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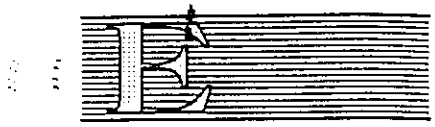

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ECONOMIC COMMISISON FOR AFRICA

Second Meeting of the Committee on
Natural Resources and Science and Technology

Addis Ababa, Ethiopia
30 October – 01 November 2001

SCIENCE AND TECHNOLOGY AND COMPETITIVENESS OF NATURAL RESOURCES IN AFRICA

AN ISSUES PAPER

Preface

The Conference of African Ministers responsible for Economic and Social Development and Planning adopted Resolution No. 826 (XXXII) in April 1996, through which the Ministers structured new Organs to deal with overall development issues facing the continent. Among these organs and subsidiary bodies (para "B-6") the Ministers established the "Committee on Natural Resources and Science and Technology" as follows"(CNRST). "This Committee will subsume the functions performed by the African Regional Conference on Science and Technology and the Conference of African Ministers responsible for the Development and Utilisation of Mineral Resources and Energy. It will, however, be composed of experts in these fields." CNRST serves as a forum for the promotion of cooperation among African countries in the areas of science and technology and development and natural resources and for providing advice on science and technology issues relevant to the development of member States. The Committee meets on a biennial basis. The Terms of Reference of the Committee are as follows:

a) Promote measures to facilitate co-operation among African countries in the area of natural resources, science and technology;

b) Provide a forum for exchange of information and sharing experiences in these areas;

c) Assist the Commission in the formulation of programmes for the development and application of science and technology; and

d) Advise the Commission on ways to strengthen its support to member States in the area of natural resources management.

The sustainable development and management of natural resources requires, interalia, pertinent policies, capacities and capabilities especially in science and technology and adaptation of new technologies in order to make these resources competitive in international markets.

The first session of the Committee (CNRST-1) met on 15-18 November 1999 in Addis Ababa, Ethiopia, and having considered the status of natural resources and science and technology, adopted a number of recommendation to enhance Africa's efforts in this regard. Also, taking note of the challenges and opportunities of globalisation and its implications for the competitiveness of African products, CNRST-1 decided that its next session (CNRST-2) should focus on science and technology (S&T) and competitive development and utilisation of Africa's natural resources in a globilised environment. Specifically, the Committee requested that its second session focuses on the following themes:

- Enhancing Africa's competitiveness: Policy issues in natural resources and science and technology;
- New and emerging technologies and Africa's natural resources; and
- Enhancing science and technology systems to promote Africa's natural resources.

This issues paper on "Science and Technology and Competitiveness of Natural Resources in Africa" is intended to serve as a background to the deliberations of CNRST-2.

The document identifies the major factors affecting the competitiveness of the natural resources sector as related to science and technology development in Africa. Though by no means comprehensive and exhaustive, it is intended to be a concise, yet informative guide to the participants to define more precisely how Africa could utilise its relative abundance of natural resources for its development, exploiting the high potential of S & T by giving them. a synoptic idea of the relative importance of the issues affecting natural resources development and utilisation in Africa. Where necessary, detailed information and an in-depth-analyses have been provided to substantiate the issues and emphasize the importance of the topics under review. The scope of information given is, to the extent possible, the most recent.

To place the review within an appropriate context, a theoretical background on the notion of competitiveness is provided. The role of science and technology, as well as the challenges and constraints inhibiting an optimal exploration, utilisation and conservation of natural resources have been defined. The paper focuses primarily on some natural resources sectors such as mining, energy and water. In this regard, it reviews their current status and development challenges. It has been assumed that the issues that affect competitive development and utilisation in these sectors are basically the same as those affecting agriculture and other natural resource sectors. Particular attention is given to the elucidation of costs structures and related technological parameters, which would have impact on improving their competitiveness. A way forward has also been suggested; it is anchored on the need to:

- Create an enabling policy environment;
- Promote good governance, peace and stability;
- Strengthen human capacity building;
- Improve supporting infrastructure;
- Improve technology acquisition and development and pay particular attention to new and emerging technologies;
- Strengthen technological systems of innovation;
- Facilitate financial resources mobilisation, and promote investment;
- Enhance private sector participation, strengthen public-private partnerships, and optimise the role of governments;
- Mitigate environmental impact;
- Address health issues;
- Foster local participation;
- Define new responsibilities for co-operating partners; and
- Promote regional cooperation and integration.

The options and priority actions identified could constitute elements of an actionable plan. It is believed that unless Africa comes out with an implementable plan, based on deep science and technology knowledge, its rich natural resources will probably have only a limited contribution to development. Although the advent of a knowledge-based society has illustrated that the availability of natural resources alone does not constitute a comparative advantage, the issues paper advocates that if Africa harness scientific knowledge and promote greater resource diversification and a natural resources-driven-sustainable development approach, it can use its rich resources base as a springboard for its renaissance. It is therefore vital that the CNRST-2 should seize on this opportunity to provide guidance to policy makers in such a vital area to Africa's development.

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I. INTRODUCTION

1. Africa is rich in natural resources. Yet, the continent has not been able to effectively harness this ample potential in the past and is presently challenged by important scientific and technological developments, which are fastly transforming international trade and the way business is done. The emerging trends will have far-reaching implications for Africa's development and competitiveness. Already, dynamic exporters have progressively squeezed out inefficient produeers. Available information suggests that even where Africa has traditional comparative advantage, its competitiveness has been eroded, thereby affecting the volume of its international trade. Africa's share of global export trade fell from 5.9% in 1980 to less than 2% at the end of the 1990s. This drop is significantly reflected in the share of most primary products. Sub-Saharan Africa in particular suffered a decline in its market share of global manufacturing value added (MVA) from 0.6% in 1970 to a low 0.3% in the 1990s. Also, manufacturing share in GDP fell from over 12% in 1990 to less than 10 per cent at the end of the 1990s. As globalisation and liberalisation advances, companies need to compete not only in foreign markets in order to prosper, but also to compete in their own national markets to survive. Africa should therefore act speedily to face up to counter the possibilities of this double - internal and external – squeeze and increase its competitiveness and diversity its economies in a globalised environment.

2. At the core of the erosion of competitiveness is the lack or dearth of the continent's scientific and technological capacities.[1/] Indeed, Africa is practically invisible on the world research map as it accounts for less than 1.0% of the world's research and development effort. Investments in technological acquisition and innovation are extremely low. This impairs its capacity to utilise and transform its natural resources and limits possibilities for forward and backward linkages.

3. As the parameters of international trade are gradually shifting in favour of science and technology-based competitiveness, the abundance of natural resources and the huge reservoir of low-cost labour do not necessarily constitute decisive comparative advantages for producers of these products. Indeed, the entire technological landscape of the world is witnessing significant transformations, revealed dramatically by the growth of high technology products with substantial research and development input. As they are science-based and knowledge-intensive, they are closely connected to universities and research institutions and rely on growing pools of technical and scientific labour.

4. Technology, particularly new information and communication technology (ICT), is now one of the most important assets of enterprises to compete on the world markets. Most technologically advanced countries are making massive investments in these technologies – around 5% of GDP or more than $1,000 per capita per year –. That means that public infrastructure cannot be viewed

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1/ The technological capacity of countries can be assessed by series of indicators, such as the resources invested on research and development, the number of science and technology personnel, scientific publications, registered patents, technology licensing fees, technology import, FDI related to technology transfer, computers, internet hosts and internet users per inhabitants, etc. According to these indicators African countries rank among the least technologically advanced countries in the world.

only in the traditional terms of roads, railways, power, ports and airports. Modern technological infrastructures have become key assets for the competitiveness of countries. The availability of fast, affordable and reliable connections to the internet and development of mobile telephones are some of the new technological infrastructure that nations need to put in place in order to become or remain competitive. Some countries, such as the Republic of South Africa, are leapfrogging some technological infrastructures, for example, by developing mobile rather than fixed phones and by using the internet to deliver services to isolated areas – such as banking, financial, information, distance-learning and health services. The internet enables companies to have global reach and conduct efficient business transactions. Other new technologies, such as biotechnology, material technology, solar technology, and manufacturing technology, are also changing the technological landscape and affecting competitiveness.

5. These technology-based transformations and gyrations in international trade, spurred by liberalisation and globalisation, imply that Africa should do its utmost to adjust and adapt more quickly and efficiently to the changing world economy, to keep up with the development of new and emerging technologies in order to maintain or enhance competitiveness. This requires the development of long-term perspectives and foresight to address the related issues, notably: research and development (R&D), modern management capacities, requisite institutional set-ups, and the creation of an enabling environment for diversifying and supporting productive structures, and ensuring the competitiveness of the natural resources sector. African countries need to produce a critical mass of skilled and highly trained labour force, including scientists, engineers, technicians, programmers, policy-makers, managers and entrepreneurs, capable of fostering technological innovation and change and of raising the degree of competitiveness of their industries. They need to strengthen their capacities to generate and use knowledge and participate in the knowledge economy. Strengthening their national systems of innovation is a matter of critical importance to achieve competitiveness and growth. The issue goes beyond establishing more laboratories and university research facilities to enhancing investment in social capital and infrastructure development and connectivity and improving efficiency. To this effect, the establishment of a vibrant manufacturing sector anchored, to the extent possible, on viable resource endowments should be vigorously pursued together with mining a wider variety of mineral deposits, and engaging more strongly in mineral beneficiation ventures and harnessing other natural resources. The rest of Africa could learn from the experience of South Africa, Finland and Sweden, which used the exploitation of their mineral resources as springboard for broad-based development. There is ample scope for developing forward, backward and lateral linkages in the natural resources sector across the continent. It was suggested that such potential could be maximised should small and medium scale enterprises be encouraged to participate in the development and utilisation of these resources. Artisanal small-scale mining, for example, could be an instrument of rural development and poverty alleviation.

