MINERAL RESOURCES FOR LIFE SUPPORT

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Summary

It is acknowledged that never before has humankind been at crossroads such as that facing us at the beginning of the twenty-first century, where our own expansion and our own success as the dominant species is threatening our very survival. This reasoning unfolds in such a way that a change of course is now urgent and inescapable. The misuse of ecosystems, the depletion of natural resources, and worldwide environmental problems, which serve as a backdrop for a world rampant with poverty, injustice, disease, and war, are firm evidence that the understanding of development in terms of the values on which the current paradigm is based, is a dead-end road.

During the 1970s, many efforts were made to forecast scenarios of supply and demand of minerals, including fuel, for the next 100 years. A fear of shortage of important raw

materials was present in many scientific meetings held worldwide. Fortunately, those expectations were wrong as far as we can see 30 years later. If we consider global trends for the improvement of conservation policies, recycling of materials in general, materials-saving design, miniaturization, and other technological advances, there is no fear of scarcity of minerals in the next 100 years. Apparently, there is no well-founded reason to expect scarcity of minerals as announced by the Club of Rome report back in 1972.

It is quite obvious that recycling and sustainability follow converging paths, guaranteeing the future availability of materials. Most metals at the beginning of the twenty-first century have a significant part of their supply through recycling, varying according to each country and its particular economic development stage. In most applications, recycling provides environmental benefits in terms of energy savings, reduced emissions associated with energy savings, and reduced volumes of wastes.

For over a century the mining industry has posed some problems to the environment, in spite of numerous efforts developed by companies for avoiding them. Each country has its own legislation in order to establish rules and procedures to be followed by all mining firms. The reaction to the old behavior concerning the exploitation of natural resources was embodied in the concept of "green accounting," meaning that national income accounting conventions should reflect adequately the services provided by environmental assets, ecological services, and the depletion of natural resources.

There is a universal trend in academia to agree that issues related to geological features, ecological systems, and life support should be addressed holistically. In this context, biocomplexity emerges as one of the answers to fill the gap. It refers to phenomena that arise as a result of dynamic interactions that occur within biological systems, including humans, and between these systems and the physical environment.

The major concern regarding minerals and life-supporting systems relates to two basic issues: resources shortages, and uneven distribution. However, this discussion is not restricted to minerals or energy, but more open to the availability of food, shelter, health, potable water, sanitation, education, job opportunities, and other items that are necessary to assure a minimum quality of life for any person in any tract of this planet. The great challenge of the twenty-first century will be to find an acceptable way to reduce the disparities that marked humankind in the preceding centuries. This means converting the availability of natural resources into an effective supply to those who need them at a fair cost. Last, on a higher level, the greatest challenge of our times is to make sustainable the unsustainable Earth 's system, as we know it from our past experience.

1. The Sustainability Concept and Economic Thought

There are different interpretations of the conceptualization and role of sustainability or sustainable development as a goal to be attained. Several authors have been concerned to find a definition with which both economists and biological and geological scientists are comfortable, provided that the ideas and intuitions linked to sustainability represent a real set of concerns which need to be addressed.

The concept of sustainability is not new. As early as in 1972 Herrera et al. emphasized that:

"*...underdeveloped countries cannot advance by retracing the steps of...the developed countries...it would imply repeating those errors that have led to...deterioration of the environment...The solution...must be based on the creation of a society intrinsically compatible with its environment*."

Later, the Brundtland report produced the following widely quoted remark:

"*Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs*."

The concerns expressed in Bariloche and Brundtland seem to be twofold:

- recognition of the long-run impact of resource and environmental constraints on patterns of development and consumption;
- concern for the well-being of future generations, particularly in so far as this is affected by their access to natural resources and to environmental goods.

We should remember that at the dawn of modern microeconomics, Hicks defined income as "the maximum amount that could be spent without reducing real consumption in the future." It is clear that there is a concept of sustainability here, showing points of contact with the Brundtland report's concern. So, in Hicksian terms, Brundtland may be simply saying that we, the present, should consume within our income. However, for this to be true, the concept of income involved would have to be a sophisticated one indeed, encompassing income of all types, psychic as well as monetary, from environmental assets, and adjusting monetary income to allow for the depletion of environmental assets. This observation naturally raises the issue of "green accounting"—national income accounting conventions, which reflect adequately the services, provided by environmental assets and the depletion of natural resources. Developing a satisfactory set of conventions in this area is intimately linked to provision of a satisfactory definition of sustainability.

