to access. Distances between residence and working places as well as distances between residence and shopping areas are getting longer and longer. Many African cities are witnessing the presence of many unemployed people and homeless people including children.

Over the last four decades Africa has witnessed high rate of urbanization accompanied by low level of economic performance. Over the 1970-95 period, the average African country's urban population grew by 5.2% per annum while its GDP declined by 0.66% per year. Today, up to two thirds of African urban dwellers live in informal settlements with inadequate transport, water, sanitation, electricity, and health services.

By the year 2050, 61 percent of Sub-Saharan Africa's population will live in cities. This rapid urbanization is evident in large cities of Africa as depicted in Figure 5.

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10 FAO(1995)
Figure 5: Population of Selected Large Cities in Sub-Saharan Africa, 1965, 1990, and 2015

2.3.1.4 Solid waste
The solid waste problem consists of mainly the issue of municipal solid waste, plastic waste and old electronic products and electronic waste.

The total amount of municipal solid waste is increasing rapidly. The major cities in West Africa produce between 150,000 to 300,000 tons of MSW per year. Residents in Accra, Ghana, generated about 800 tons of solid wastes per day in 1990, with an annual increase of 6%13. The solid waste generation of selected cities in Africa ranges from 0.3 to 1.9 kg per person per day (Table 3). This increase is a serious problem considering the fact that it is happening in urban centres in Africa that do not have any kind of waste management other than a mere dumping site. With little equipment to manage the refuse, garbage was only collected in high-income areas. The rest was dumped in unauthorized dumping sites,

11 UNDESA (2008)
12 UN-PD (2000)
13 Palczynski (2002)
primarily along waterways. Associated health problems included high incidences of cholera, diarrhoea, and dysentery, especially in children.\textsuperscript{14}

**Table 3: Per capita Solid Waste generation selected African cities\textsuperscript{15}**

<table>
<thead>
<tr>
<th>Country</th>
<th>City</th>
<th>Per capita solid waste generation (kg/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benin</td>
<td>Porto Novo</td>
<td>0.5</td>
</tr>
<tr>
<td>Burkina Faso</td>
<td>Ouagadougou</td>
<td>0.7</td>
</tr>
<tr>
<td>Burundi</td>
<td>Bujumbura</td>
<td>1.4</td>
</tr>
<tr>
<td>Cameroon</td>
<td>Douala</td>
<td>0.7</td>
</tr>
<tr>
<td></td>
<td>Yaounde</td>
<td>0.8</td>
</tr>
<tr>
<td>Congo DR</td>
<td>Kinshasa</td>
<td>1.2</td>
</tr>
<tr>
<td>Congo Rep.</td>
<td>Brazzaville</td>
<td>0.6</td>
</tr>
<tr>
<td>Cote d'Ivoire</td>
<td>Abidjan</td>
<td>1.0</td>
</tr>
<tr>
<td>Egypt</td>
<td>Cairo</td>
<td>0.5</td>
</tr>
<tr>
<td>Gambia, The</td>
<td>Banjul</td>
<td>0.3</td>
</tr>
<tr>
<td>Ghana</td>
<td>Accra</td>
<td>0.4</td>
</tr>
<tr>
<td>Guinea</td>
<td>Conakry</td>
<td>0.7</td>
</tr>
<tr>
<td>Mauritania</td>
<td>Nouakchott</td>
<td>0.9</td>
</tr>
<tr>
<td>Morocco</td>
<td>Rabat</td>
<td>0.6</td>
</tr>
<tr>
<td>Namibia</td>
<td>Windhoek</td>
<td>0.7</td>
</tr>
<tr>
<td>Niger</td>
<td>Niamey</td>
<td>1.0</td>
</tr>
<tr>
<td>Nigeria</td>
<td>Ibadan</td>
<td>1.1</td>
</tr>
<tr>
<td></td>
<td>Lagos</td>
<td>0.3</td>
</tr>
<tr>
<td>Senegal</td>
<td>Dakar</td>
<td>0.7</td>
</tr>
<tr>
<td>Tanzania</td>
<td>Dar es Salaam</td>
<td>1.0</td>
</tr>
<tr>
<td>Togo</td>
<td>Lome</td>
<td>1.9</td>
</tr>
<tr>
<td>Tunisia</td>
<td>Tunis</td>
<td>0.5</td>
</tr>
<tr>
<td>Uganda</td>
<td>Kampala</td>
<td>0.6</td>
</tr>
<tr>
<td>Zimbabwe</td>
<td>Harare</td>
<td>0.7</td>
</tr>
</tbody>
</table>

Moreover, there is a shift in the complexity of the waste stream as many and many new fractions make it into the municipal waste flow. The organic part of the waste stream that is common to all countries which is either poorly managed or not managed at all is a health threat that can be related to child mortality and other sanitary challenges. MSW from Accra, Ibadan, Dakar, Abidjan, and Lusaka shows organic content ranging from 35-80\% (generally toward the higher end of this range); plastic, glass, and metals at less than 10\% on wet basis at delivery.\textsuperscript{16} Others include paper, ashes from fuel wood and charcoal as well as the remains of common foods such as sugar cane, mangoes, and bananas.

African cities have not been able to set up adequate system for the collection of municipal and industrial waste due to their poor infrastructure base, limited resources and lack of proper urban management. These cities and municipalities are spending 20-50 percent of their budget in solid waste management; only 20-80 percent of the waste is collected.\textsuperscript{17}

\textsuperscript{14} Palczynski (2002)  
\textsuperscript{15} Achankeng (2003)  
\textsuperscript{16} Palczynski (2002)  
\textsuperscript{17} Achankeng (2003)
Most African countries have yet to adopt policies for waste prevention such as the prevention of the generation of plastic waste. The specific challenge with plastic waste in the African context is their non-biodegradable nature and their penetration even to the remote rural parts of Africa in the form of cheap and in some cases free-of-charge thin and flimsy plastic bags. These bags end-up in farms hindering the deep rooting of planted crops and hindering natural conditioning and aeration as well as moisture balance. Besides, they may be eaten up by domestic animals choking and killing them. These domestic animals in millions of rural households of Africa form the pillars of livelihood. In 2003, the year South Africa introduced a ban on thin plastic bags, it used 8 billion bags a year. Kenya uses 4000 tonnes of these plastic bags each month. In the urban areas it is common plastics litter everywhere and creating a situation for breeding of vectors and parasites aggravating an already worse health situation including worsening malaria, the number one killer of the continent.

A significant increase in old electronic products imported to Africa has been observed during recent times. 500 tonnes used electronics 75% of which can be considered as e-waste are shipped to Nigeria on daily basis. There is no proper way of managing this waste in the continent and it is increasing rapidly due to stricter controls of such shipment to Asia. A large number of chemicals used during the manufacturing of tiny to large electronic aggregates are already part of the water, soil and air compartment of the natural environment in Africa.

2.3.1.5 Water and sanitation
Although improved drinking water coverage in sub-Saharan Africa increased by 7% between 1990 and 2004 (from 47% to 55%), the actual number of people without access to improved drinking water sources increased by 60 million. This is a result of increased population growth. Current trends suggest that by 2015 the number of people with no access to proper water and sanitation service in sub-Saharan Africa will grow by a further 47 million. Current coverage of water supply and sanitation service in Africa is depicted in Figure 6.

The water problem in Africa can be expressed both in the form of scarcity and pollution. Scarcity of water varies not only from country to country but also from place to place within countries. Women fetch water from long distances at least once a day in addition to shouldering the responsibility of raising kids, fetching firewood from even longer distances and cooking as well as housekeeping. Many surface waters passing through or in the vicinity of urban centres are polluted from industrial effluents or wastewater and municipal solid wastes. The tragedy is most of these waters are used as a source of drinking water downstream incurring innumerable health problems.
Figure 6: Water Supply and Sanitation Coverage in Africa\textsuperscript{18}

Different parts of Africa have different levels of access to improved drinking water and thus differ in terms of MDG target (Figure 7)

\textsuperscript{18} UNEP (2002c)
2.3.2 Health and Environmental Challenges

While recognizing the relationship between health challenges and environmental challenges namely climate change, desertification and biodiversity loss, they are consciously presented as different subsections with the intention of providing better resolution.

2.3.2.1 Health challenges

Health problems such as malaria, tuberculosis and HIV/AIDS are the biggest health challenges faced by many countries in Africa (see Figure 8 for Malaria prevalence). Child mortality and maternal mortality are still responsible for a significant number of deaths in Africa. Millions of African children suffer from diseases that can be traced back to malnutrition. Average life expectancy in Africa is the global lowest.

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19 WHO and UNICEF(2006)
2.3.2.2 Climate change

Although Africa contributes with a mere 3% of total global greenhouse gases, it will be the one to suffer most from the consequences of climate change as pointed out by IPPC’s recent report of 2007. Agricultural productivity and health conditions related to water supply and sanitation will worsen as a result of rise in ambient temperature. Many coastal areas of Africa will take their share of problems due to sea level rise. Figure 9 shows regional vulnerability to different impacts associated with climate change including desertification, sea level rise, reduced freshwater availability, cyclones, coastal erosion, deforestation, loss of forest quality, woodland degradation, coral bleaching, the spread of malaria and impacts on food security.