II. COMPETITIVENESS: AN EVOLVING CONTEXT

6. The concept of competitiveness has evolved over time with economic development and with the formulation of development theories. Classical economists viewed competitiveness as arising

from "market mechanisms" (Smith), which force enterprises to measure up with each other in the production and distribution of goods and services at the best possible price and quality. Other economists saw competitiveness as mainly based on "land, capital, natural resources and labour". The famous theory on comparative advantages (Ricardo), for example, is an effort to understand how and on what basis nations compete with each other. The theory was later refined by other economists to attach more importance to "socio-economic factors", since many countries with an abundance of land, capital, natural resources and labour were not performing as well as others less endowed countries. It was noted that countries with no "capitalist class" (Marx) or no "entrepreneurial class" (Schumpeter) were not industrialising even if they had comparative or competitive advantages according to the classical views. Competitiveness is also a function of a country's "culture and value system". A century ago, a close relationship was found between certain values and development (Weber). The value systems underpinning the success of England, Germany and the United States in industrial development, for instance, are similar to those of some countries in Asia today, such as Japan, Korea and Taiwan. The Confucian principles of "personal effort, responsibility, loyalty, hard work, discipline, restraint, saving and the quest for knowledge" are quite akin to the ethic and values that dominated Europe and the United States in the 18th and 19th centuries, which fuelled the industrial revolution and the unprecedented development that followed. Lately, a number of economists have emphasised "technological innovation", "information", "knowledge", "ideas" and "brains" as the new bases for competitiveness (Solow, Lundvall, Mytelka, Garelli, etc.). A growing body of literature has emerged in the last fifteen years that lays emphasis on these growth and competitiveness factors that had been previously neglected.

7. At a low level of development, the importance of the natural resources sector in relation to the total economy is greater than it is at a higher level of development. In most advanced countries today, over 60% of the economy is based on services. Economists refer to this evolution as the "dematerialisation" of the economy, which means that the amount of natural resources used by unit of GDP is decreasing with the increase in the level of development. Furthermore, the importance of natural resources endowment for a given country is eroded by trade liberalisation, which makes it easier to import raw material from other countries. Most African countries rely more heavily on natural assets than on processes for their development. These countries are not considered very competitive on the world markets. On the other hand, some others, such as Tunisia and Mauritius, are poor in natural resources and essentially rely on transformation processes, using mature, off-the-shelf technologies for their development. In light of available evidence it appears that the process-oriented economies are more competitive than the assets-oriented economies. This led some economists (Sachs, 1997) to view natural resources as a "spell" or a "curse" that leads to dependency that discourages learning and technological upgrading. They see ample evidence of asset-rich nations that have not developed in spite of their enormous wealth, particularly where the exploitation of these natural resources is of an enclave nature. They also note, in contrast, that many resource-poor countries such as Japan, Taiwan, Singapore and Korea have developed from these observations, it is conjectured that the endowment of natural resources is a "trap" for it leads countries to concentrate or focus too much on their natural resources for their development and to neglect other important sectors, particularly high value-adding sectors. It would however be unsafe to conclude that natural resources assets constitute 'negative assets" for the development of a country. Some countries, such as Canada, Norway, Sweden and others, have historically developed by relying on the exploitation of their natural resources. In addition, the natural resources sector

has evolved from a low-tech sector based on low-cost labour to become a high-tech sector. From the above, it is evident that competitiveness does not necessarily depend on the endowment of resources, but rather on the technological capacity to process them and the quality of human resources and organisational efficiency. Adopting a strategic development orientation that emphasises processes and building technological capacities to become competitive in these processes is thus the key factor.

8. Quantum shifts will, however, depend on the efforts made to develop entrepreneurial capacity and enlarging the pool of skilled labour as well as on strengthening supporting physical infrastructures. Moreover, there is a need for establishing a capable services sector (design, engineering), putting in place strong research and development facilities and harnessing the possibilities of regional integration. The new competitive context brings new challenges for African enterprises, which need to upgrade their capacity to compete. It also brings new challenges for African economies, which need to transform themselves in order to be able to mobilise and organise the necessary resources to face the new challenges of competitiveness.

9. Given the continent's poor initial conditions and international challenges, Africa's competitiveness would need to be anchored at least on four critical parameters. These are:

(i) The recognition that African countries could only make a viable competitive economic space through strengthening regional integration arrangements, where common goals could be pursued, policies streamlined and institutions harmonised and strengthened;
(ii) Establishing a policy environment that is friendly to domestic development as well as suitable for creating conditions that attract foreign investors to locate in and operate from Africa;
(iii) A capable state that observes and practices good governance, and creates and nurtures conditions for dynamic comparative advantage particularly through removing infrastructural deficiencies and enhancing institutional capacity; and
(iv) Acquiring, adapting and internalising technological competence.

10. Competitiveness would require attainment of high efficiency at both the micro and macro levels. At the micro level, for example, firms should function efficiently and cost effectively with a perspective for modernisation to meet existing and emerging demand for products. At the same time, countries should function, or be perceived, as constituting a viable environment for new investment.[2/]

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[2] The Davos-based World Economic Forum established a global competition index for specific regions of the World consisting of such elements as: growth rates, openness of the economy, government policies, financial system, infrastructure, technology, labour and skills and civil institutions. For a ranking of the countries and regions see (1) The Annual Global Competitiveness Report and the Annual African Competitiveness Report.

III. SCIENCE AND TECHNOLOGY AND NATURAL RESOURCES DEVELOPMENT AND UTILISATION

11. Science and technology play crucial roles in any process affecting the exploration, utilisation and conservation of natural resources. Hence the need to harness this capacity to meet the projected higher needs for these resources, associated with future development and population growth, as well as their conservation for future generations. Not only that they provide the cutting edge for exploiting known resources, but also provide basis for new knowledge of potentials. As new techniques will result in reduced costs per unit of output, they would also help ensure the sustainability of development and thereby contribute to averting the otherwise ominous prospects of depletion of/or serious degradation of natural resources which, if it occurs, would seriously impair future growth and development.

12. While there are a number of ways that science and technology could contribute to the effective exploitation of natural resources, priority should be given to areas where efficiency, increased availability and sustainabilit could be ensured. In the minerals sector, for example, competitivity, irreplacebility and environmental issues merit particular emphasis. Likewise, in the water sector, attention would need to be placed on issues of availability, safety and on the issues of shared water resources. Similarly, in the area of energy, technological advances could be targeted in particular to ensuring most economic approaches to exploiting existing sources and exploring new sources as well as intensification of efforts to render non-conventional energy sources more economical and dependable. In agriculture, advanced knowledge and applications in biotechnology carry particular hope for realising a green revolution in Africa.

13. One of the major constraints inhibiting the development and utilisation of natural resources is lack of adequate data and information on the magnitude, quality, range and geographic incidence of these resources. The quality of the data will critically depend on the techniques used and the resources committed to this effect. Hence the importance of using advanced techniques of data gathering and standardisation. A complementary aspect is the assembly of the information presently scattered in the countries themselves, kept by foreign companies and institutions or maintained in the databases of international institutions and organisations. Such data however need to be classified, evaluated and regularly updated.

14. An essential prerequisite for the suitability of the application of science and technology in the development and utilisation of natural resources is the establishment of a critical mass of science and technology-based institutions. These institutions will be able to act as think-tanks, as well as instruments of dissemination of technical information to society at large. Through training, they would also contribute to building a critical mass of trained personnel. The 30 odd ECA-sponsored institutions were established with precisely this objective in mind. However, these Centres of Excellence need to be strengthened and better utilised.

15. The horizon of technological advances is extending by the day and likewise their applications. The micro-chip technologies have provided humanity with tools for almost infinite theoretical explorations and practical possibilities that could intensely examine possible approaches

to their utilisation in the area of science and technology. They could therefore improve our insights in the working of the physical system and mankind's understanding of nature. Such revolution should make it possible for Africa to probe more deeply and systematically into ways and means of knowing more about its resources and potentials and how to utilise them. Given Africa's present technological lag, such effort could be deployed in partnerships with other technologically more advanced operators. Foreign Direct Investment (FDI) could be a reliable source of obtaining such competencies.

IV. COMPETITIVENESS AND COSTS IN SELECTED AFRICAN NATURAL RESOURCES SECTORS

(i) Mining

16. Development and competitiveness in mining have been largely determined by changes in exploration concepts and techniques, metallogenetic models (ore deposit models), new analytical techniques and mining and ore processing and recovery methods (Borg, 2000). Competitiveness has also been affected by economic and financial factors such as the price of minerals, availability and cost of raising finance, and the prevailing fiscal regime.

17. Some of the most recent developments with lasting impact on mining include:

- New ore deposit types (Olympic Dam/Ernest Henry and; Voisey's Bay);
- New exploration techniques (e.g. High resolution aeromagnetics; and Hyperspectral scanning);
- Electronics/Software (GPS; Satellite-phones; Modems; Data-driven and knowledge-driven GIS; New techniques for transmission of compressed large data sets (McMullan, 2000) such as the Enhanced Compressed Wavelent (ECW); New data processing techniques; and E-mapping);
- Laboratory analytical techniques (e.g. Bulk Leach Extractable Gold (BLEG); Mobile Metal Iron (MMI) techniques; and ICP- Mass Spectrometry);
- Ore Processing/Metal Recovery techniques (e.g. Solvent Extraction Electro-winning (SX-EW) of Zn, Cu and Pb; High-Pressure Acid Leach (HPAL) of Ni and Co; Bioleaching of base metal sulphide ores with SX-EW finish; and, Au-chloride leaching);
- Ore mineral identification methods and techniques(e.g. Laser-and optical sorting; Micro-probes; and Electro-microscopes); and
- Mining Techniques (e.g. low-cost, open cast, heap leach and, off-shore mining).