One of the major issues at the brink of this new millennium is, as expressed by Elizabeth Dowdeswell, Executive Director of UNEP:

"*Will society, through the state, the entrepreneurial sector and other social sectors, be able to forge a new culture that is more altruistic and equitable to replace our society of superfluous consumption and inequitable holdings of land and resources, where the short-term earnings of the few prevail over the integrity of nature and the well-being of present and future generations?*"

A majority of thinkers and decision makers recognize that never has humanity been at such a crossroads, where its own expansion and its own success as the dominant species is threatening its very survival. This means that a change of course is now urgent and inescapable.

In order to make these changes happen, there are three myths to be overcome.

The first myth is that sustainable development is really the same old development-plus-growth model clothed in green. Environment is all-inclusive, encompassing the socioeconomic as well as the physical environment. Besides, development policy, if it is to arrive at satisfactory solutions to environmental and resource problems, cannot rely on incremental or piecemeal approaches. It is true that such approaches may buy us time. But for long-term solutions, integrated and structural approaches are imperative.

Envisaging a future that will ensure production to meet the needs of the growing population, safeguard environmental values, and review consumption trends requires, first and foremost, an in-depth analysis of our old concepts of development.

The reductionist framework of conventional economics has given rise to misguided economic policies. Their essence is the attainment of economic growth, a quantitative increase in production, which has become identified with "development."

The misuse of ecosystems, the depletion of natural resources, global environmental problems, which serve as a backdrop for a world rampant with poverty, injustice, disease, and war—all too familiar to us—are firm evidence that development understood in terms of the values on which the current paradigm is based, is a dead-end road.

The goal of the new economic thought is to achieve development. Nevertheless, the concept of development is taking on new meaning. It no longer refers simply to maximizing production and consumption—which frequently means pollution and the plundering of natural resources—but rather to the optimum attainment of human well-being maximizing potential.

The new development approach entails a different perception of the relationship between society and nature. It is a shift towards a new worldview that demands a profound change in values.

After two decades of efforts to draw up specific policies to protect the natural environment and improve the quality of life, we require innovative socioeconomic solutions driven by environmental policies. We must identify new ways to modify lifestyles and induce behavioral changes. In addition, institutional mechanisms, domestic and international, must be restructured to make these changes a reality.

Perhaps the greatest challenge in realizing this new "development" is the challenge of modifying the attitudes of producers and consumers to recognize the future that increasing scarcity of resources and expanding population growth will bring—and to seek creative solutions. Evolution towards more frugal societies (some would say more responsible societies) and more vulnerable and interdependent economies is to a large extent dependent on the possibilities for profound social, economic, and institutional change.

The second myth is that sustainable development can be achieved without fundamentally affecting people's lifestyles. We have yet to fully understand the social and ecological limits of economic growth and consumption. But it should be obvious that some forms of consumption behavior are incompatible with the sustainable development concept).

Can we translate this awareness into practical measures in environmental management and economic policy without affecting the required quality of life? Change is not automatically negative but, clearly, it will require from us all comprehensive measures that would reflect the full cost of environmental damage. It is also a question of directing change now or suffering the consequences later.
Sustainable consumption embraces ideas and practices such as pollution prevention, cleaner production, clean technology, waste minimization, recycling, resource conservation, eco-efficiency, eco-labeling, and preservation of biodiversity. However, it also focuses on strategies and actions that define the market forces and systems, implying a redefinition of relationships between people and the products they consume and their habits and practices. Therefore, on a more fundamental level, sustainable consumption implies a change in the global economy, sociocultural values, and economic relationships between the North and the South Hemispheres as well as within all societies.

Just one example will suffice—the manufacture of the automobile, a symbol of mobility and affluence. Manufacturing a car requires metals like steel, copper, and aluminum. It also requires plastics, rubber, water, and chemicals. Obtaining the iron ore requires mining, smelting, and cooling. Petroleum that fuels the car requires oil wells and refineries. Driving the car requires roads. Roads require land. Every time it is driven, the car emits a range of harmful pollutants. And when the car reaches the end of its useful life, it has to be disposed of, creating even more environmental problems. But this is not all. Individual use of cars requires thousands of times the resource that the more efficient mass transportation systems use.