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Figure 8: Malaria affected areas in Africa

20 UNEP (2002d)
2.3.2.3 Desertification
Expansion of desert areas is prevalent in many parts of Africa. This expansion is manifesting both in the large deserts such as the Sahara and pockets of regional and national arid areas. The desertification problem is gripping on previously fertile agricultural areas.

2.3.2.4 Biodiversity depletion
Africa is one of the most important global biodiversity spots. Africa’s biodiversity is already to a large extent affected. Many species are already in the red list of being extinct and even more are on the way to being listed under the same category with an alarming rate. Figure 9 shows number of threatened and endangered animal species in Africa.

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21 UNEP (2002e)
In a nutshell, the foregoing section can be summarized as follows.

The prevailing pattern of production of products and service in Africa both in size and content is not capable of adding value to the level that is required to addresses social and economic needs of Africa within an ecologically sustainable framework. The big challenge in terms of consumption is to break-up from the circle of poverty.

The section has outlined the areas of concern in a two-pronged fashion that cover complex and interlinked aspects. The first one is the production and infrastructural challenge. This includes agricultural productivity, energy supply, urbanization, solid waste, and water and sanitation. The second one is health and environmental challenges covering diseases such as malaria, tuberculosis and HIV/Aids and environmental problems including climate change, desertification, and biodiversity depletion.

It is important to take the specific context of Africa into account in order to succeed in shifting to a sustainable consumption and production system within the regional reality.

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22 UNEP/GRID-Arendal (2002)
3 Sustainable consumption and production (SCP)

3.1 Definitions

Sustainable consumption (SC) is defined as “the use of goods and services that respond to basic needs and bring a better quality of life, while minimizing the use of natural resources, toxic materials and emissions of waste and pollutants over the life cycle, so as not to jeopardize the needs of future generations.”

Sustainable consumption and production are interlinked. WBCSD looks at SCP from the perspective of who is involved saying that: "Sustainable production and consumption involves business, government, communities and households contributing to environmental quality through the efficient production and use of natural resources, the minimization of wastes, and the optimization of products and services."

Sustainable production and sustainable consumption have different areas of emphasis. The focus of sustainable production is on the supply side of the equation, focusing on improving environmental performance in key economic sectors, such as agriculture, energy, industry, tourism and transport. Sustainable consumption addresses the demand side, looking at how the goods and services required to meet basic needs and improve quality of life - such as food and health, shelter, clothing, leisure and mobility - can be delivered in ways that reduce the burden on the Earth's carrying capacity.

Recent discussions have taken up sustainable consumption part. According to a document on consumption issues in Europe and Asia, sustainable consumption should be understood as a situation where consumer needs and demands are fulfilled in an as efficient and resource lean way as possible, resulting in a minimized negative environmental, social and economic impact. The same document underscores improved quality of life for all consumers as the ultimate goal of sustainable consumption.

UNEP defines sustainable consumption as the use of services and related products which respond to basic needs and bring a better quality of life while minimizing the use of natural resources and toxic materials as well as the emissions of waste and pollutants over the life cycle so as not to jeopardize the needs of future generations.

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23 IISD (2007)
24 Falkman (1996?)
25 Robins and Roberts (1997)
26 ibid
27 UNEP (2005)
28 UNEP (2004a)
3.2 Current activities related to SCP

3.2.1 Worldwide

The Johannesburg Plan of Implementation (JPI) endorsed by all governments at the 2002 UN World Summit on Sustainable Development (WSSD) called upon governments to “change unsustainable patterns of consumption and production” (Chapter 3 of JPI). The JPI specifically called for governments to promote the development of a 10YFP in support of regional and national initiatives to accelerate the shift towards sustainable consumption and production (SCP).

The Marrakech Process, named after the host city for the First International Expert Meeting on the 10YFP held in 2003, refers to the international joint effort to promote and support the implementation of SCP and to develop the 10YFP. The proposal for a 10YFP will be presented and reviewed at the 2010-2011 cycle of the Commission on Sustainable Development (CSD). The United Nations Environment Programme (UNEP) and the United Nations Department for Economic and Social Affairs (UN-DESA) are the joint coordinators of the Marrakech Process.

The development of the 10YFP consists of the following four phases:

**Phase 1:** Organizing regional consultations in all regions to promote awareness and identify priorities and needs for SCP (through regional expert meetings and national/regional roundtables)

**Phase 2:** Building regional strategies and implementation mechanisms with regional and national ownership (which, when possible, are endorsed by regional institutions, such as the African Union, the African Ministerial Conference on the Environment and the Forum of Ministers of the Environment of Latin America and the Caribbean)

**Phase 3:** Implementing concrete projects and programmes at the regional, national and local levels for developing and/or improving SCP tools and methodologies (with the Marrakech Task Forces and the Cooperation Dialogue as the main implementation mechanism)

**Phase 4:** Evaluating progress, exchanging information, and building international cooperation and coordination

Under the Marrakech Process, the Marrakech Task Forces have been organised with the main objectives to supporting the implementation of concrete SCP projects, to focus on specific SCP themes or sectors to develop and or improve SCP tools and methodologies and to strengthen North-South cooperation in the SCP implementation.

These Task Forces are voluntary initiatives led by countries or groups of countries that – in cooperation with other partners – commit themselves to carrying out a set of activities which support the implementation of specific SCP projects. Four Task Forces were initially launched at the Costa Rica Meeting in 2005.

* “Phases” do not necessarily imply a chronological order. The activities related to those phases need to be implemented in parallel in the Marrakech Process.
To date, seven Task Forces are active on the following themes:

- Cooperation with Africa (hosted by Germany)
- Sustainable Products (hosted by the UK)
- Sustainable Lifestyles (hosted by Sweden)
- Sustainable Public Procurement (hosted by Switzerland)
- Sustainable Tourism (hosted by France)
- Sustainable Buildings and Construction (hosted by Finland)
- Education for Sustainable Consumption (hosted by Italy)

Some of the activities and material developed by the TFs include demonstration projects on National Action Plans on SCP, manual on communicating sustainability (and training workshops in Brazil, China), Tool Kit on Sustainable Public Procurement (and a demonstration project in Argentina), study on Sustainable Building and Construction and Climate Change; study on Tourism and Climate Change; manual on Sustainable Costal Management; a campaign on sustainable holidays in Brazil; collection of best practices by all task forces, among many other activities.29

The global SCP taskforce on Cooperation with Africa lead by Germany has the goal of supporting the planning, development and implementation of ARSCP’s activities. It is meant to encourage and support African countries in the integration of SCP in existing plans and programmes and in developing national and/or city-wide action plans on SCP. The TF is developing and implementing a number of projects for the region, such as a project on developing an African eco-labelling scheme; the development and implementation of SCP action plans at the national and local level; and a collection of Best Practice on SCP projects by development agencies.30

### 3.2.2 Africa

The starting point for a regional roundtable as a forum for sharing experience and disseminating information in Africa was the nine National Cleaner Production Centres (NCPCs) that operate in the continent. The First Roundtable on Cleaner Production and Consumption was organized in Nairobi in 2000 followed by the Second African Roundtable on Sustainable Consumption and Production (ARSCP) held in 2002 in Arusha, Tanzania.

ARSCP-3 was organized in Casablanca in 2004 with the objective of institutionalizing ARSCP and developing a regional strategy under the 10YFP through the first expert meeting.31

In the conclusion of its first status report of 2002-2004, ARSCP highlighted what is imperative to do with regard to SCP in Africa namely, ensuring the institutional sustainability of NCPCs, broadening the scope of activities from CP to SCP, improving

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29 UNEP(2008)
30 ibid
31 ARSCP (2004)
the context-relevance of SCP to African countries, and promoting national and regional networking on SCP.\textsuperscript{32}

ARSCP facilitates development of national and regional capacities for SCP and promotes effective implementations of concepts and tools of SCP in African countries. It also organizes regional expert meetings. It is established as a regional institution assuming a not-for-profit NGO form with registered individual and institutional paying members. ARSCP enjoys a close relationship with the African Ministerial Conference on Environment (AMCEN).

In March 2005 ARSCP succeeded in developing and getting the African 10 Year Framework Programme endorsed by AMCEN\textsuperscript{33}. The second SCP regional status report including the result of a study on awareness of SCP in the region was produced in 2006\textsuperscript{34}. During the Fourth African Roundtable on Sustainable Consumption and Production (ARSCP-4) held in May 2006, five issues have been identified as regional priority areas for action through concerted effort. The priority areas for which corresponding technical teams are established are biofuel production and utilization; water services and sanitation; ecolabeling of African products; solid waste management; and knowledge and information sharing\textsuperscript{35}. ARSCP co-chairs the Task Force on Cooperation with Africa. On the basis of the outcome of the regional meetings, ARSCP began to work with two pilot projects namely, SCP for plastics as a demonstration of integrated solid waste management and a regional training and awareness programme on lifecycle assessment as a planning and decision-making tool.

Another relevant scheme at the African level is the new partnership for African development (NEPAD). It is initiated by African head of states as a vision and strategic framework for Africa’s renewal. NEPAD was adopted in 2001 by AU (then OAU) as an integrated socio-economic development framework for Africa designed to address the current challenges facing the African continent. NEPAD has three initiatives namely the \textit{infrastructure initiative}, \textit{environmental initiative} and \textit{science and technology initiative} that are articulated in African level important documents.