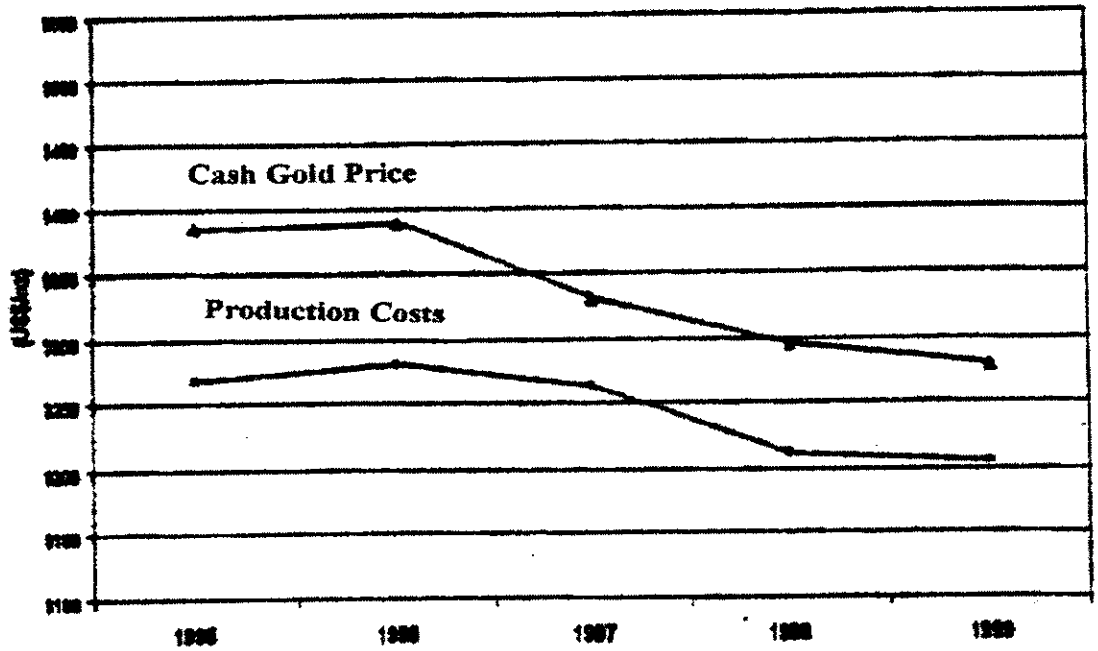
18. For example, new hydrometallurgical processes which can be installed at lower capital costs and on a smaller scale near to mine sites, make the mining of copper ores possible despite declining copper prices. Heap leaching techniques made mining of high-volume, low-grade ores, such as porphyry copper deposits like Chuquicamata in Chile or the extremely fine-grained and disseminated Carlin type gold deposits in Nevada, USA possible. Automation and new refrigeration techniques improved the depth at which ores can be mined. Continuos mining equipment and conveyor systems, improved the efficiency at which coal seams could be mined. Research on non-explosive continuous mining methods currently in progress will have significant impact on deep level mining productivity since it would allow around the clock underground mining in a confined working space. In Africa, MINTEK is in the forefront of R&D work in ore processing and

recovery, a rare example in the continent. South Africa is recognised as the world leader in shaft sinking and hoisting technology, cooling of deep mines, rock mechanics design and general underground mining technology. It has been through the development of such technologies, that mining of high-deep-level gold-bearing reefs was made possible.

19. Low metal prices have forced mining companies to introduce techniques that permit them to mine profitable through cost reduction methods. An optimal and highly attractive target would be one that is amenable to open pit mining, heap leach recovery of metals, operating costs of less than US$ 150/oz (in the case of gold) and with a low capital cost and a fast payback period (Borg, 2000). Generally, however, profitability of a mining operation depends on the following factors: size, type and grade of the deposit and the costs relating to mining and milling, mine and mill equipment, electric power; transportation; labour; taxes; as well as prevailing metal prices.

20. On average, mining costs have climbed steadily between 1989 and 1999 (Western Mine Engineering, Inc Website) following the trend of inflation. 1999 mining costs were more than 20% higher than those of 1989, while during the same period metal prices have in general plunged dramatically (42% for copper; 35% for zinc; 27% for gold; 5% for silver; and 55% for nickel). Rising equipment prices (50% increase in a 10 year period) contributed most to the increase in capital costs, while labour costs also rose 29% in the same period, increasing operating costs by 2% per annum. Management rationalisation, expansion of current production with a view to lowering unit costs, and technology improvements were some of the measures which have been adopted world-wide to reduce operating costs. This has resulted in lower mining industry cost curves, as in figure 1 below which depicts the evolution of gold production costs in Australia between 1995 and 1999.

Figure 1: Australian Gold Production Costs by Year (in US$)



Source: Modified from Metals Economics Group

21. As illustrated in Table1, in a typical mining operation, about 44% of the operating costs are represented by labour costs, while supplies and materials constitute about 30%. With regard to capital costs, equipment represents about 52% of the total, while engineering and management, and buildings represents about 12% and 10% of the total cost respectively.

Table 1: Typical Cost Structure of a Model Open Pit Mine producing 5,000 tons and 5,000 tons waste per day

Operating Costs	
Description	**% of Total Cost**
Supplies And Material	31%
Labour	44.5%
Administration	15%
Sundry Items	9%
Capital Costs	
Description	**% of Total Cost**
Equipment	52%
Haul Roads	5%
Pre-production stripping	2%
Buildings	10%
Electrical system	0.3%
Working capital	6%
Engineering and Management	12%
Sundry items	9%

Source: Modified from Western Mine Engineering INC website

22. Generally, in Africa, starting-up a mine will require large capital outlays mainly because of unavailability of local supplies and poor infrastructure. In most cases, the mine developer would have to build the infrastructure from scratch including roads, power and water supply. In the mining phase, despite the relatively lower labour costs prevailing in the continent, the operating costs are also aggravated due to inefficiencies and unavailability of supplies and materials. For example, engineering and other support services have in most cases to be sub-contracted from foreign-based service providers, or their local subsidiaries at higher costs than in other competing parts of the world where such services are competitively available domestically.

23. In comparison to other continents and as depicted in Table 2 for the case of gold production, costs in Africa are relatively higher despite lower labour costs. Though reasons for these higher costs are not reported, it appears that the main ones could be related to lack of local skills, and domestically produced mine inputs, inadequacy of or lack of a good services sector, and poor physical infrastructure (power supply, roads, water supply etc.). However, in the case of the South African gold industry, producing costs have increased due mainly to persistent double-digit inflation and increasing working costs which are caused by declining ore grades, rises in administered prices (such as cost of water and electricity) and wage increases an other improvements in the terms and conditions of employment of mining industry employees (Chambers of Mines of South Africa, 1992). This has contributed to a loss of international competitiveness for the South African mining gold industry.

Table 2: Selected Gold Projects and Estimated Costs

Project	Operator	Location	Gold Grade (g/mt)	Contained Gold (oz)	Planned Capacity (oz/y)	Projected Cash Costs/oz	Estimated Capital Costs (US$mil)
Midas	Franco-Nevada	United States	25.2	2,431,000	350,000	$98	$84
Gosowong	Newcrest Mining	Indonesia	19.6	423,000	154,000	$113	$61
El Penon	Meridain Gold	Chile	10.0	1,560,000	250,000	$75	$48
Geita	**AngloGold**	**Tanzania**	**3.5**	**5,514,000**	**500,000**	**$180**	**$165**
Morila	**AngloGold**	**Mali**	**3.8**	**3,560,000**	**420,000**	**$137**	**$102**
Red Lake	Goldcorp	Canada	38.5	3,560,000	240,000	$88	$56
San Martin	Glamis Gold	Honduras	0.9	1,090,000	80,000	$150	$27
Bulyanhulu	**Barrick Gold**	**Tanzania**	**14.67**	**10,001,000**	**400,000**	**$160**	**$280**
Target	**Avgold**	**South Africa**	**7.79**	**6,462,000**	**350,000**	**$200**	**$270**
Ridgeway	Newcrest Mining	Australia	2.46	4,262,000	310,000	$113	$175
Yatela	**AngloGold**	**Mali**	**2.10**	**2,532,000**	**240,000**	**$175**	**$69**
Carosue Dam	Pacmin Mining	Australia	1.98	1,213,000	125,000	$190	$25
Beaconsfield	Allstate Expl	Australia	17.40	671,000	100,000	$167	$30

Source: Modified from Metals Economics Group

24. As mining companies consolidate and their portfolios increase, the hurdle rates for new mining development for such larger companies also continue to rise. In order to maintain their market position and share, these companies are required to make significant discoveries every year or make acquisitions of significant nature on a regular basis.

25. A simple implication for Africa is that due to the fact that doing business in the continent is relatively more costly than elsewhere and that its country- and – project related risks are higher, then for it to be able to attract large mining companies it has to generate world class deposits on a regular basis. Unfortunately, such deposits are rare. On the other hand, developing only world class deposits would contribute to an irrational and wasteful utilisation of mineral resources. Alternatively, the continent will have to address those elements that lead to raising costs in the region. Moreover, as suggested by the World Bank (World Bank technical paper No.181) "the development of the missing middle (represented by junior mining companies and venture capitalists) is a critical aspect of expanding the mining sector in Africa" and addressing some aspects of the cost structures related to large scale mining.

26. Furthermore, mechanisation of mining in Africa which would contribute to improving the competitiveness of mining in countries like South Africa, would also require higher and multi-skilled manpower that is also able of performing multiple tasks. The resulting reduction in the labour force have socio-economic implications that need to be factored in.

(ii) Energy

27. The development and utilisation of energy resources in Africa can be made competitive through the application of recent developments in technology, particularly in deep-sea oil exploration, gas-to-liquid (GTL) technology, the roller compacted concrete (RCC) dams, the integration of wind-generated electricity to existing power grids, and rural electrification with

photovoltaic (PV) solar energy technology. In addition, deregulation of the power sector made participation of the private sector possible and consequently increased the financial resource base from which to fund new projects.

28. In the exploration and production of oil and gas resources, improvements in technology, such as three-dimensional (3D) seismic surveys and extended-reach drilling, have allowed higher recovery rates from existing reservoirs and the profitable development of fields once considered uneconomic or technically beyond reach. For example, in Côte d'Ivoire, United Meridien International Corporation (UMIC) of the US has reinterpreted and reprocessed exploration data left behind by the previous developers, British Gas and Walter, and was helped by the 3D seismic data provided by the national oil company, Petroci, for its discovery of Panthere gas deposit in December 1993. Actually, oil and gas discoveries are being made in most of the countries of the Gulf of Guinea using deep-sea exploration technology.

29. As another example, the South African company, Sasol, is involved in the exploration of natural gas resources that can be beneficiated in Sasol's South African facilities, as well as those that can be monetised through the Group's unique gas conversion technology- the Sasol Slurry Phase Distillate (SPD) process- that can be exploited competitively to produce premium high-quality fuels and naphtha. Proven and probable gas and oil reserves to which SPI has access in Mozambique and elsewhere in Africa have doubled in a year, and are estimated at 260 million barrels of oil equivalent. This was achieved at a finding cost of US 47 cents a barrel of oil equivalent, which is below industry average. Sasol is planning to build a 900-km gas pipeline (600 km within Mozambique, and 300 km within South Africa) from the Temane/Pande gas fields to Secunda in South Africa.

30. The Sasol's gas conversion process has huge potential and continues to attract interest from oil and gas companies and gas-rich countries. For example, Sasol is working with Chevron Nigeria Limited in developing a gas-to-liquids (GTL) project at the existing Nigeria National Petroleum Corporation /Chevron joint venture oil and gas facilities at Escravos in Nigeria. The planned GTL plant, which is envisaged for commissioning before the end of 2004, will have a daily production capacity of 33,000 barrels.