Sustainable consumption is much more than choosing an "environmentally friendly vehicle." We are already living in a time of environmentally driven change. Recognition of the limit of Earth's carrying capacity will lead inevitably to long-term structural economic change. Artificial low prices for resources cover up severe environmental stress at both ends of the materials cycle—production that should not have been necessary and disposal of materials that could have been used again. Our purpose is to redefine not only the goals of industrialization itself but also its attendant ramifications such as urbanization, transportation, energy, land use, and their relationship to broader societal concerns.

Gunnar Myrdal wrote in 1975:

"*All the talk about a new international economic order without changing lifestyles in the developed world is just humbug*."

And the third myth—sustainable consumption only affects those in developed countries. There is a notion that consumers in the North can alter and reduce resonance

consumption input without affecting the economies, resource allocation, price structures, and so on of the South. This logic ignores the compact of stronger economic and production links between North and South (especially with respect to durable goods). Given the real globalization of economic markets, any significant change in Organization for Economic Co-Operation and Development (OECD) countries cannot take place in isolation.

More and more countries are being drawn into trading networks as producers and consumers of goods on a worldwide scale. The global proliferation of industrial systems means that there is no prospect for any nation–state insulating itself from changes in the economic climate, from global change, major pollution flows, and from the actions of international actors, such as the multinational corporations.

And, this process of globalization is not complete. Expansion in world trade has yet to encompass hundreds of those who live on the margins of the industrialized world. Like inequality, patterns of unsustainable consumption are not limited either to the North or the South. They manifest themselves in contrasting patterns within the geographical boundaries of individual nation–states, between regions, between urban and rural areas, and between the lifestyles of the rich and the poor. Just consider the replication of unsustainable patterns of development in rapidly industrializing countries. Yes, changes in consumption and production patterns need to start in the North, but we need to broaden the scope of the debate options to include the perspectives of the South.

There will be implications for trade flows, upstream resource extraction, development and employment. It seems wishful thinking to expect that any real changes can occur in consumption patterns also affecting core economic issues.

Let's consider three implications.

First, what are the implications of cleaner production methods on developing countries? Although sustainable consumption places considerable premium on eco-efficiency, some empirical work by the United Nations Conference on Trade and Development (UNCTAD) suggests that developing countries are at a disadvantage in implementing cleaner production, because of questions of scale, higher capital and operating costs, etc.

Second, what are the implications in terms of investment flows? It remains unclear how private markets will respond to this policy call. Analysis by the United Nations Environment Programme (UNEP) suggests that equity finance remains largely indifferent to environmental technologies. Hence, there is some real work to be done in looking at links between capital markets, debt finance, and longer-term targets associated with sustainable consumption.

Third, what are the effects of integrated "green budgets"? Experience suggests that there is little to be gained from shifts in market signals to sustainable consumption patterns, if gross environmental distortions remain in other core areas, including monetary policy, subsidies, transport, and other areas. This whole complicated area brings in the question of pricing reforms, and the implications of market-based instruments on developing countries—both in terms of trade and market access issues (when used in OECD

countries and applied to imports from less-developed countries), as well as applicability of market-based instruments in developing countries, which do not have formalized markets.

Some regard international free trade agreements with suspicion on the grounds that they promote "harmonization" of national standards by reducing the lowest common denominator, rather than seeking a general increase in quality thresholds. There is agreement that the problem of the balance between trade liberalization and restrictions based on the need for sustainability is immensely complex. Restrictions on trade could be claimed on environmental grounds as a convenient excuse for protectionism.

So, building sustainable consumption and production patterns globally is a task of immense complexity. It means changing the underlying economic principles, including the relationship between the North and the South in a cooperative long-term endeavor. It means examining our societal goals and lifestyles, and injecting an ethical perspective into our actions. It means living within the ecological limits of our planet and the social limits of society. It means reducing our "footprint" on Earth.