### 3.3 Implications of SCP activity or system

With SCP in the planning mindset, different economic activities can be re-structured in order to meet two principal objectives: provision of basic services and promotion of sustained economic growth for sustainable development.

From the perspective of countries in the South including African countries, the lack of access to basic services gives achievement of sustainable consumption a different set of framework than is the case in the countries in the North. Among these strategically

\begin{itemize}
  \item \textsuperscript{32} UNEP (2004b)
  \item \textsuperscript{33} UNEP (2006)
  \item \textsuperscript{34} ARSCP and UNEP (2006a)
  \item \textsuperscript{35} ARSCP and UNEP (2006b)
\end{itemize}
important services are food, water, transport and waste management. Developing and implementing mechanism of supplying these services using SCP approach contributes to 36:

- Ensure secure food items by applying, among others, a labelling system, supported by independent testing/verification of product features.
- Avoid depletion of water reserves by applying water usage plans, by minimizing distribution losses and pollution of water reserves, and by promoting technologies using less water (in industry and households).
- Provide access to safe and affordable transport, by giving preference to public transport systems for medium distances, and non-motorized transport systems for short distances.
- Avoid littering and illegal waste dumping by promoting sustainable product design and by establishing a recycling system supported by economic incentives.
- Establish markets for sustainable products, such as organic food, by adopting green procurement policies.

In Africa, the grand mission of reducing and gradually eliminating poverty and hunger while attaining environmental sustainability can be accomplished through actions that are directly relevant to SCP. These actions include37:

- Acceleration of sustainable industrial development
- Promotion of the development of SMEs
- Increase of sustainable agricultural production for food security.
- Avoid depletion of water resources by water conservation measures.
- Increase energy efficiency and access to affordable energy sources.
- Establish markets for sustainable products, such as organic food, by adopting green procurement policies.
- Human-resource development and capacity building, including universal primary and secondary education.
- Better terms of trade with developed countries.
- Improvement of infrastructure and sustainable human settlement patterns: to reduce congestion and pollution and improve access to infra-structural services such as Water and Sanitation.
- Improvement of the scientific and technological base relating to environmental management.

SCP contributes to sustainable economic development by ensuring that resources are utilised in an as efficient way as possible, through improved technologies, increased consumer awareness, better integration of governmental policies, economic instruments, legislation, etc38.

36 UNEP (2005)
37 ARSCP and UNEP (2006a)
38 UNEP (2005)
PART II- SCP AND LEAPFROGGING

4 Leapfrogging

4.1 Definition and concepts

The terms leapfrogging has assumed different meanings depending on the contexts of its use.

Alex Steffen of Worldchanging defines leapfrogging as the notion that describes a situation where areas which have poorly-developed technology or economic bases can move themselves forward rapidly through the adoption of modern systems without going through intermediary steps. According to Worldchanging, one doesn’t “need a 20th century industrial base to build a 21st century bio/nano/information economy”.

Leapfrogging as a process was first noted back in 1962 by a political philosopher named Alexander Gerschenkron in his contribution entitled "Economic Backwardness in Historical Perspective". He then argued that, sometimes, not having invested in a particular industry or technology can be beneficial when a paradigm shift occurs, as the society does not have to deal with sunk costs and legacy issues. The society can often adopt the new systems more rapidly and completely than can other, ostensibly more "advanced," societies, gaining the social and economic benefits earlier.

Leapfrogging can be done by skipping over generations of technologies e.g. the use of cellular phones in rural Africa skipping landlines, or avoiding the use of fossil fuels, and go straight to renewable energies, avoid the proliferation of private cars, and promote sustainable mobility in the urban, medium cities, etc. It can also mean leaping further ahead to become the technological leader surpassing contemporary leaders, e.g. Korean leapfrogging in the steel sector.

Industrial systems in a given area, say a country or region, can undergo technological evolution through three patterns of catching-ups, namely path-creating catching-up, path-skipping catching-up, and path-following catching-up. The first two cases of catch-ups can be interpreted as leapfrogging.

Based on a useful typology of technological innovation, four kinds of technological change can be discussed, namely:

- **incremental innovations**: usually occur virtually continuously as industries try to improve quality, design, performance, and adaptability;

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39 Steffen (2006)
40 Ibid
41 Gallagher (2006)
42 Lee and Lim (2001)
43 Freeman (1992)
• **radical innovations**: discontinuous inventions that are usually the result of deliberate research and development that lead to a radical departure from previous production practice;

• **changes of technological systems**: far-reaching changes in technology as a result of a cluster of radical innovations that affect several branches of an economy;

• **changes of techno-economic paradigm**: those technological systems that affect directly or indirectly every other branch of the entire economy (such as the information and communication technology revolution).

Leapfrogging can happen accidentally, situationally, or intentionally. A situation that fits well the first case is where the only systems around for adoption in the area under consideration are better than legacy systems elsewhere. In the second case where leapfrogging occurs situationally is where, for example, in a sprawling rural area decentralized communication systems are adopted. The intentional one happens in the case where policies by design are developed, for example, to promote the installation of WiFi and free computers in poor urban areas.

### 4.2 Leapfrogging as an Opportunity for poverty alleviation

Policies and actions supporting SCP can serve to bolster poverty reduction efforts and support sustainable long-term growth. Measures which reduce inefficient use of energy and other resources are particularly relevant in low-income countries where severe resource scarcities mean that wastage has high opportunity costs. By conserving natural resources and the revenues they generate and in particular avoiding degradation of soil and other ecosystems, SCP measures can protect the incomes of the poor and enhance food security (MDG 1). A more efficient and less polluting use of natural resources can improve quality of life by preserving the regulating functions of ecosystems and reducing environmental health problems (MDGs 4, 5 and 6). SCP also contributes directly to ensuring environmental sustainability (MDG 7) and global partnerships (MDG 8) that can support the development of innovative products and services that help to meet basic needs in a more sustainable manner. In other words, SCP could help countries in the South to ‘leapfrog’ to sustainable models of development.

SCP could also help countries to develop new markets for sustainable products and new sources of employment as well as to better position themselves as producers for export markets. More efficient use of resources would enable businesses to achieve cost savings for acquiring, processing and disposing materials. Sustainable products and services that meet basic needs in an efficient manner could present viable business models and create new local employment.

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44 Steffen (2006)
45 UNEP and UNDESA (2007)
46 Ibid
African countries face the challenge of meeting basic needs in a sustainable manner. Sustainable consumption should aim at meeting basic needs while protecting the environment and also allows finding new market opportunities and hence better employment opportunities, e.g. markets for organic food, fair trade, sustainable housing, renewable energy, etc.\(^{47}\)

If Africa is to follow the conventional economic model of growth, it will be a long and inefficient way where at the beginning of an economic growth path, increase in GDP corresponds with high environmental degradation. This will be evident in the absence of environmentally friendly technologies. The increase in environmental degradation with an increase in GDP will continue up to a certain point beyond which environmental quality is enhanced by higher GDP per capita, increased environmental awareness, better technologies in industries and services as well as enforcement of environmental regulations.\(^{48}\) This relationship can be shown in an inverted U-shaped curve known as the Environmental Kuznets Curve (EKC). With proper composition of economic activities and the use of better technologies, a tunnelling through the EKC becomes a possibility (Figure 10).

![Figure 10: Tunnelling through a bell-shaped EKC\(^{49}\)](image)

The tunnelling scenario, for which leapfrogging is an important contributor, delinks economic growth from environmental degradation. Instead of following A-B-C-D-E leaping into the A-B-D-E path saves a lot in terms of future cost of environmental degradation. Following the former will be far from being beneficial from ecological,

\(^{47}\) Zacarias and Aprilia (2005)  
\(^{48}\) Stagl (1999)  
\(^{49}\) Jackson and Roberts (2000)
economic and social point of view. Hence leapfrogging helps to tunnel into the beyond-peak-part of the path.

Leapfrogging in this context makes sense as it is attached to a societal function or service for which a new way of provision is developed and/or implemented. Leapfrogging can’t fully be understood without characterising its three aspects namely, the take-off baseline condition, the path and the landing platform.

The first aspect is covers questions like where is the society or community leaping from? How did the situation look like before the leaping happens? How were the services or functions to be produced through the new mechanism of delivery to the community or region under consideration channelled before the leapfrogging?

The second aspect associated with the path dimension pose the following questions: what are the current widespread mechanisms of delivery of the same services and functions in well established economies of the world. What were and are the historical conventional steps that led to these current mechanisms? Which of these conventional steps are being bypassed by undergoing leapfrogging? What is the type of development expected to happen under ordinary circumstances in the absence of leapfrogging? Is the new arrangement a leap relative to what is currently dominant worldwide or relative to the reality in the specific area or region of implementation?

The third aspect related to the landing platform dimension can be characterized through questions such as: what is result of the leapfrogging? What kinds of gains is it leading to when it comes to the production and delivery of the services and functions? What is the sustainability dimension of this gain compared to the conventional development? Is it the economic sustainability, socially sustainability or ecologically sustainability or all three elements of sustainability that are resulting from the leapfrogging?

With this framework of analysis as an inspiration, it is possible to assess some examples of worldwide and African cases of leapfrogging.

### 4.3 Examples of Cases of leapfrogging

Leapfrogging cases in the information and communication technologies (ICT) are found in Africa, South Pacific, India, Latin America, China, Eastern Europe, and Russia. The rapid expansion of mobile phones, relative to landlines, associated to the relative easiness of installing cellular towers in China, India and African countries is a commonly cited example of leapfrogging.