31. Hydropower development projects costs could be reduced by recent technology improvements. On dam construction, progress was made with the roller compacted concrete dams (RCC). The lower cement content and the mechanised placing of the concrete yield a relatively low unit cost of around US$ 30-40 per cubic metre of dam body, which is less than half the price of conventional placed concrete. The RCC technology has made many dams feasible that previously appeared economically unattractive since this technique allows rapid placement in such a way that dams can grow by 60 centimetres (two compacted layers) per day, allowing building of a 200-metre-high dam in less than a year. Due to the lower cement content, less heat is developed during hardening, which is an added advantage. With RCC dams, river diversion during construction is often in-river, rather than by means of diversion tunnels, which permits savings in time and money (Oud and Muir, 1997). For smaller structures, dams with geo-membrane lining (up to 80 metres high) are becoming acceptable for low rock-fill or earth-fill dams.

32. The present installed hydropower system cost ranges from US$ 1,000 to US$ 1,500 a kilowatt for the most favourable sites, but can be higher than US$ US$ 3,000 a kilowatt in practice, because hydropower projects are site-specific. There are some expectations that technology advances can reduce costs, but in small amounts since the present technology is optimised. With low investment costs and favourable financing conditions (interest rate of 6%, and payback period of 30 years), generation costs for an average capacity factor of 45% is 0.04-0.06 US$/kWh.

Because the hydropower plant is usually placed far from the electricity load, investment required for transmission lines would add another 0.01 US$/kWh. For small-scale hydropower plants, the unit cost would be expected to be higher than for large-scale hydropower plants, and would be in the order of 0.04-0.10 US$/kWh for the most favourable sites. Refurbishment of plants has shown that advanced technologies can significantly increase the energy output at essentially unchanged primary water flows, like in the case of Owen Falls hydropower plant in Uganda whose capacity was upgraded from 150 MW to 180 MW and work was completed in December 1996.

33. Deregulation of the power sector is being accompanied by the private sector participation in the generating function. This has led to the emergence of the Independent Power Producers (IPPs) which are private companies specifically created to finance, develop, own and operate generating power stations. IPPs are interested in projects that can easily be funded and generate profits in the short-term, unlike hydropower projects which are capital intensive and generate profits in the long-term. For this reason, a few hydropower projects have been developed by IPPs. However, Uganda has succeeded to develop the 250 MW Bujagali hydropower project (www.bujagali.com) under a BOOT financing arrangement with AES of the United States as the developer for an estimated investment of about US$ 500 million, including the associated transmission lines. Mozambique is also considering developing the 1200 MW first phase of Mepande Uncua hydropower project, in co-operation with South Africa, under an IPP financing arrangement.

34. In recent years, enormous progress has been made in the development of wind turbines for electricity generation. In the mid-1970s the typical size of a wind turbine was 30 kW of generating capacity, with a rotor diameter of 10 metres. Modern electronic components have enabled designers of wind turbines to control output, within the operational envelope of wind speed, and produce excellent power quality. These developments make wind turbines more suitable for integration with the electricity infrastructure. For example, the 50 MW wind farm installed at Koudia al Baida in Morocco, commissioned in 2000, is composed of 84 wind generators of 600 kW each with a total installed capacity of 50.4 MW, and was developed by a consortium of French companies, including Electricité de France (EdF) under a "build, own, operate and transfer (BOOT)" scheme for an investment estimated at FF 360 million (US$ 63 million). The Office National de l'Electricité (ONE) is planning the construction of wind farms in the Tangier and Tarfaya regions totalling 200 MW of installed capacity for an estimated investment of US$ 200 million.

35. The energy generation costs of wind turbines are basically determined by five parameters:

- Turnkey project cost, ranging from US$ 460 to US$ 660 a square metre of swept rotor area;
- Energy output of the system;
- Local average wind speed which should exceed 5 m/sec at a height of 10 metres to allow economic exploitation of grid-connected wind turbines;
- Availability of the system which should exceed 96% for modern wind farms; and
- Lifetime of the system (A lifetime of 15-20 years could be confidently used for economic calculations).

If the average wind speed at the hub height range from 5.6-7.5 m/sec, the corresponding electricity production cost would be 0.12-0.05 US$/kWh.

36. The average power density of solar radiation is 100-300 watts per square metre (W/m^2. The net conversion efficiency of solar electric systems or photovoltaics (PV) solar systems (sunlight to electricity) is typically 10-15 percent. The turnkey cost of a PV system, determined by the module cost and the BOS costs, is typically of 5-10 US$/W for grid-connected, and 8-40 US$/W for standalone systems. PV electricity costs are determined by turnkey costs, economic lifetime (depreciation period), interest rates, operation and maintenance costs (including possible replacement of components), electricity yields of the system (a function of insolation/geographic

location), insurance costs, etc. PV electricity production costs are in the range of 0.3-1.5 US$/kWh depending on solar insolation, turnkey costs, depreciation periods, and interest rates.

37. PV solar energy technology can be considered as a viable alternative for rural electrification in Africa. It is cost-effective in providing electricity to meet basic energy needs in rural areas (less than 100 watts) in areas with no access to grid electricity and where electricity demand is characterised by such low levels and infrequency that even diesel electricity cannot compete. The potential for PV technology to support rural electrification arises from the fact that it can be used for households lighting, operate radio and television sets, and to refrigerate medicines in rural health centres. One important obstacle to wider utilisation of PV technology in rural areas is the limited financing available for such small systems.

38. A good example of solar electrification of rural households on a large-scale is the 3-year Shell Renewables/Eskom joint venture project of supplying more than 50,000 households with 50 Wp PV systems capable of powering small black and white TV sets, radios and three to four lights. The systems will remain the property of the joint venture company; the electricity service is for sale, not the hardware. The system incorporates a prepayment meter integral with the charge controller. Customers will pay a US$ 30 installation fee, while the monthly service is US$ 8. Community-owned and operated companies will undertake marketing, prepayment card sales, installation and maintenance.

39. Table 3 below summarises the current electricity production costs from some renewable energy technologies (RETs).

Table 3: Current Status and Potential Future Costs of Renewable Energy Technologies

Technology	Capacity factor (%)	Turnkey investment cost (US$/kW)	Current energy cost	Potential future energy cost
Biomass energy	25-80	900-3000	5-15 cents/kWh	4-10 cents/kWh
Wind electricity	20-30	1100-1700	5-13 cents/kWh	3-10 cents/kWh
Solar photovoltaic electricity	8-20	5000-10000	25-125 cents/kWh	5-25cents/kWh
Hydroelectricity				
Large	35-60	1000-3500	2-8 cents/kWh	2-8 cents/kWh
Small	20-70	1200-3000	4-10 cents/kWh	3-10 cents/kWh
Geothermal energy	45-90	800-3000	2-10 cents/kWh	1-8 cents/kWh

Source: Adapted from "Energy and challenges of sustainability": World Energy Assessment

(iii) Water

40. African countries may wish to consider a variety of measures in order to be competitive both within and outside Africa and cost effective in the water sector. These measures can be both quantitative and qualitative in nature and may include, inter-alia, the following:

- Enhancing system efficiency for water uses in domestic water supply, sanitation, irrigation, industrial and mining sectors.

- Reducing system losses due to leakage, wastage and other unaccounted for water losses. At present 40% to 50% of water in most African urban water systems are lost because of leakage and other unaccounted for losses.
- Making use of innovative scientific and technological methods and processes in abstraction of water, treatment of drinking water and waste management systems and thereby reducing system costs and enhancing system efficiency.
- Making use of modern technologies like spray and drip irrigation, water conservation methods, reduction of water losses due to excessive seepage in irrigation systems with a view to enhancing water efficiency by producing "more crop per drop" of water. This will in the long run reduce the current share of water uses of 70% to 80% of all freshwater withdrawal by the agriculture sector alone.
- Adopting Integrated Water Resources Management (IWRM) approach to water management at local, national and subregional levels to ensure stakeholders' participation at all levels.
- Moving to full cost recovery for water services provided with appropriate targeted, transparent and accountable subsidy to the poor segments of the society. Water provided free of cost does not get utilised wisely and conservatively and would encourage wastage. Full recovery of both capital and investment, operation and maintenance costs will not only ensure treating water by all as an economic rather than a social good, it will also make the systems run by public sectors more efficient, cost effective and prevent them from being persistent money loosing concerns as is the case in most developing countries including those in Africa. Furthermore, it will encourage private sector involvement in capital investment, operation and maintenance from within and outside Africa.
- Enhancing inter-country co-operation for integrated development of sharedwater resources by adopting the win-win principle for all riparian countries in line with agreed formula of water-sharing. This will ensure that only the required minimum amount of fresh water from large international rivers in Africa drains away to the sea. These types of amicable arrangements will not only help achieve the goals and objectives of regional co-operation and economic integration in Africa, but also encourage the involvement by international donors and finance agencies as has been evidenced by recent success stories in the Nile basin under the Nile Basin Initiative (NBI).
- Encouraging both public and private sector (regional and international) investment in large-scale water development projects/programmes by creating an enabling environment with fair, transparent water and other legislation, and also by putting in place mechanisms for investment protection and profit sharing.
- Encouraging and promoting investment in research and development in new emerging and innovative technologies with a view to reducing costs in water and waste treatment processes including desalination, rain water harvesting more cost effective and sustainable well drilling (both shallow and deep wells) especially in rural areas for domestic, agricultural and other uses of water.
- Adopting best practices, and emulating success stories both from within and outside Africa such as the Egyptian experience in large scale irrigation; the Moroccan experience in use of small dams; the Ethiopian experience of sub-basin-wide water management; the Libyan experience of large scale inter basin/inter aquifer water transfer "The Great Man-made River"; and Israel's experience of cost effective drip irrigation.
- Improving national, sub-regional and regional infrastructure in al economic sectors including water. This will encourage the inflow of FDI especially for large scale cross-country irrigation, flood control and hydro-power generation projects which would otherwise be beyond the means of small African economies.

V. THE STATUS AND CHALLENGES FACING THE DEVELOPMENT AND UTILISATION OF NATURAL RESOURECS IN AFRICA

(i) Mining

41. In the last decade, economic liberalisation and continued mining sector reform have renewed international interest in Africa. According to the Metals Economic Group of Canada, in 1997, 1998 and 1999, mineral exploration and development investment in Africa accounted respectively for 16.5% (US$662 million), 17.5% (US$499 million) and 14.7% (US$371.1million) of the global exploration expenditure. Despite the fact that, in the same period, Latin America attracted more mineral investments with respectively 29.0%, 28.8 % and 29.1 % of the global exploration expenditure, Africa accounted for the largest percentage increase compared with other regions during the entire 1990–1999 period. Several factors including low and volatile commodity prices as well as the collapse of several emerging markets have contributed lately to a decreasing interest to invest in mining by global investors. For Africa in particular, adverse political and economic climates have further contributed to a reduction of the continent share of foreign direct investment. The political risk and political risk insurance associated with Africa have recently increased.

42. Mining is losing its financial power. It's declining returns arising partly from falling mineral prices, coupled with many and varied challenges the sector faces, of which environmental issues are among the most important, makes it a less competitive sector compared to ICT. It may be worth noting that the combined assets of the ten largest mining companies in the world are less valuable than half of Microsoft. The depressed status of the industry world-wide makes raising finance for new mineral ventures increasingly difficult and expensive. This has been exacerbated by the Bre-X gold stock scandal in 1996,which later contributed to the loss of liquidity in the equity markets for junior exploration companies.

43. As reported by the Metals Economic Group, following global trends, exploration expenditures in Africa have been declining at an average rate of 23-25 % per year since 1997. Exploration expenditure in 2000 was only US$293.1 million, which represent 44.27 % of the figure in 1997. The share of global expenditure decreased from 16.5 % in 1997 to 12.6 % in 2000. Whilst in 1997, Africa followed Latin America as top exploration destination for exploration expenditure, in 2000, it trailed both Latin America (28.3%), Australia (17.3%) and Canada (14.9%). Only the United States, the Pacific/Southeast Asia regions and the rest of the world (Europe, Middle East, etc) performed worse than Africa.

44. Some sources advocate that in order to maintain the investment competitiveness of Africa, there is a need to: (i) improve the geological attractiveness of the continent; (ii) to encourage political stability and confidence; and (iii) sustain fiscal incentives, while maintaining an investment-friendly environment. However, this alone will not contribute to the achievement of minerals-driven sustainable development. Sustainability will be attained only if: (i) greater equity and self-reliance is achieved, (ii) health, income and living conditions of the poor majority are improved, and (iii) an equitable and sustainable use of the environment and natural resources for the benefit of present and future generation is promoted.

45. Sustainability within the minerals sector (Mike Solomon, 2000), depends entirely on the ability of governments' and other stakeholders to:

(i) Plan their mineral economies in such a way to maximise the development of mining-related secondary and tertiary sectors during the currency of mining operations;
(ii) Encourage the development of non-mining related activities around mining service industries and mining infrastructure;
(iii) Diversify the use of mining infrastructure while it is being subsidised by mining sectors to the extent that the closure of the mines for which the infrastructure was developed does not cause its collapse; and
(iv) Actively encourage non-mining investment in mining regions to reduce the dependency of local, regional and indeed national economies on minerals, and to simultaneously reduce the dependence on local infrastructures on mines. This requires:

- An effective collection and distribution of mineral rents;
- Promoting the creation of a local mine inputs industry, engineering, supply and other domestic services;
- Increased local processing of minerals into consumer items and other inputs for local industries; and
- Development of mineral industry processes which can be transferred and applied in other sectors of the economy.

46. Promoting a mineral resources cluster development strategy requires appropriate R&D support infrastructure. In Africa, this is possibly available only in South Africa, which developed with a certain degree of success minerals-based upstream industries. The case of manufacturing for export of platinum catalysts for cars is illustrative. Mine refrigeration techniques for deep-level mining (more than 4,000. meters) being developed by MINTEK is a another example of indigenous cutting edge research and development work which can be laterally exploited for other industries. MINTEK is promoting what they call a "Resources-based Technology Growth Strategy (RBTGS) that argues that South Africa economic growth can be accelerated through industrialisation based on its natural resource wealth". RBTGS suggests "that there are three mechanisms for exploiting the development potential inherent in a natural resources endowment. The first, is downstream processing or beneficiation. The second, is the development of an internationally competitive capital and consumable and services inputs industry supplying the natural resources sector. The third, establishes a linkage from the inputs industry to other high-technology industries. Generic technologies and skills from the minerals inputs industry can be used as a platform for entering and/or servicing other industries". Atlas Copco equipment which was first developed in Sweden for the mining industry, but now is exported world-wide for other purposes too, is a clear example of successful transfer of generic mining technologies to other industries. Similar, but less ambitious strategies can also be advocated for other resource-rich African countries based on co-operative arrangements. The Southern and Eastern African Mineral Centre (SEAMIC), an ECA-sponsored institution, is undertaking research on applications of industrial minerals which could be considered

as a good example of such less ambitious programmes. Another example of relevant R&D work for Africa, is the new gold leaching process based on chloride leaching which has been developed by MINTEK. This new process is simple and appropriate for gold processing for small miners. In addition it is safer, low cost, and represents an alternative to the utilisation of mercury for amalgamation of gold which is environmentally hazardous. With this method mineral recoveries are higher and the quality of the final product (gold) is better (99.9% gold compared to 70% - 90% gold using the amalgamation method). Furthermore, the reagents are easily obtainable.

47. Improving the geological attractiveness of the continent requires improvements in Africa's geo-infrastructure. The lack of basic geologic data and maps is a constraint to doing business in Africa. The Geological Survey Organisations (GSOs) are the national custodians of mineral data and is vested upon them the responsibility of disseminating the data in a suitable, good quality, easy and cost effective manner to the widest possible potential users (Pedro, 2001). Mineral data is an indispensable commodity to stimulate explorationists' interest in any country. Unfortunately, the status of the GSO's in Africa is deplorable. They lack sufficient human, technical and financial resources to adequately discharge their duties.

48. In Africa, most of the available data is in analogue form and in some cases in poor state of conservation. There is an urgent need to transform the analogue archives into digital ones. In addition, and as the future lies in disseminating data electronically through the web, national and sub-regional data exchange mechanisms and geo-information gateways should be established such as the one launched by SEAMIC. These one-stop-shops for mineral data contribute to improving data accessibility and reducing the costs to procure it, promoting good governance in data management and ultimately promoting competitive mineral investments. The development of real-time image viewing through e-mapping and e-commerce would increase data synergies and provide income generating possibilities to the GSOs that could ultimately contribute to the improvement of their financial sustainability. As stated by David Ovadia (Ovadia, D.C. 2000), the challenge for any developing country is "to present: (i) suitable and relevant national geoscience information; (ii) in a form suitable for its intended use; (iii) at a level of quality that meets international expectations; and (iv) in a manner that is easy to use and cost effective to transmit to target recipients, such as international mining or oil companies, in order to attract them to place investment funds in that developing country. This challenge is more pronounced in Africa".

49. Generating and disseminating new data is a pre-requisite to increasing the project pipeline in Africa. This calls for an increase in the mapping coverage of the continent, which is the least covered of all continents. The advent of new remote sensing technologies such as hyperspectral scanning, provides and opportunity to launch a fast, cheap, effective and detailed geological and geochemical mapping of the continent.

50. Revamping Africa's GSO's with a view to creating the necessary basic infrastructure to attract private sector investment requires assistance from multilateral agencies such as the World Bank, as alone Africa does not have the requisite resources. Moreover, and as Africa does not have a strong domestic private sector with enough financial resources to develop a capital intensive sector as mining, foreign direct investment (FDI) needs to be mobilised.

51. In recent years, most African countries have been adjusting their mining laws and regulations with a view to attracting additional mining investment. These efforts are aimed at providing guarantees to investors, security of tenure, acceptable fiscal regimes, the right to repatriate profits, and management and equity control.

52. There has also been efforts aimed at harmonisation of mining policies and legislation at the sub-regional level. The most notable examples are efforts by UEMOA and SADC. In addition, attention has also been geared towards facilitating the access to, and provision, co-ordination and harmonisation of mineral resources development support services through regional centres. SEAMIC is a case in point.

(ii) Energy

53. Access to energy services has been limited by the high investment cost of rural electrification programmes due mainly to long distances, difficult terrain (hilly and densely forested areas) and low population density in rural areas. Provision of decentralised electricity generation systems in rural areas has been limited by high capital costs (renewable energy technologies) or by high operations and maintenance costs (diesel generators). In urban areas, extension of electricity distribution networks has been limited by the low income of population and difficulties to pay connection fees and high electricity tariffs.

54. Until recently, most of energy enterprises in Sub-Saharan Africa (SSA) have been characterised by low technical efficiency and poor financial performance, due mainly to inefficient pricing policies, low quality of service, high technical and non-technical losses, low equipment availability, and inefficient investment choices. This is why many countries have started to implement energy sector reform and privatisation programmes aimed at making the sector more commercially and financially viable, improving and sustaining the overall efficiency and performance of energy utilities, and attracting capital resources. Competition and deregulation are being introduced in the energy sector, thereby bringing some improvements in service delivery.

55. Due to the small size of African countries' economies, many energy projects are only feasible in a sub-regional and multi-country context. Most of the Regional Economic Communities (RECs) have in their objectives the strengthening of sub-regional co-operation in the energy field by facilitating energy pooling through the interconnection of electricity grids, oil and gas pipelines networks, and joint development of hydropower projects. Some of the hydropower projects in Africa rely on power export to become feasible. This is the case for the Mepande Uncua hydropower project (1200-2400 MW) in Mozambique, the Sounda Gorge hydropower project (1000 MW) in Congo, and Grand Inga Dam project (40,000MW) in the Democratic Republic of Congo. These projects are likely to be implemented within the framework of interconnection of electricity grids and/or the sub-regional power pools, such as the Southern African Power Pool. In the oil sector, the outputs of most African refineries are not competitive compared with imported petroleum products due to their small size and outdated technology. There are countries that are planning the construction of new refineries, such as Angola. These refineries could be designed in such a way that they become competitive in terms of capacity and technological improvements to meet sub-regional energy requirements.

56. Rural electrification programmes, by extension of national electricity grids, have not achieved the objective of improving significantly access to electricity by the rural population. Innovative approaches include the promotion of rural energy technologies (RETs) such as solar

energy and mini-hydropower stations, the private sector participation and the formation of energy co-operatives. Some bilateral and multilateral aid agencies have shown interest in financing rural electrification projects, such as the involvement of the African Development Bank in Cameroon, and the World Bank in Uganda.