The following section provides three examples of cases that can be interpreted as leapfrogging showcases from the world. The next section highlights on Africa.

#### 4.3.1 Worldwide

The following are few examples of the leapfrogging cases that can be mention worldwide. They represent areas of biofuel, ICT, solar power as well as iron and steel manufacturing covering from Brazil to South Korea.
Biofuel
The development of large-scale ethanol based mobility made Brazil the world’s major laboratory for the use of ethanol as a fuel. The National Ethanol Programme of 1975 has successfully reduced the number of cars running on gasoline in Brazil by 10 million. This Brazilian leap has avoided the conventional phase of using fossil fuels for many Brazilians who leaped direct from a situation of no-access-to-fossil-fuel to a new situation of using ethanol. As the Brazilian ethanol is based on the most efficient crop namely home grown sugar cane, the leapfrogging is evident.

One of the major economic benefits of this has been the obvious reduction in the country’s dependence on oil imports. Brazil achieved self-sufficiency in oil, the year when 17.7 million m$^3$ of ethanol and 11.3 TWh of electric and mechanical power were produced within the sugar-cane agribusiness. Besides, the country’s exports ethanol fuel to countries like Sweden and Japan. More than 5 million vehicles designed to run exclusively on ethanol manufactured in the country.

On the social front, improved health and large number of job opportunities in the plantations as well as ethanol industries can be mentioned. On the job front, the sugar-cane growing business is responsible for around one million direct jobs. In the State of São Paulo, there are around 400,000 direct jobs, and 95 percent of those workers are formally employed. In terms of income apportionment, the suppliers get most of the income created. In São Paulo, the home of around 11 000 sugar-cane suppliers, 62.1% and 37.9 percent of the income goes to suppliers and processors respectively.

Environmentally, the most obvious is the avoided carbon dioxide emission both in Brazil and in the countries to which the ethanol is exported. In this regard, greenhouse gas emissions avoided by the sector in 2003 are around 33.2 million CO$_2$ equivalent. Generally such reduction can correspond to 18 percent of all carbon emissions in Brazil$^{50}$. One important factor in the environmental and economic advantages of this sugar-cane based energy advancement is the ratio between the renewable energy produced to the fossil energy used which in 2005 was 8.9.

ICT
Indian Bangalore, known as the Silicon Valley of the developing world, features a massive hive of interlocking programming shops, call centres, and high-tech companies. This hub has made bypassing the conventional needs of transporting people and/or materials and leaped to a phase of “transporting” information on the ICT highway that connects to different parts of the world very far from this area.

Socio-economically a lot of jobs are created. According one estimate, Bangalore employs some 160,000 tech workers, the vast majority concentrated in value-added IT occupations, as opposed to call centres or business outsourcing. It has significantly

$^{50}$ Goldemberg (1998)
increased the speed of doing things, enhancing social connectivity between different cultures. These all happening while avoiding not only the direct emissions of transporting people and materials but also the indirect environmental impact of the need for constructing infrastructures and vehicles for such kind of transports. Considering only the direct energy use and thus emissions, a simple example shows that a videoconference requires 500 times less energy than a business trip requiring a 1000 km flight, and the disparity increases with distance.

**Solar Power**
The solar energy case shows how this can be done even in the absence of advanced technical know-how with some effort of capacity building of local community by the Social Work and Research Center (SWRC), aka Barefoot College in India. SWRC is a Non-governmental organization founded in 1972 at Tilonia, Rajasthan, India. It was started to solve local community level problems such as drinking water, girl education, health & sanitation, rural unemployment, income generation, electricity and power, as well as social awareness and the conservation of ecological systems in rural India. SWRC has trained over 340 semi-literate men and women from 16 states in India and 9 other countries in Asia, Africa and Latin America. Nearly 11,000 solar household systems and over 5,000 solar lanterns provide clean energy and light to more than 125,000 people.

In India alone, the socio-economic benefit of this initiative includes:

- Solar electrifying 300 adult education centres, or night schools.
- Solar electrifying 870 schools across the country.
- 28 remote and inaccessible villages in Ladakh have 40 Kws of solar panels that provide three hours of light in the bleakest winter to 1 530 families.
- 350 villages and hamlets(clusters) have been covered where a total number of 12,000 households have been solar electrified.

This means an improvement on the health of the students that otherwise would have to use kerosene and oil lanterns. The empowerment dimension is important as all solar panels have been installed, maintained and repaired by the village people without the assistance of any qualified engineer.

Environmentally, hundreds of thousands of litres of kerosene were saved due to this solar electrification effort and thus avoiding carbon dioxide emissions. Over 1.67 million tons of carbon emissions are saved annually as a result of the Barefoot activity.

**Iron and Steel**
The technological advancement of South Korea in the iron and steel sector is one example of leapfrogging at the sectoral level. South Korea did leapfrog from almost no Iron and Steel industry to surpass technological leaders in the sector.
To appreciate the significance of this leapfrogging, it is important to compare the number of years South Korea took to modernize its iron and steel industry relative to other countries and regions. For South Korea, Japan, US, Europe (excluding UK) and UK this amounted to less than two decades, three decades, five decades, a century and two centuries respectively\(^{51}\).

Steel consumption per capita is considered as one indication of a country’s prosperity, with large steel consumption per capita as a sign of economic prosperity. The world average for apparent steel consumption per capita in 1999 was 138.2kg. In general, the more industrialised countries utilised between 250kg and 600kg of steel per capita. The figure for South Korea is 757kg per capita.

The steel industry in the country grew in the 1970s after the government constructed the Pohang Iron and Steel Company (POSCO) mill in less than three years to service Seoul's rapidly growing automobile, shipbuilding, and construction industries. In 1988, South Korea's steel industry included 200 steel companies. In 1989, South Korea was the world's tenth largest steel producer, accounting for 2.3 percent of world steel production. South Korea continued to expand crude steel production of 19.3 million tons in 1988. In 2000, the country was the sixth largest producer of steel in the world with 43.1 million tons. POSCO is currently the third largest producer of steel in the world. Prior to the establishment of the company, South Korea barely had any steel-making capabilities at all with some production from small and obsolete furnaces. POSCO as the most efficient steel producer, was able to connect all subsystems covering the delivery of coke and ore, to the blast furnace, and on through casting and rolling in such a way that all sources of inefficiency are reduced.

Socio-economic benefits of this advancement include the consequence of developing other manufacturing industries that helped create jobs and economic growth. The iron and steel forms the first backbone of the South Korean economy for years to come. Today, South Korea is the world's largest shipbuilder with multinational enterprises such as Hyundai Heavy Industries and Samsung Heavy Industries. The car manufacturing industry has grown equally rapidly competing the top established global car brands today, lead by making the country the world's 5th largest car manufacturing nation. Prior to the development of the iron and steel sector, the GDP per capita in South Korea has grown from only $100 in 1963 to a record of $10,000 in 1995 in less than 40 years to a fully developed $25,000 in 2007.

Reduced emissions and other indirect damages on the environment associated with the efficiency of this energy-intensive industry are among the environmental benefits of the South Korean leap.

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\(^{51}\) Chen et al (2004)
4.3.2 Africa

There are small or large-scale implementation of new technologies and ideas in different parts of Africa. The following are examples from different countries covering livestock, ICT

**Livestock tracking**

Herders in Angola, Botswana and South Africa track their cattle via GPS. Compared to traditional herding this tracking system is a big leap with significant socio-economic benefits. It helps avoid the economic loss attributed to cattle rustling related conflicts. For instance, between 1999 and 2002, cattle raids in Kenya drained the national economy hugely by 15 billion Kenyan Shillings (225 million US$)\(^{52}\). The system provides many benefits for pastoralists, veterinary officers and government authorities. It can be used to locate lost or stolen cattle, and to monitor and manage disease outbreaks.

Botswana is using the system to ensure the long-term security of its beef export market and offers an additional marketing edge, enabling the country to compete worldwide for new export orders. Livestock production has a share of 80 percent the major income earner of the agricultural GDP in the country. Second to diamond, beef is an important commodity Botswana has been exporting to EU. The use of the digital animal Identification system has reduced cases of livestock theft that had earlier threatened Botswana’s lucrative EU beef export market. The new system is a complete departure from the traditional ‘hot iron’ branding and ear tagging that have little or none deterrent to cattle thieves. The Livestock Identification and Trace-Back System (LITS) project is implemented by the Department of Animal Production, Ministry of Agriculture.

From 2002-2004 alone, Botswana has significantly reduced incidences of cattle thefts by at least 60%. The digital ID system uses Radio Frequency Identification (RFID) technology, which is safe, environmentally friendly, and tamperproof to identify individual livestock throughout the country. The reticular bolus that the animal swallows contains a RFID microchip, which is coated by a very hard ceramic. The bolus has neither moving parts nor a battery and is inert, safe and does not react with stomach acids and enzymes. The bolus is technically superior to other micro chips such as injected micro-chip that is cheap but difficult to read, recover after slaughter and faces a likelihood of ban on their use by the EU in the coming years as it can easily find its way in the meat. Introduction of this system has greatly eliminated commercialization of cattle rustling in Botswana.