57. Most of the poor people in rural areas lack access to electricity and other modern fuels for their basic energy needs. They rely primarily on human and mechanical power for mechanical tasks, such as agricultural activities and transport (collecting biomass fuel for heating and cooking, fetching water, etc.), and on direct combustion of biomass (wood, crop residues, cow dung, etc.) for activities that require heat or lighting. In addition, most of the people in rural areas use small batteries to operate devices such as radios and flashlights. It would be possible to improve the living conditions of the rural population through the provision of basic energy requirements for electricity through decentralised renewable energy technologies (RETs) such as solar PV energy systems for lighting, refrigeration and water pumping and more end-use efficient technologies for cooking and heating.

58. Over the past decade, a growing number of African countries have encouraged the private sector participation in the development of the energy sector. Most public power utilities have been privatised or are being privatised in a number of countries including Cameroon, Côte d'Ivoire, Gabon, Guinea, Mali, Rwanda, Senegal, Togo and Uganda. Independent Power Producers (IPPs) are involved in the development of private power projects in Côte d'Ivoire, Kenya, Nigeria, Tanzania, Uganda among others. This would help improve the technical and financial performance of the power utilities, ensure the reliability of electricity supply, and contribute to the reduction of the cost of delivering energy services.

59. The problems affecting the energy sector development in Africa can be summarised as follows:

- Limited access to energy services;
- Small size of domestic energy markets;
- Low level of utilisation of existing capacities;
- Low capacity and technical performance of existing petroleum refineries;
- Poor performance of energy enterprises; and
- Weak regional energy market integration.

60. The challenges facing the development and utilisation of energy resources in Africa have been summarised in a recently adopted document "A New African Initiative", as follows:

- Improving access to energy services through the promotion of renewable energy technologies (RETs) and implementation of appropriate policy measures;
- Ensuring energy enterprises' performance through sector reform and private participation;
- Promoting regional co-operation and energy market integration;
- Implementing rural electrification programmes; and
- Ensuring rural energy supplies

61. The major objectives of "A New African Initiative" are as follows:

- Increasing to 36% access to reliable and affordable commercial energy supply by Africa's population in 20 years;

- Improving reliability and lower cost of energy supply to productive activities in order to achieve economic growth of 6% per annum;
- Reversing environmental degradation associated with the use of traditional fuels in rural areas;
- Exploiting and developing the hydropower potential of river-basins in Africa;
- Integrating transmission grids and gas pipelines so as to facilitate cross-border energy flows; and
- Reforming and harmonising petroleum regulations and legislation in the continent.

(iii) Water

62. Almost 30% of urban and 50% of rural Africans do not have access to safe drinking water. The percentage figures are even more dismal (50% to 80% respectively) as far as adequate sanitation facilities are concerned. A large portion of the existing water and sanitation systems are over stretched, under-repaired, and in bad shape to the point that distribution network losses (between 40%-50%) in most urban water systems are excessive by any standard.

63. Africa's infrastructure in the water resources assessment, water quality monitoring, river flow and rainfall gauging systems are mostly antiquated or inadequate and in need of massive investment for upgrading and expansion. Modern techniques for rainwater harvesting and desalination process, for example, are almost non-existent in Africa. Research and technological innovation in these areas including water treatment and modern irrigation technologies are also under-funded, and under-supported in all but a few middle income countries in Africa.

64. In the irrigation sector, large scale mechanised irrigation systems are few and dispersed in Sub-Saharan Africa. Most African small-scale farmers still depend largely on rain-fed subsistence agriculture. Ever-expanding desertification and frequently recurrent droughts take a heavy toll on this rain-fed subsistence farming and add to chronic food deficiency in the continent. Also, large-scale commercial farming is still in rudimentary stages except in a few countries.

65. The concept of integrated development of shared-water resources, though promoted enthusiastically in the early years of independence, is yet to produce tangible results in most African transboundary river/lake basins. Of some 80 major transboundary river/lake basins in Africa, less than ten have formal intergovernmental mechanisms for integrated development of their water resources. Despite years of efforts, countries sharing some major river/lake basins in Africa like the Congo, the Nile, the Zambezi, Lake Victoria and others have not so far formalised such intergovernmental arrangements for co-operation among themselves for integrated development of water resources in these basins. A few basins where such mechanisms exist, both internal and external support for them dwindled over the years for various reasons. Concerted efforts and new innovative initiatives, like the present Nile Basin Initiative (NBI), by all stakeholders including the global funding agencies, are needed to revitalise and reinforce the existing co-operation mechanisms among the riparian countries [River/Lake Basin Organisations – (RBOs)] and to bring about similar mechanisms in other trans-boundary river/lake basins where such mechanisms presently do not exist. There is need in particular to create an enabling environment for trans-African water development and utilisation, especially through strengthening sub-regional arrangements and promoting and supporting new and emerging technologies, and introducing modern management and monitoring techniques.

66. The other major challenges facing African countries in the water sector relate to internalising the goals and objectives of Africa Water Vision 2025 which was incorporated in the Global Water Vision adopted in the Hague in March 2000. The goals and objectives of Africa

Water Vision need to be incorporated into national and subregional water development plans and programmes.

67. The Africa Water Vision Group (ECA, 2001) identified ten key objectives. These are:

(i) Ensuring that all have equitable and sustainable access to safe and adequate water supply and sanitation services to meet basic needs;
(ii) Ensuring that water does not become the limiting factor in food and energy security;
(iii) Ensuring that water for sustaining environment and life-supporting ecosystems is adequate in quantity and quality;
(iv) Reforming water-resources institutions to establish good governance and an enabling environment for sustainable management of national and trans-boundary water basins and for securing regional co-operation on water-quantity and water-quality issues;
(v) Securing and retaining skilled and motivated water professionals;
(vi) Developing effective systems and capacity for research and development in water and for collection, assessment, and dissemination of data and information on water resources;
(vii) Developing effective and reliable strategies for coping with climate variability and change, growing water scarcity, and the disappearance of water bodies;
(viii) Reversing growing man-made water-quantity and quality problems, such as over-exploitation of renewable and non-renewable water resources, and the pollution and degradation of watersheds and ecosystems;
(ix) Achieving sustainable financing for investment in water supply, sanitation, irrigation, hydropower and other uses, and for development, protection and restoration of national and trans-boundary water resources; and
(x) Mobilising political will, creating awareness and securing commitment among all with regard to water issues, including appropriate gender and youth involvement

68. Overall, the challenges facing the water sector are the following:

Water supply and sanitation

- Massive public and private sector investments
- Plans and programmes to provide these services as widely as possible
- Institutional mechanisms for cost recovery – user-pay principle with adequate regulatory measures to ensure the basic needs of the disadvantaged segments of the society
- Funding for proper maintenance, repair, upgrading and expansion
- Technical, scientific and educational facilities for training

Water resources assessment, quality monitoring and gauging networks

- Increased investment in these sub-sectors for maintenance, repair, upgrading and system expansion
- Adequate educational/training facilities
- Increased emphasis on research and development

Irrigation

- Expansion of irrigated agriculture to reduce food deficiency
- Promotion of small and large scale irrigation systems
- Promotion of public and private investments in the sub-sector
- Promotion of agriculture extension services

Trans-boundary water development.

- Promotion of inter-country co-operation
- Mobilisation of resources both from internal and external sources
- Creation of awareness on the benefits of integrated shared water resources
- Exchange of information, experience, best practices, etc.

African Water Vision for 2025 implementation

- Promotion of African Water Vision at all levels
- Incorporation of Water Vision in national and sub-regional planning strategies
- Increased investment

VI. OPTIONS AND PRIORITY ACTIONS FOR THE DEVELOPEMNT AND UTILISATION OF NATURAL RESOURCES

69. African countries must consider all options at their disposal to enhance their socio-economic development, in order to be more competitive in the global economy. Improved physical and natural resources infrastructure, such as transport, communication, information technology, health and environment facilities together with a conducive macro-economic environment would encourage the flow of FDI and facilitate regional and international private sector involvement. In turn, these will encourage undertaking of large-scale infrastructure programmes and projects such as multi-country irrigation and power generation and supply projects and joint venture mining projects. Such undertakings will enhance regional integration, provide more employment and contribute to raising the standard of living of millions of Africans.

70. To this effect, a number of priority actions should be considered:

- **Creating an enabling policy environment**

The enabling environment for foreign and domestic investments would include:

- Political stability;
- Improved legal and regulatory framework;
- Deregulation and liberalisation;
- Reducing complexity of bureaucracy;
- Strengthening financial institutions;
- Reducing inflation and real interest rates;
- Sufficient investment in human capital;
- Sufficient institutional capacity;
- Reducing the host country risk to entrepreneurs;
- Improving perceptions about Africa;
- Creating an appropriate fiscal regime; and

- Promoting flows of capital, skills and labour through elimination of barriers and greater regional integration.

- **Promoting good governance, peace and stability**

71. Democratic governance and political and social stability are necessary conditions for socio-economic development. Accordingly, Africa must establish a credible political track record and promote good governance, peace and stability. Achieving sustainable development and growth, including that of integrated management of natural resources, requires an environment where decentralisation of responsibilities, privatisation, beneficiary-community participation and increased role of women is promoted, and accountability, transparency and the rule of law ensured.

- **Strengthening human capacity building**

72. Human resources development is essential for natural resources development and management. There is need to develop a reservoir of skilled labour force and invest in people's education and training.

- **Improving supporting infrastructure**

73. To improve the quality and competitiveness of natural resources development and utilisation in Africa, particular attention should be given to enhancing infrastructure, notably in transport, communications and public utilities.

- **Improving technology acquisition and development**

74. In order for Africa not to lag further behind in the area of science and technology, there is need for a deliberate programme to enhance capacity and to internalise modern techniques and methods in the development and utilisation of natural resources. Such programme should have as a core, enhancing the capacity of learning and training institutions. Research and development assumes particular importance in this regard. Moreover, local research and development capabilities need to be strengthened and expanded with a view to increasing the rate at which natural resources are used domestically and exported with added value. In the case of small-scale mining, for example, there is need for developing appropriate technologies that should be simple to use, but effective in improving ore recovery, productivity and income, and reducing environmental impacts. In a wider context, efforts should be deployed to strengthen the regional Centres of Excellence that have already been established by African countries in various related areas.

- **Facilitating financial resources mobilisation**

75. Paucity of development finance is a crucial constraint to the exploitation and utilisation of natural resources. As official development assistance is stagnant or declining, alternative sources of financing need to be tapped, notably from the private sector. Additionally, regional development institutions such as the Southern African Development Bank (SADB), the West African Development Bank (BOAD), and the East African Development Bank (EADB), who are active in financing projects, are called upon to attach particular importance to financing regional infrastructure and natural resources development and utilisation projects.

- **Enhancing private sector participation, strengthening public-private partnerships, and optimising the role of governments**

76. African countries will need to create an enabling environment in order to encourage domestic and foreign private investment in the development of natural resources, science and technology so that they can operate efficiently. A productive and symbiotic relationship should be developed between the public and the private sector. Governments should take lead in creating basic infrastructure and an enabling environment for private sector participation in natural resources development.

- **Investment promotion**

77. Some investors have poor and uninformed perception of available investment opportunities in Africa. There is need therefore for concerted, focused and effective marketing campaigns. African governments would have to draw prioritised results-oriented action plans, specific to each country's needs and endowments. To this effect, information on Africa's natural resources endowments needs to be collected, collated and widely and cost-effectively disseminated to potential investors. This requires that connectivity is ensured and that data bases, meta-databases, and data exchange mechanisms are established and efficiently managed.

- **Mitigating environmental impact**

78. There is need to pay more attention to addressing the problem of environmental degradation caused in the process of exploiting natural resources. Firstly, practices leading to environmental degradation should be discontinued (for example coal-fired power plants should be progressively decommissioned). Secondly, use of environment-friendly techniques and technologies should be promoted. Thirdly, new corporate behaviour based on improved performance, better and more inclusive relationships and engagement with stakeholders should be instituted.

- **Addressing health issues**

79. The long-term implications of HIV/AIDS on the workforce represent another constraint that needs to be addressed. In the mining sector, for example, operating costs escalate because the social welfare and health care costs of employees are primarily the responsibility of the mining companies. Governments and the private sector have to articulate options to effectively reduce the spread of HIV/AIDS and minimise its impact on the economy.

- **Promoting regional co-operation and integration**

80. The utilisation and exploitation of natural resources should be pursued to the extent possible within a regional integration framework. Wider economic space and markets can provide impetus for the establishment of competitive industries and enterprises.

- **Fostering local participation**

81. Deliberate actions are needed to create vehicles that will facilitate local participation in the development process of African economies. This involves community participation, especially women, in the planning and implementation of projects and programmes. It is only through consultation with the communities that their needs and aspirations can be realised.

- **Defining new responsibilities for co-operating partners**

82. The development and utilisation of natural resources is an involved and costly undertaking. Hence the importance of partnerships with development partners, particularly the UN agencies, bilateral sources, and international and regional financial institutions. No doubt, the type of partnership and assistance required would vary from country to another. To have a consistent and productive partnership, a clear and transparent accountability framework should be agreed upon between the parties.

83. Partnership should to the extent possible be premised on:

- Enhancing the flow of foreign direct investment (FDI);
- Financing of core projects and programmes;
- Co-operation on the transfer of knowledge and technology;
- Enhancing private sector participation;
- Promoting capacity building and institutional strengthening, through:
  - Support to projects;
  - Exchange programmes;
  - Twinning schemes; and
  - Other collaborative arrangements.
- Establishing an agreed framework for co-operation
  - Between African countries (e.g. New African Initiative), through regional co-operation and integration (e.g. Africa Water Vision; SADC programme of action; electricity grids; ECA-sponsored institutions; etc.)
  - At the international level with multilateral and bilateral partners.

VII. ISSUES FOR DISCUSSION

84. The discussions should focus on the ways and means by which natural resources could be developed and utilised to enhance the welfare of the African people. They should help articulate a viable African Vision in this regard, given the emerging challenges of competitiveness and sustainability of the environment. The discussions should also help define the role of science and technology in this context and how national plans and programmes could be conceived optimally taking on board regional dimensions to overcome the problems of small economies. The policy and institutional implications should emerge with specified roles for all operators, notably the government and the private sector.

85. The issues for discussion could be captured in response to the following questions:

86. **Vision:** What should constitute the goals and objectives of Africa's campaign to develop and utilise its natural resources? Is there a need for a common African strategy? Can natural resources development be a basis for a solid African industrialisation programme? Hadn't import-substitution strategies been largely unsuccessful in the past? Should Africa, instead, focus on value-addition and export competitiveness to secure foreign exchange to develop diversified industries? How could efforts to develop small- and medium-scale enterprises in mining, energy and water be reflected in such a Vision?

87. **Competitiveness.** What does competitiveness in the area of natural resources mean, and what would it involve in terms of requisite actions? Is there a case for Africa's comparative advantage in natural resources? What are the parameters that relate to individual sectors, namely

water, energy and minerals? How could Africa's competitiveness be situated within the context of globalisation and WTO agreements?

88. **Science and Technology.** How could science and technology contribute to enhancing the availability, quality, productivity and competitiveness of Africa's natural resources? How does this relate to demand factors? Have African countries science and technology policies in place? How relevant or effective are Africa's R&D activities? How strong are national systems for innovation and technology development? How effectively are African patents and intellectual property rights protected? How successful has Africa been in transferring or adapting technologies critical to the development and utilisation of its natural resources? What are the efforts made to make society at large technologically literate? How strong or equipped are our institutions of research and application? Are these institutions matching those of competing countries in terms of capacity? Does Africa need to establish more science and technology-based institutions? What is the scope for twinning and partnership for the advancement of science and technology and its application in Africa? Science and technology can only be applied successfully where suitable legal, political and social institutional frameworks are in place (Mackined, 2001). What policies and structures need to be put in place in Africa? Where should priority lie?

89. **National policy issues:** What should constitute a conducive national policy environment for the development and utilisation of African natural resources? How should this policy vary from one sector to the other? How could the community at large be involved in policy-design? What needs to be done to ensure that macro-economic policy is supportive rather than constraining of natural resources development and utilisation? How could such policy be designed to contribute to alleviation of poverty in rural areas? How could national policies be geared to ensure conservation of these resources?

90. **Mega policy issues:** Africa is required to conform to standards relating to international commons such as the environment (United Nations Agenda 21). Is there necessarily a conflict between enhanced exportation and conservation of these resources? Most of the environmental problems in Africa, such as water and air pollution, soil erosion, deforestation and desertification, are associated with the abuse or overuse of natural resources. What natural resource management mechanisms should be put in place to address these problems? How could science and technology contribute to the success of such efforts and the maintenance of ecological balance? How could the overall policy be geared to promote the competitiveness of African products?

91. **Conflicts:** Natural resources have been at the centre of conflicts and civil wars in a number of African countries. Conflicts constrain utilisation of natural resources and discourage inflow of Foreign Direct Investment (FDI). Not only that they hinder development of the resources and lead to wasteful use of human and financial resources, but also result in perpetual tension between neighbouring countries. How could the scourge of conflict be eliminated? What common security arrangements could be put in place to protect natural resources development and utilisation from such threat? How could, for example, regional agreements be worked out to address resource scarcity, and especially in sharing water, as a possible cause of conflict?

92. **Institutional aspects:** How effective are the national institutional structures created to support natural resources development and utilisation? Are they inter-linked nationally and sub-regionally?

93. **Complementarity between the public and the private sector:** Who are the main development actors (locally, regionally and internationally) in natural resources development and utilisation? To what extent are they effectively resourced to discharge their responsibilities? What needs to be done to strengthen the capacity of these actors? How could the State be made capable?

What should be its niche? How could the private sector's role in natural resources be enhanced? How could symbiotic relationships between the public and private sector be promoted?

94. **Investment and finance:** Investment, both public and private, is key to enhancing capacity for development and utilisation of natural resources. Foreign Direct Investment (FDI) in particular constitutes a major source of technological diffusion and capacity building. What measures are needed to attract FDI? How could joint ventures between national and foreign investors contribute to the competitiveness and sustainability of African natural resources? What needs to be done to encourage regional and international finance institutions to contribute to financing regional projects? How could opportunity costs be paid to local communities to compensate them for utilisation of their proximate natural resources, particularly for mining purposes?

95. **Data:** Data are crucial for assessment of the quality of deposits and investment decisions. What new techniques need to be introduced to improve the quality of data? What mechanisms for data exchange should be put in place? What steps should be taken to increase availability of data, generate, collect, collate and disseminate new data? What role should the international community play to that effect?

96. **Regional integration:** Regional integration could help in overcoming problems of economic space and plant size. Are there any institutional arrangements in place to promote sub-regional co-operation in natural resources and science and technology development? What needs to be done to make them more effective? What process is needed to harmonise national plans for development and utilisation of natural resources with regional imperatives?

VIII. EXPECTED OUTCOMES

97. During CNRST-2, the participants are expected to engage in an in-depth analysis of natural resources development and management in Africa with particular emphasis on application of science and technology, including adaptation of new and emerging technologies in order to enhance their competitiveness in the global economy. The analysis is expected to lead to the formulation of concrete and actionable proposals and recommendations aimed at enhancing Africa's capacity in science and technology, and improving its competitiveness in all sectors. To this effect, the meeting will identify gaps and deficiencies and recommend sector-specific remedial measures. Such deliberations will help ECA to sharply focus its work programme in the area of natural resources development and utilisation. Within this context, concrete recommendations and views will emerge from the discussions.

98. The discussions should specifically ensure that:

- The role of science and technology for the development of natural resources in Africa is better defined;
- Information on new technologies for natural resources development is shared and disseminated;
- Factors affecting sustainable and competitive natural resources development are better understood;
- Factors affecting the competitiveness of African products and services are indicated;
- Niches where African countries can compete in global markets are proposed;
- An in-depth analysis of challenges and issues of natural resources, science and technology development affecting the competitiveness of Africa is carried out, and

gaps and deficiencies which hinder natural resources, science and technology development are identified;

- Strengths, Weaknesses, Opportunities and Threats (SWOT) facing the development and utilisation of natural resources in Africa are identified;
- Logical framework analysis (LFA) is carried out;
- Action Plan is defined with the main actors identified, their responsibilities clarified and a time frame for its implementation is established;
- Appropriate policy measures are outlined; and
- CNRST makes a contribution to the identification of priority areas for ECA's work programme.

Reference and Bibliography

Adeboye, T. (1997). "Models of Innovation and Sub-Saharan Africa's Development Strategy", in: Technology Analysis and Strategic Management, Vol. 9, No. 2, pp. 213-235.

Alioune, S (ed). (2000). "The Future Competitiveness of African Economies", Proceedings of the Dakar Forum, March 199, Future Africains, Abidjan,

Borg, G. (2000). " The application of new exploration techniques and geoscience databases within the new economic framework of African mineral exploration", SEAMIC

Carlsson, B. and Stankiewicz J. (1991) "On the nature, function, and composition of technological systems," Journal of Evolutionary Economics, 1(2), 93-118.