Pilot testing of the same system is going on in areas of pastoralists in Kenya, to individually identify a livestock, its owner, district, movement permits, and vaccination records among a handful of other useful data. Integrating the bolus system with satellite tracking technology using Global Positioning System (GPS) and Geographic Information System (GIS) would not only be individually and digitally identified but would also be traced to ascertain where it is at a given point in time.

Implementation of this digital livestock identification system in East Africa will open up access to important livestock markets such as EU Other than managing cattle records and

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\(^{52}\) ITDG (2004)
deterring cattle thefts, The EU beef market regulation requires that imported beef be traceable from the export slaughter facilities to the individual animal from which the meat came from. This regulation was made in response to the mad cow and foot and mouth diseases outbreaks in Europe and other parts of the world.

The costs for introducing LITS that covers about 80 percent of the total cattle population were about 26 million US$. Since 2005, annual costs to ensure the maintenance and upgrading of the system occur, which are estimated to be about 2.3 million US$ each year.

The environmental benefits of this system are associated to saving on the natural environment as a result of sound management of resources and avoided conflicts.

ICT
Bypassing landlines, cell phones in rural Ethiopia are already improving households’ access to information regarding commodity prices and marketing of goods and services in neighbouring villages.
Ethiopia has embarked on four initiatives
- **WoredaNet**: a government network which would link nearly 600 local districts (‘woreda’) and 11 regional government offices across the country with each other and with the federal government headquarters in the nation’s capital, Addis Ababa. The project would provide these offices with videoconferencing, e-mail, Internet access, and file sharing capabilities-creating a foundation for e-government.
- **SchoolNet**: an education network which would provide more than 450 secondary educational institutions with access to general ICT, e-mail, and the Internet. Most importantly, though, it would allow these institutions to receive streamed Internet- and broadcast TV-based educational content from media agencies-creating a foundation for e-learning.
- **AgriNet**: an agriculture network which would link more than 30 research and operational agricultural centers to stimulate the growth of this cornerstone of the economy.
- **HealthNet**: a healthcare network connecting all major referral hospitals around Ethiopia and form the basis for a nationwide telemedicine infrastructure.

For the dominant part of country, this leap is from nothing to ICT networked information sharing system (see Box 1).
Socio-economically this is resulting in saving the meagre economic resources of the country by reducing consumption of imported transport fuel which is eating up the lion’s share of export revenues. Environmentally, the reduction in transport emissions can be mentioned.

**Solar Power**
There is a successful solar-generated electricity project implemented in a desert grasslands rural part of the Jigawa State, Northern Nigeria. Solar Electric Light Fund (2007). The project has garnered a great deal of media attention both within Nigeria and internationally with coverage from CNN. It has been visited by the Governors of surrounding states, by the former Nigerian President Obasanjo.

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This project of leaping from no modern energy use to Solar power was developed to demonstrate the comprehensive use of solar-generated electricity in a village setting to introduce solar home lighting and improve water supply, health, education agriculture, commerce, security and women’s opportunities for implementation in three villages where over 7,500 people would benefit from the results.

Home lighting
The solar home lighting introduced in each village, compared to the kerosene lights that they replace, offers a better light without the inherent fumes and fire danger of the old lamps. It is now easier for children to do their studies and for home businesses to thrive under the better lighting conditions. Jigawa Alternative Energy Fund (JAEF), a non-government organization formed specifically to promote the use of renewable energy, will be able to continue electrifying houses using a micro-credit scheme where the payments for each system will accumulate to purchase additional systems for more homes.

Water
Having a reliable water supply in the semi-desert of Jigawa State where there are few rivers or other sources of water on the surface of the land is a big challenge. Typical methods of getting water range from open wells with rope and bucket, to hand pumps, to government supplied diesel-powered pumps that work only until they break down or until villagers run out of money to buy the expensive diesel fuel. Powerful solar-powered pumps designed to run maintenance free for eight to ten years or more and are currently supplying the villages with clean, fresh water from deep wells. Because the wells are tied into a village distribution system with numerous taps, the time that families used to spend getting water has been reduced as well.

Health
The village health clinics now benefit from solar energy. Lights enable health officers to see patients at night for the first time, vaccine refrigerators allow more people to be vaccinated at greater frequency and fans increase the comfort level of staff and patients alike.

Education
Village primary schools now have at least two illuminated classrooms and teachers report that they are being heavily used in the evenings for adult education and as places for children to come and do their lessons. Each school has also been provided with a computer and computer instruction for the teachers. These are the first computers in the villages and there are plans to eventually hook them to the internet via the State’s broadband system.

Increased security
In such a hot climate where people enjoy the cool of the evening, a great deal of business and socializing take place after sunset. Streetlights now give people bright places to congregate. Several new food-selling businesses are now open for business beneath the lights at these new market locations. Many streetlights are located conveniently by water taps and all supply much valued security for people at night.

Small businesses
Solar-powered micro-enterprise buildings serving as centres provide electricity to six small businesses per centre that would otherwise not have access to electricity. The shared PV system, much less expensive than individual systems for each shop, allow tailors to move up from manual sewing machines to electric, barbers, from manual clippers to electric, and similar improvements in productivity for other types of businesses.

**Irrigation**

One of the villages, Wawan-rafi, has a lake nearby that is used to irrigate cash crops during the rainy season. However, many of the poorest farmers are limited in their growing ability by only being able to water their fields using a slow and labor intensive process. For these farmers, a cattle or person pulled cart with fold-out unbreakable solar modules powering an efficient pump that can be moved from field to field is developed. More efficient irrigation will enable farmers to produce and sell more to provide greater income for their families.

**Increase Income for women**

The only source of income for most village women is the production and sale of peanut oil. Traditionally, small amounts of oil are made in a process taking great amounts of time and strenuous labor. In Wawan-rafi, a solar-powered oil expeller is incorporated that will save time and labor while earning more income for women. Rendering the introduced system a technical, financial and organizational sustainability, JAEF provides both local and professional staff technicians to frequently check each system. Small, affordable fees collected from users will be used to pay technicians and to maintain an inventory of spare parts.

An obvious environmental advantage is the pollution-free power generation as well as the avoided consumption of other resources such as wood. 

The next phase will bring the multiple benefits of PV to thirty more villages.
BOX 1: ICT Leapfrogging and SCP

The relevance and implication of leapfrogging cases to the SCP approach of meeting basic needs and hence alleviating poverty and hunger is illustrated by the case of Ethiopia.

As mentioned earlier the most common and widespread case of leapfrogging has happened in the area of ICT and usage of cellular phone both in Africa and other parts of the world. This leapfrogging has shown already a positive impact on the economic development of countries that have leapfrogged, albeit at a hitherto insufficient level. Ethiopia has so far installed 4,500 kilometres of fibre optics. It has covered all its 600 districts and well above half of its 15,000 Kebeles, the smallest unit of administration. Although still the project is mainly in the phase of developing the infrastructure, even the low level of utilization so far has resulted in appreciable magnitude of results. Different activities carried out through video-conferencing such as educating over 6,000 people in an area very far from the point of instruction has created, among other things, the reduction of consumption of transport fuels imported by hard currencies. Connecting district courts to high courts has reduced the discomfort of citizens who would have travelled long distances for appeal procedures leaving their jobs behind. Moreover, the expenditure of the government in terms of the allowances given to employees who used to travel from place to place has now reduced due the fact that such trips are made unnecessary. It has become common now to send reports from the smallest units of administration to the regional and federal government offices electronically and thereby making the whole process faster and effective.

This is happening even in previously inaccessible areas such as Rash Dashen, the highest mountain in Ethiopia with an elevation of 4,620 meters above sea level where road construction etc is very costly due to topographic difficulties.

As a test case of the health-net initiative in Ethiopia, a hospital in Ethiopia is connected to a specialist hospital in India thereby sharing patient information electronically in real-time simultaneously with the possibility of exchanging ideas regarding diagnosis and treatment. Once around 20 hospitals in the country are connected, this same technique will help patients in rural parts of Ethiopia to have access to the best medical doctors of the country without being transferred over long distances.

All these will have a propagating effect of huge improvement in the production and consumption realm due to efficient communication, connectivity and access, leading to better health services and education. Besides, to consumers and retailers as well as farmers the connectivity dimension provides access to better market information.
5 SCP Areas attractive for leapfrogging in Africa

Many of the leapfrogging discussions and literatures on successful cases and suggestions for the future, specifically targeting Africa, focus on the ITC sector. As one important missing link in the development of Africa is lack of access and connectivity, cellular phones and desktop and laptop computers will play a vital role in transforming daily life of Africans.

In addition to this indispensable role of ICT in the economic and social development, there is an obvious need to consider leapfrogging possibilities in other sectors namely agriculture, manufacturing and service sectors. In all three clusters outlined below i.e. Infrastructure Planning and Development, Production and Manufacturing, and Service Delivery, the role of ICT in enhancing their implementation and operation significantly is very crucial. The areas that are selected worthwhile to look at are those that are related to meeting basic needs and have an infrastructural importance in terms of pulling millions of Africans out of poverty.

5.1 Infrastructure Planning and Development Cluster

5.1.1 Energy

There is a need for leapfrogging both in the area of fossil fuels and renewable sources. In oil rich countries such as Algeria, Angola, Libya, Nigeria, Cameroon, Chad, Congo, Côte d’Ivoire, Egypt, Equatorial, Guinea, Gabon, Mauritania, Sudan, and Tunisia the technology used for oil extraction is important. The same is true for the natural gas producing countries namely, Algeria, Egypt, Libya, and Nigeria.