Chambers of Mines of South Africa. (1992). " Mining into the Next Century – Context for Survival and Grouth", Johannesburg.

Chender, M and Lowrey, J. (2001). "The Outlook for Primary Gold Production", Metals Economics Group.

Cho, S. (2000). "Development Finance in Africa: Required Resources and Financing Sources to Attain Overarching Development Goals," ESPD Working Paper 2000/4. Economic, Commission for Africa, Economic and Social Policy Division, Addis Ababa.

Christensen, J.L. (1993) "The Role of Finance in National Systems of Innovation" in B.-A. ERNST, Ganiatsos, D. T. and Mytelka, L. (eds) (1998). "Technological Capabilities and Export Success in Asia", U.K., Routledge.

Dosi, G. C., Freeman, G. Silverberg, and Soete, L. (1988) "Technical Change and Economic Theory". London (UK): Pinter Publishers.

Dosi, G., Pavitt, K. and Soete, L. (1990) "The Economics of Technical Change and International Trade". New York (NY): Columbia University Press.

Eaton, J. and Kortum, S. (1999) "International Technology Diffusion: Theory and Measurement," International Economic Review, 40(3), 537-570.

ECA (2000). "Compact for African Recovery - Operationalising the Millennium Partnership for the African Recovery Programme". Economic Commission for Africa, Addis Ababa

ECA (1999). "Growth Strategy for Africa: Lessons and Proposals." Background paper presented to the Ad-Hoc Expert Group Meeting on Growth Strategy for Africa, ECA/ESPD/EXP/O3/99 and ECA/ESPD/OP/05/99. ESPD, Economic Commission for Africa, Addis Ababa.

ECA (2001). "Transforming Africa's Economy: Overview" Economic Commission for Africa, Addis Ababa

ECA (1999). "Africa and the Multilateral Trading System and the World Trade Organisation: Seattle and Beyond." Economic Commission for Africa, Addis Ababa.

ECA (1999). "African Country Profiles: National Information and Communication and Infrastructures". DISD Economic Commission for Africa, Addis Ababa

ECA (1999). "Economic Report on Africa: The Challenge of Poverty Reduction and Sustainability". Economic Commission for Africa, Addis Ababa.

Edquist, C., ed. (1997). "Systems of Innovation: Technologies, Institutions, and Organisations". London (UK): Pinter Publishers.

FAO (1995). "Water Sector Policy Review and Strategy Formulation: General Framework", FAO land and water bulletin, Vol. 3, Rome.

Mytelka, L.K (ed.) "Competition, Innovation and Competitiveness" in For Analysis

Garelli, S. (2001). "Competitiveness of Nations: the Fundamentals", in WCY

Grossman, G. and Helpmann E. (1991). "Innovation and Growth in the Global Economy". Cambridge (MA): MIT Press.

IIMD. (2000). "World Competitiveness Yearbook", Lausanne, Switzerland, in Developing Countries, Paris, OECD, pp. 15-27

ECA (1998). "Issues and Options in selected African Countries". Publication No. FSSDD/Env/044/98/Rev. Economic Commission for Africa, Addis Ababa.

Kim, L. (1999). "Management of Technology in Developing Countries: Lessons for Africa". A paper produced for ECA in the framework of "Visiting Scholar" scheme. Economic Commission for Africa, Addis Ababa.

Kim, L. (1980). "Stages of Development of Industrial Technology in a Developing Country: A Model", Research Policy, 9, pp. 254-277.

Kim, L. (1991). "Pros and Cons of International Technology Transfer: A Developing Country View" in Tamir Agmon and Mary Ann von Glinow (eds.), Technology Transfer in International Business, Oxford University Press: New York, pp. 223-239.

Kim, L. (1993). "National System of Industrial Innovation: Dynamics of Capability Building in Korea," in Richard R. Nelson (ed.), National Innovation Systems: A Comparative Analysis, Oxford University Press: New York, pp. 357-383.

Kim, L. and Dahlman, C. J. (1992). "Technology Policy for Industrialisation: An Integrative Framework and Korea's Experience", Research Policy, 21, pp. 437-452.

Kim, L. and Hosun L. (1987). "Patterns of Technological Change in a Rapidly Developing Country: A Synthesis," Technovation, 6, pp. 261-276.

Kim, L. and Youngbae K. (1985). "Innovation in a Newly Industrialising Country: A Multiple Discriminant Analysis," Management Science 31, pp. 312-322.

Kim, L. (1997). "Imitation to Innovation: The Dynamics of Korea's Technological Learning", Harvard Business School Press: Boston.

Kortum, S. (1997). "Research, Patenting, and Technological Change," Econometrica, 65(6), 1389-1419.

Lee, J. B., Zong-Taeand, C. and Dong, K. (1988). "Technology Development Processes: A Model for a Developing Country with a Global Perspective," R&D Management, 18, pp. 235-250.

Lundvall, B. A. (1988). "Innovation as an Interactive Process: From User-Producer Interaction to the National System of Innovation," in G. Dosi, ed., Technical Change and Economic Theory. London (UK): Pinter Publishers: 349-369.

Makinda, S. (2001). "From Natural Resources to National Wealth: Ethical National Interest and Policy Issues for Africa in the New Millennium", UNEP, UNU/INRA Annual Lectures 2000, UNU/INRA

McMullan, S.R. (2000). "New technology for data dissemination", SEAMIC

Metals Economics Group (2001). "Corporate Exploration Strategies."

Mikesell, R.F. (1997). "Explaining the resource curse, with special reference to mineral-exporting countries", in: Resources Policy, Vol. 23, No. 4, pp. 191-99.

MINTEK (2001). "Resource Based Sustainable Development"

Mirko,B., (1992). "Global Economy in the Age of Science-based Knowledge", UN, New York,

Mowery, D. and. Rosenberg, N. (1998). "Paths to Innovation". Cambridge (UK): Cambridge University Press.

Mytelka, L.K (1999). "Competition, Innovation and Competitiveness: A Framework"

Mytelka, L.K, (1991). "Crisis, technological change and the strategic Alliance" in L. Mytelka (ed). Strategic Partnerships and the World Economy, London, Pinter Publishers.

Nelson, R. R., ed. (1993). "National Innovation Systems: A Comparative Analysis". New York (NY): Oxford University Press.

Niosi, J., ed. (1991). "Technology and National Competitiveness: Oligopoly, Technological Innovation, and International Competition". Montreal (PQ): Mc-Gill-Queen's University Press.

Oud, E. and Muir T.C., (1997). "Engineering and Economic Aspects of Planning, Design, Construction and Operation of Large Dams Projects", Proceedings of the Workshop on "Large Dams: Learning from the Past, Looking at the future"

Ovadia, D.C. (2000). "The contribution of Geoscience Information to Economic Development". SEAMIC

Oyeyinka, B. and Pack, H. (1994). "Productivity and Industrial Development in sub-Saharan Africa", in: World Development, Vol. 23. 1994, pp.1-10.

Patel, P. and Pavitt, K. (1994). "National Innovation Systems: Why They Are Important, and How They Might Be Measured and Compared," Economics of Innovation and New Technology, 3(1), 77-95.

Pedro, A.M.A. (2001). "Good Governance in Geoscience Data Management: An Investment Tool". SEAMIC

Porter, M., (1985). "Technology and Competitive Advantage," The Journal of Business Strategy 5, no. 3 (Winter).

Porter, M., and Gregory C. B. (1999). "Innovative Capacity and Prosperity: The Next Competitiveness Challenge," in The Global Competitiveness Report 1999, Geneva, Switzerland: World Economic Forum.

Porter, M., and Rebecca E. W. (1995) "Global Competition and the Localisation of Competitive Advantage," published in Proceedings of the Integral Strategy Collegium, Graduate School of Business, Indiana University, JAI Press, Greenwich, Connecticut.

Porter, M.,(1998). "Competitive Advantage: Creating and Sustaining Superior Performance", New York: The Free Press, Republished with a new introduction.

Porter, M., (1998). "Competitive Strategy: Techniques for Analysing Industries and Competitors", New York: The Free Press, Republished with a new introduction.

Porter, M. (1998). "On Competition". Boston, Harvard Business School Press.

Porter, M., Scott S., and Jeffrey L. F. (1999) "The Determinants of National Innovative Capacity," Harvard Business School Working Paper 00-034.

Sasol, (2000). "Adding value to life"; Sasol annual report.

Donkor S. and Wolde, E. Y. (1999). "Integrated Water Resources Management".

Sakakibara, M. and Porter M. E. (2000). "Competing at Home to Win Abroad: Evidence from Japanese Industry," Review of Economics and Statistics, forthcoming.

Solomon M.H. (2000). "Growth and diversification in mineral economies, Planning and incentives for diversification", UNCTAD.

Solow, R. M. (1956). "A Contribution to the Theory of Economic Growth," Quarterly Journal of Economics, 70, 65-94.

UNCTAD (1999). "World Investment Report". Geneva.

UNDP, UNDESA and WEC (2000). "Energy and the Challenges of Sustainability, World Energy Assessment".

UNCTAD. (2000). "World Investment Report". Geneva.

UNDP (1998). "Human Development Report", New York: Oxford University Press.

UNDP. (1999). "Human Development Report", New York: Oxford University Press.

ECA, AfDB, and OAU (2001). "Safeguarding Life and Development in Africa: A Vision"

ECA, WMO (1995). "African Conference on Water Resources"

UNEP (1997). "Global Environment Outlook. Global State of the Environment Report".

UNEP, UNDP, WB, (1998). "African Water Vision, 2000"

UNESCO. (1998). "Statistical Yearbook", Paris.

UNESCO. (1998). "World Science Report", Paris.

UNESCO (1970). "Statistical Yearbook", Paris.

UNIDO (1998). "Domestic Capacity-Building for Enhancing Productivity and competitiveness in Africa", Vienna.

UNIDO (1996). "Technology and Competitiveness: Development of Technological Capabilities". A Technical Paper presented at the Regional Meeting Ministries for Industry in Latin America and Caribbean Countries.

UNIDO (1999). "African Industry 2000: The Challenge of Going Global", Vienna.

United Nations, (1970). "Natural Resources of Developing Countries: Investigation, Development and Rational Utilisation", Report of the Advising Committee on the Application of Science and Technology Development. United Nations Headquarters, New York.

Utterback, J. M. (1994). "Mastering the Dynamics of Innovation", Harvard Business School Press: Boston.

World Bank, (1990). "Strategy for African Mining" Technical Paper No. 181.

World Economic Forum, (1998). "The African Competitiveness Report", Geneva.