In the renewable energy front, examples of leapfrogging technologies to consider for the African context are solar nano tubes, magnetic wind power turbines and bioenzymic processes that can convert cellulose materials to fuels for cooking and transport. The bottom line is to have access to ecologically sustainable, economically affordable and socially acceptable energy solutions.

Once an energy system that is based on renewable systems is set, clean or carbon-neutral industrialization can be developed.

On the infrastructure front while expanding Grid-based systems in the urban areas a balance of decentralized solutions is worth considering in rural areas. On the supply side depending on the prevailing condition of each country and sub-region, a resource mix of renewable and non renewable should be sustainable developed. On the consumption side, efforts of promoting efficient use of energy and conservation as well as other demand-side managements are of necessity.

5.1.2 Building and construction

Building materials incurring less embedded energy and chemical inputs on one hand, winning social acceptability on the other, should be widely used with due attention to local contexts. A life cycle perspective of selecting the materials is necessary. Development and use of local renewable materials that can fulfil structural and safety
requirements with a considerable life length have economic, social and ecological merits in comparison with the current exercise in the countries in the North of using a complex aggregate of synthetic building materials that contain over twenty thousand substances. Once well developed, these kinds of local and renewable materials can be used to phasing out materials that contain chemicals that threat human health and the environment. In addition to material selection, land-use planning and appropriate building design are important points of entry.

5.1.3 Transport and Communication
The approach of leapfrogging in the transport sector should cover an integrated development of sustainable infrastructure, manufacturing and procurement of vehicles, as well as production and use of renewable fuels. The planning and development of infrastructure should facilitate a sustainable transport of people and goods within cities and countries as well as between different parts of Africa. With regard to the development of renewable vehicle fuels, Africa has the potential to leapfrog to be the Middle East of biofuels. In doing so, it is critical to pay due attention to the social and ecological implications of large scale venture on bio-ethanol and bio-diesel development. A crucial aspect is to consider non-food diversified sources and use whenever possible marginal land to develop the biofuels. There should also be a development in the area of telecommuting in realizing tele-meeting and tele-work in reducing the need for people to travel to a meeting place or work place. Such tele-presence can be attained using different IT solutions that enable attending meetings and performing the required work.

5.2 Production and Manufacturing Cluster

5.2.1 Ecological farming
Any incremental and transformational improvement in the farming sector in Africa will benefit a majority of the African population. It will mean a lot in terms of food security, foreign exchange, development of agro-industry, and job creation. There is a need to look at the whole system of irrigation and use of fertilizers and pesticides. This kind of transformation leading to a green revolution is of urgent necessity in Africa considering the challenge of feeding the rapidly increasing population of the continent.

5.2.2 Symbiosis of agriculture and industry
There is a natural reason for developing a robust linkage between the agriculture and industry in the African context. There is a need to enhance the cross-fertilization of the agricultural sector as a supplier of raw materials, and the industrial sectors as processor of the input from the agriculture. This symbiosis can be done at the highest level of sectoral units as well as at the local level where firms and farms exchange material and energy and thereby closing the loop. The different sub-systems in the symbiosis can be developed as socio-technical organisms that are related in a positive feedback within a modular structure that leads to the sustainable integration of different sectors of the economy.
5.2.3 Biotechnology
Development of biotechnologies that are consistent with bio-safety principles that can enhance agricultural and industrial productivity, and improve the health conditions in many African countries are of paramount importance. Conscious development and implementation of technologies have the potential to transform the lives of millions of Africans. Such development and application should be subject to local contexts and factors including social, ethical, environmental, trade and economic issues associated with the development and application of modern biotechnology.

5.2.4 Mining
Africa will continue to depend on the mining sector. There is a big opportunity to enhance the benefits of this sector by running it in a sustainable manner. In this regard, it is worth to note that mining technologies and systems that are compatible with the natural ecosystem are very necessary. The efficiency of the extraction processes should be enhanced. More importantly there is a need to increase the value of the minerals in terms of processing it locally and there by contributing to a number of jobs and thus playing its role in the local economy.

5.3 Service Delivery Cluster

5.3.1 Water supply and sanitation
In addressing both the scarcity and pollution problems, water supply in Africa demands for water saving and conservation measures both in urban and rural parts. Devising a spectrum of solutions consisting of separate water supply systems that enable the use of different quality of water for different water functions is desirable. Promoting and developing local water harvesting and establishing demand side management should be prioritized.
Locally suitable decentralized and modular sanitation systems that account for nutrient recycling, hygiene and water scarcity need to be prioritised considering cost, social acceptability and maintenance possibilities.

5.3.2 Tourism
Africa has not so far utilized its tourism potential to the required level. Investing on socially, economically and ecologically well-planned ecotourism activities supported by innovative IT and GIS solutions can significantly contribute to the social and economic development of Africa.

As a summary, the areas attractive for leapfrogging in Africa are presented in Table 4 below in relation to the basic needs respective area contributes to.
<table>
<thead>
<tr>
<th>Cluster</th>
<th>Area</th>
<th>Basic needs and services</th>
<th>Technological Transformation</th>
<th>Prerequisite for Success</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infrastructure Planning and Development</td>
<td>Energy</td>
<td>Electricity, Cooking, Heating</td>
<td><strong>Baseline</strong>: Poor or no access, diesel generators, coal powered generators and hydropower <strong>Technologies required</strong>: micro hydropower Solar power, wind power, biofuel technologies</td>
<td>Decentralized systems, renewable based systems, well-trained manpower</td>
</tr>
<tr>
<td></td>
<td>Building and construction</td>
<td>Shelter</td>
<td><strong>Baseline</strong>: poor access  <strong>Technologies required</strong>: Local ecological materials, energy and water efficient building technology</td>
<td>Integrated approach, Well-trained manpower</td>
</tr>
<tr>
<td></td>
<td>Transport and communication</td>
<td>Mobility, Goods transport</td>
<td><strong>Baseline</strong>: No access, petrol, diesel <strong>Technologies required</strong>: public transport service systems, bio-vehicles, ethanol, biodiesel</td>
<td>Diversified non-food biofuel systems, Well-trained manpower</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Connectivity (Telephone and Internet)</td>
<td><strong>Baseline</strong>: For Telephone, No Access, landline telephone  <strong>For Internet</strong>: No Access, Dial-up, copper broadband <strong>Technologies required</strong>: Cellular telephone, Optical fibre broadband</td>
<td>Integrated approach, Well-trained manpower</td>
</tr>
<tr>
<td>Production and Manufacturing</td>
<td>Ecological Farming</td>
<td>Food</td>
<td><strong>Baseline</strong>: poor productivity, subsistence  <strong>Technologies required</strong>: fertilizers, mechanization, irrigation, high-productivity seeds, pesticides</td>
<td>Integrated approach, Well-trained manpower</td>
</tr>
<tr>
<td></td>
<td>Symbiosis of agriculture and industry</td>
<td>Food, clothes, income</td>
<td><strong>Baseline</strong>: None  <strong>Technologies required</strong>: Closed loop symbiotic agro-industry systems generating no or minim waste</td>
<td>Infrastructure, Well-trained manpower</td>
</tr>
<tr>
<td></td>
<td>Biotechnology</td>
<td>Food, clothes, medicines</td>
<td><strong>Baseline</strong>: None  <strong>Technologies required</strong>: Advanced R&amp;D laboratories</td>
<td>Integrated approach, Well-trained manpower</td>
</tr>
<tr>
<td></td>
<td>Mining</td>
<td>Income</td>
<td><strong>Baseline</strong>: Low level of value added  <strong>Technologies required</strong>: High yield technologies, Value adding technologies</td>
<td>Integrated approach, Well-trained manpower</td>
</tr>
<tr>
<td></td>
<td>Service Delivery</td>
<td>Water and Clean Water</td>
<td><strong>Baseline</strong>: poor or no access</td>
<td>Decentralized local</td>
</tr>
</tbody>
</table>

Table 4: Leapfrogging areas for promotion in Africa
6 Opportunities and challenges for leapfrogging in Africa

6.1 Opportunities for leapfrogging
Sustainability as well as SCP should not be seen as issues of concern only to countries in the North, and something that countries in the South cannot afford. As it has been mentioned before leapfrogging can offer unique benefits to Africa. The opportunities for leapfrogging into SCP in Africa include the following.

6.1.1 Rich natural resources
Technological leapfrogging both in terms of developing and using new technologies obviously requires biotic and mineral natural resources. Africa is endowed with both types of resources. These rich natural resources create an opportunity for Africa to use and where possible develop technologies that can really bring about a leap. Africa is relatively well endowed with energy resources. In 2004, its proved oil, gas and coal reserves were 9.4%, 7.9% and 5.54% respectively of the world total, compared to 8.5%, 4% and 2.19% respectively for South and Central America, taken together. The hydropower potential of the continent amounts to 13% of the world with over 1.1 million GWh of exploitable hydro capacity. Because of its geographical location across the equator, Africa has abundant solar irradiation ranging from 5 to 7 kWh/m2, all year round, and it enjoys a relatively strong wind power potential in Northern, Southern and Eastern Africa. Finally, the continent has an estimated geothermal energy potential of 9 000 MW in the Rift Valley area in East Africa54.

6.1.2 Low technological development
It is not at all easy to abandon investments made in obsolete technology in a given area. This is because there are a lot of technical, institutional and political layers embedded on this technology. Hence any replacement process would be evolutionary. This is not the case in most African countries where such extensive technological systems are nonexistent. This makes them suitable for leapfrogging to clean and lean technologies.

54 UNECA (2006)
6.1.3 Very low infrastructural expansion
It's easier for African countries to push for widespread adoption of community solar power since integration with existing power systems is not a problem. Shifting to fuel cell vehicles, for example, will be easier as there are smaller existing networks of gas stations that would need to be converted from gasoline/diesel to hydrogen. Other institutional and structural infrastructures surrounding this new core system can be added without the need to re-do things.

6.1.4 Limited corporate establishment
One of the bottlenecks of introducing technological leapfrogging into a given area is the influence of existing large corporate companies that often dominate a given market in such a way that the new comer technology fails to compete unless done by the same large companies.
The level of dominance of the market by large corporate companies specializing in conventional technologies is still not that big.

6.2 Challenges for leapfrogging
Challenges manifest at pre-leap phase in the form of platform and framework (e.g. global economic structure), vehicles (e.g. low level of education), and at the post-leap phase (e.g. lock-in problems).

6.2.1 Global economic structure and access to technology
Past and current global economic structure that has had its own share of leaving Africa behind with a number of disadvantages is not going to make leapfrogging in different sectors easy.
Global market structures involving tariffs and subsidies contributed significantly in keeping Africa mainly as exporter of primary agriculture produces and importer if manufactured goods resulting in little of what could have been gained from consuming and exporting locally processed products.
Compare to the countries in the North, there is an associated problem of access to high technologies that is a necessity to realizing leapfrogging.

6.2.2 Low level of education
The low level of education and hence low level of capacity at the individual and household level poses a challenge for technological dissemination. This is specifically a real challenge in rural Africa in terms of children completing primary school (Figure 12).
Murphy\textsuperscript{55} identifies economic, social, political, and cultural factors limiting the capability of rural people to rapidly switch into using and/or supplying technologies. This capability has technical, organizational, and institutional components and is manifest in individuals’ capacity to adapt to new technologies, their ability to take economic risks, and in their desire to modify their behaviour\textsuperscript{56}.

\textsuperscript{55} Murphy (2001)
\textsuperscript{56} Murphy (2001)
Although the basic level of education serves as the foundation for employment of simple and low-level technologies, lack of advanced technical education and training is a will hamper the move towards the technological development that is sought.

6.2.3 Lack of institutional capacity
The idea of having different projects of new technologies and new technical systems in many parts of Africa has not delivered the needed result of economic and social transformation. The reason, among other things, is the inexistence of institutions that are robust and capable enough to sustain whatever good intentions or results the projects bring about. This covers both leadership and technical capacity of institutions

6.2.4 Instability
Many African countries are found in conflict situation that makes a significant part of the region instable. This instability discourages investments that can catalyze transformational changes. Peace and stability is the basic infrastructure for economic development.

6.2.5 Limited purchasing power of consumers
The reason why some countries in Africa have difficulty even to achieve a subsistence economy is far from a mere shortage of food. Even in areas where there is enough food the low level of purchasing power of the people makes it difficult for them to have access to these food. Needless to say these counties no matter how kin for leapfrogging they are this problem of very low purchasing power will remain to be a challenge for profit-driven public and private enterprises to venture on new technologies in these countries.

6.2.6 Low level of job creation
Any economy-wide leapfrogging that doesn’t result in job creation in Africa is far from being sustainable. The livelihood of households can only improve if there is a sufficiently enough and permanent source of income in the form of new decent jobs created.

57UNECA (2006)
Resource rich countries that boast high level of total GDP have a significant number of their people suffering from poverty due to the fact that their economies haven’t created enough number of jobs at the local community level.

### 6.2.7 Lock-in
One of the important reasons behind the delays of shifting to hydrogen economy and other economies which are more sustainable than the current fossil based economy is the challenges of lock-in. Each type of economy requires its own institutional, infrastructural, financial and social as well as legal supports that in the first place establish it and later operate it. Each type of economy is also characterized by a certain set of technologies. Once such structural and institutional supports are well developed around the set of technologies to which they are created only incremental changes and improvements becomes viable, not a transformational change of leapfrogging. That is why at higher or at the systems level there is this problem of lock-in around a specific set of dominant technologies and a set of corresponding surrounding support systems.

### 6.2.8 Rebound effect
This phenomenon describes a situation where a gain in improved energy and material use efficiencies is counteracted or offset by the increase in the total use of energy and material. For example, the gain made by leapfrogging into effective energy technologies has a potential to lead to a reduced energy cost that can simulate increased energy consumption. In the long run, this poses the same challenge of over-consumption in Africa as in other countries in the North.

### 7 Creating enabling conditions for leapfrogging
In the effort of turning around the challenges into opportunities, it is crucial to identify enabling conditions that make leapfrogging landing into a higher plateau of success rather than stepping into a muddy pond of failure. These enabling conditions define the landing platform so that all the leapfrogging exercise does not derail the most pressing issue of poverty alleviation and meeting basic needs. They also create an inclusive socio-economic development for the majority of the African population. With the view of the foregoing challenges, the conditions that facilitate possible leapfrogging in Africa are briefly outlined as follows under four clusters namely, political and institutional cluster; infrastructural cluster; development context and cooperation cluster; and instrumental cluster.

#### 7.1 Political and Institutional Cluster
Government policies, education as well as institutional capacity building are included under this cluster.

##### 7.1.1 Government policies
Governments have the role of providing policies on science and technology as well as on SCP to enhance the shift to sustainability. In Brazil, the success story of ethanol
programme is associated with the governmental policy that led to disincentives for conventional gasoline-fueled automobiles. In addition to policy provision, governments are well positioned to use economic and fiscal instruments to trigger and reinforce different activities that significantly contribute to long-term changes. In this regards, the government of Brazil purchased a guaranteed amount of ethanol; provided economic incentives for industries to produce ethanol; and set the price of gasoline at twice the price of gasoline in the US to create a strong disincentive for the consumption of gasoline\textsuperscript{58}. Governments should operate in setting a good role model through, for example, of employing green procurement in their offices. The regulatory systems should be far from being fragmented across countries and sectors. Countries need to work out detailed policies on technological change and transformation that encourage green production, technologies and sustainable consumption.

7.1.2 Education
The minimum for a robust leapfrogging is having a large number of people that can read and write. A sufficient condition is increasing the number of educated people that can work for the economy that will be created along the trajectory of leapfrogging. Integrating aspects of sustainable production and consumption at all levels of curriculum is necessary. Both access to and quality of education should be improved. In supplying the required high-level manpower to enhance technological development that not only pulls the countries from the traps of poverty but also maintains a sustainable economic growth, focus should be give to quality technical education and training.

7.1.3 Institutional capacity building
There are a lot of examples where implementation of technologies with good performance failed to deliver something positive due to lack of institutional capacity of operating and maintaining the technology. This capacity is required not only at the operational level but also at the planning and legislative level. The magnitude and quality of trained staff at all relevant institutions with hand-on knowledge in technology transfer, development and dissemination should be the focus of policy makers and development partners.

7.2 Infrastructural Cluster
Africa can adopt and contextualize the Chinese model of Circular Economy and Japanese 3R (Reduce, Reuse and Recycle) initiatives. For this to happen there is a need to focus on the technological infrastructure and associated decentralized systems.

7.2.1 Technological infrastructure
Technical and social leapfrogging will require different levels of technological infrastructure. Unlike project-oriented initiatives, leapfrogging actions entail an economy-wide measure. The technological leap should render an improvement that is better than current best practice and compatible to the natural resource riches of Africa. Technology implies more than the hardware component and technical arsenals. In the case of energy

\textsuperscript{58} Moriera and Goldemberg (1999)
technology, aspects of energy efficiency; the mix of industrial and household level fuels; structure of the economy expressed, example in terms of the relative size of different industries by energy intensity are implied in the term technology. The level of technology leap should take physical factors such as geography and climate. Accounting for social, economic or environmental performance, leapfrogging technologies can be assessed using different parameters such as carbon intensity per GDP, number of jobs created per GDP, or number of households pulled out of poverty per GDP etc.

In Brazil, in addition to the government policy on disincentive for conventional gasoline-fueled automobiles, the development of an efficient sugarcane-to-ethanol conversion technology along with the creation of supporting agricultural and distribution systems was necessary.

### 7.2.2 Decentralized systems

Decentralized systems have a lot of advantages over centralized ones. These include modularity, easy operation and maintenance, adaptability, etc. Utility services such as water supply, energy production as well as wastewater treatment can be carried out in effective and manageable manner through decentralized systems that can easily be adapted to the requirements and realities of local conditions. The decentralized systems should cover many elements of technological infrastructure such as research and development institutions; technology and industry-level support centres such as NCPCs; and centres for development, operation and maintenance of modular systems.

### 7.3 Development Context and Cooperation Cluster

This cluster is where the soft parts of stakeholder participation, cooperation as well as partnership are highlighted.

#### 7.3.1 Stakeholder involvement

The list of projects started in many African countries that failed sooner or later is not short. One of the important factors behind such failures can be traced back to the weakness of achieving an inclusive stakeholder involvement both before and during the projects. Direct and indirect stakeholders including the public should be involved not only during the implementation process but also during the planning stage from the very outset.

#### 7.3.2 Effective and efficient regional integration

Any effort of leapfrogging should look for a prioritization of grand gains that will not leave some African countries at disadvantage and thus create a dividing line between a given country and another country next door. The quest should be for an effective and efficient regional integration that ideally facilitates the development of specialized roles within an organic cooperation between countries of economic and other form.
7.3.3 South-South Cooperation

Cooperation between African countries and other countries both from the North and South is of necessity for a mutual benefit. This can be done in light of exchanging experiences, sharing resources as well as technology transfer and development. A good example in this case is a technology alliance launched by India, Brazil and South Africa. The alliance will focus on finding solutions to agricultural, health and environmental challenges.

7.3.4 Revitalized North-South Development Partnership

Development agencies, development NGOs and development banks should leapfrog in terms of their role in national and regional development activities. They should finance and support leapfrogging initiatives because when such leapfrogging initiatives are carried out under favourable institutional and technical arrangements, they have the following advantages:

- **Cost-effectiveness**
  Leapfrogging can be a one-time shoot that can inject a vehicle for pulling out of poverty through implementing a long-term sustainable solution from the outset.

- **Saving on local and global environment**
  Considering the solar, hydropower, and biomass riches of Africa, any leapfrogging solution can be developed and run in a carbon-neutral fashion where a lot of environmental savings can be attained both the local and global level.

- **Social empowerment**
  Leapfrogging technologies have the potential to empower individuals and communities by enhancing the connectivity creating domestic and international networking thereby facilitating mutual development.

- **Basic Hardware and Operating Software**
  Most of the time development partners are involved in supporting what can be compared to the installation of application software type solutions. The shift should be to engagement in the creation of a context of leapfrogging that can change the poverty landscape by assisting the development of what can be compared to development of the basic hardware and operating software type of solutions.

- **Fishing net versus fish**
  The emphasis on the infrastructural aspect of leapfrogging is a conscious prioritizing effort of providing the fishing net rather than the fish. African countries are endowed with a lot of biotic and abiotic resources that can be harnessed to materializing regional and global sustainable development by utilizing such leapfrogging infrastructure.

All stakeholders including development partners have a role in participating in the cultivation of the first seedlings of sustainable leapfrogging systems (SLS). The propagating effect of these new systems as shown in Figure 13 results in a series of positive impacts that bring about reduced poverty and satisfaction of basic needs in a sustainable way through job creation, increased income and purchasing power and eventually leading to the domestic development of the next generation SLS with no or little external support.
Once the first step is done right through multi-stakeholder involvement, the people at the bottom-of-the-pyramid move from being aid recipients, to playing the role of producers and consumers as well as innovators and business partners, albeit at different stages.

### 7.4 Instrumental Cluster

Aspects that are related to the prevailing condition on the ground in Africa are parts of this cluster.

#### 7.4.1 Cultural Context

Indigenous knowledge has a potential to contribute in making leapfrogging successful if the knowledge is relevant in the given specific case. More importantly due consideration of indigenous knowledge will at least minimize hindrances.

Africa is a mosaic of different economic, social, political and historical as well as ecological circumstances. The cultural context of technology development and that of use of the technology should not be alien to each other. It is imperative to check that any leapfrogging effort is made in such a way that the eminence of the cultural diversity in Africa is well recognized.

Hence the context under which a successful and well developed leapfrogging can be realized should be considered into account before promoting any kind of technology and area for leapfrogging in Africa in general or in any African country in particular. It is vital to avoid one-size-fits-all approaches.

#### 7.4.2 Overcoming the temptation of quick fixes

Short term problems tend to call for quick fixes that would jeopardize the possibility of developing long term and sustainable solutions. Stakeholders in Africa should overcome...
this temptation of going for quick fixes and should be able to balance efforts of solving acute and local ills with strategically important future plans and policies.

### 7.4.3 Enhancing Stability

Many African countries are rendered unstable due to internal conflicts and/or conflict with their neighbouring countries. Other countries, no matter how stable internally they are, are affected by their mere position in an unstable neighbourhood. These all affect the economic and social development of these affected countries. Hence, mechanisms that take root on local and indigenous initiatives should be developed to bring about and enhance stability in these countries.

### 8 Conclusion

Leapfrogging to SCP is both desirable and possible in Africa. The major opportunities for leapfrogging in Africa are the rich natural resource endowment of the continent; its currently low level of technological development; infrastructural expansion; and corporate establishment.

The core benefit of leapfrogging to SCP is the possibility to pull millions of Africans out of poverty through meeting basic needs and setting a sustainable economic growth without incurring severe local and global environmental damages.

To enable leapfrogging to SCP in Africa, required policies and actions can be categorized into four clusters namely; political and institutional; infrastructural; development context and cooperation, and the instrumental cluster.

#### Setting the Perspective

Economy-wide changes rather than projects and singular product lines are required. Such systems-level leapfrogging provides a feasible way for Africa to seek more sustainable forms of development by increasing the overall eco-efficiency of economic systems. It is beneficial to go beyond the search for a single remedy to all ills, and instead seek feasible combinations of solutions.

There should be a focus as much on the infrastructure that will make leapfrogging possible as on the specific technologies. The infrastructure can be developed in such a way that it leads to a society-wide transformation. What matters is the flexibility and degree of decentralization of the infrastructure so that pre-existing large scale networks may not be required for specific modular systems to function. This will help create a strategy to avoid lock-in problems. The focus should thus be on creating conditions to scale up the transfer of environmentally friendly systems instead of promoting specific type of technologies.

Once appropriate infrastructure and vehicles that enable leapfrogging to SCP are in place, a prioritisation of areas that result in grand gains is important. The required changes can start at parts of the economy that have a strategic role for other consecutive changes. Economically important areas that have a trans-sectoral propagating effect across the economy need to get the priority. These areas include ecological farming, energy, solid waste management, water supply and sanitation, etc.

Pulling African urban and rural households out of the trap of poverty should form the denominator of all leapfrogging efforts. The efforts should lead to poverty reduction and eradication through satisfying basic needs in a sustainable way. Initiatives that generate new jobs thereby increase the purchasing power of households have a higher chance to
succeed in transforming the role of those at the “bottom-of-the-pyramid” into a higher level of contribution towards sustaining the overall economic growth. In the absence of increased purchasing power of households, an undesirable situation of so much to consume with few affording to do so is created.

Policy issues
It is important to highlight the role of legislative and policy level measures that can pave the way for leapfrogging. As in the case of the Brazilian ethanol case, for any kind of technological change that can be characterized as some form of leapfrogging to succeed, strong government policies and good technological capabilities are both needed in order to achieve widespread deployment of the technologies.

In this regard, policies that can provide the platform to leapfrog past the environmentally damaging development path historically taken by the countries in the North are required. The policies need to be adapted and contextualized to provide support to efforts of minimizing the dependence on external resources; and reducing harmful impacts while meeting basic needs and eradicating poverty. The policy planning exercise is better done if preceded by an attempt to understand the context of the problems and then find solutions.

Capacity Building
The enforcement of polices and regulations cannot be efficient and effective in the prevailing lack of human and financial resources. For the same reason, transfer of technologies from different countries to Africa is unlikely to be implemented or sustained.

Leadership and operational capacity is of necessity in order to make the shift from the current focus on short-term economic benefits of development to a strategic and systematic focus on sustainable development.

At the level of private and public consumers, there is a need to promote environmentally friendly technologies as well as sustainable products and services. Adequate technical capabilities and financial resources should be allocated to address the supply side simultaneously. This approach will change the trend of increasing pollution and energy consumption that currently outpaces economic growth in Africa.

There is a need to maximize the effort of creating human and institutional capacities in the region to encourage public participation that can make soft landing of leapfrogging technologies a possibility.

Development Partners’ role
Leapfrogging to SCP should be viewed as a continuous systems-level process not as a set of disorganized small projects with a limited life time. Schemes that can drive such a systems-level process should be developed as a partnership between Africa and development partners. If implemented in a consciously planned manner, such schemes will result in a win-win situation for both Africa and the rest of the world. Facilitating exchange of experiences and creating access to best practices in selected areas from other countries are two important areas that development partners can greatly contribute to.

One example of areas under the domain of the role of development partners on which the Task Force for Cooperation with Africa is working on is ecolabelling of African products. An ecolabelling scheme supported by a genuine and standardized basis can positively influence both the production and consumption components of SCP at the same time. In doing so, it has the potential to motivate and catalyze other leapfrogging
The role of development partners in supporting similar initiatives is necessary. An important contribution of development partners can be building the capacity of African institutions that can carryout holistic strategic planning. This can be done by allocating resources in order to design and implement projects using the experience of sustainable leapfrogging solutions that are successfully tested in other places.

**Final remarks**

Obviously, leapfrogging is not and can not be a panacea for all problems and development challenges of Africa. On the other hand, it is an alternative that has the potential to avoid future social, economic and environmental costs of conventional alternatives.

Integrated and holistic policies and strategies should be developed and implemented to amplify its merits while minimizing its demerits. To this end, the role of development partners is important provided that they support contextualized leapfrogging solutions in a less prescriptive fashion.

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