It may not be fashionable to say so, but, ultimately, the question of achieving and maintaining sustainable patterns of production and consumption hinges on the fundamental dimensions. We have to ask ourselves simple but fundamental questions: How should we live? How much is enough? What way of life ought human beings to pursue? Simple questions are often the most profound, for they challenge the security of our accustomed norms. We have to develop the ecological holistic worldview, which connects us with our environment and other people and species—both materially and spiritually.

2. The Balance between Supply and Demand in the Next 100 Years

Since 1985, the balance between supply and demand for minerals has been established more effectively than in previous periods. This equilibrium can be explained by the simultaneous action of several factors: (a) a trend to oversupply of most minerals as related to global consumption; (b) the surge of new producers from developing countries eager to find a niche in the market; (c) the expansion of mines, plants, and smelters located in traditional producer countries, aiming at gaining a better position regarding market-share; and (d) the declining intensity of use of basic materials by industrialized countries, shifting to a service economy pattern. There are no significant signs that this situation can reverse to a pattern similar to those prevailing in the post-World-War-II period, when high rates of consumption were quite common.

If we consider global trends for the improvement of conservation policies, recycling of materials in general, materials-saving design, miniaturization, and other technological advances, there is no fear of scarcity of minerals until approximately AD 2080–2100. It is very important to consider the efficiency of new techniques (including geophysical, geochemical, and remote-sensing tools) used for exploration in the five continents, and also the exploration of seabed deposits even at great depths, far from the coastline.

From the consumption side, the industrialized countries have dramatically reduced their

consumption per capita (intensity of use) since AD 1980. Developing countries have had historically higher rates, for example in Southeast Asia and to a lesser extent in Latin America. Even if China resumes its higher consumption rates, it is foreseeable that the supply would be adjusted to cope with new demands. Apparently, there is no well-founded reason to expect scarcity of minerals as announced by the Club of Rome report in the 1970s.

Fossil fuels provided energy for the Industrial Revolution, which changed the face of the planet and the lives of its inhabitants. Humans are indebted to the abundant supply of fossil fuels provided by nature and those people who dedicated their lives to the discovery and development of these natural resources. Crude oil is the source of 38% of the world's energy at the beginning of the twenty-first century. Coal and natural gas provide 25% and 22% of world energy, respectively. Thus, fossil fuels account for 85% of the world's energy supply. Fossil fuels have been an inexpensive energy source for the entire twentieth century. At the turn of the century, these fuels are coming under increasing attack as atmospheric pollutants and contributors to possible global warming by increasing the so-called greenhouse effect. The twenty-first century will see an irreversible change in world energy supplies, which will lead to alterations in the lifestyles of most of the world's population. The most important point is the forecast that world crude oil production will peak at 90 million barrels per day (33 billion barrels per year) in AD 2020. In decreasing order, the sources of world energy in AD 2100 will probably be combined renewable sources, coal, nuclear, unconventional oil, hydroelectricity, natural gas, and conventional oil. It is becoming predictably clear that consumption of oil and gas as fuels will last only until AD 2100.

Coal, because of its great availability at a competitive price and its high heating value (3.5 barrels per ton of oil equivalent), will probably continue to be used despite its negative environmental effects. World coal production could remain constant or increase to 10 billion tons per year by AD 2100. China's abundant coal reserves will be predominant in its energy matrix; China is expecting a 160% increase in energy between AD 2000 and AD 2030.

World unconventional crude-oil resources in natural asphalt deposits (tar sands), heavy oil deposits, and oil are huge. Potential economically recoverable oil from Canadian tar sands is estimated to be approximately 300 billion barrels of oil. The Orinoco heavy-oil belt in Venezuela is estimated to have 270 billion barrels of recoverable oil from an in-place resource of 1200 billion barrels of oil. World oil shale in-place resources are estimated to contain over 2000 billion barrels of oil technically recoverable oil from greater than 30 gallons per ton of rock, though it is predicted that recovery costs may exceed US$50 per barrel.

Even though natural gas is recognized as a cleaner fuel than coal or oil, world natural resources are not yet fully used. Natural gas production can increase significantly by AD 2030 by constructing major new pipelines and liquid natural gas tankers. Gas hydrates in the oceans and arctic tundra could double the reserve if these hydrates could be produced profitably.

3. The Production and Consumption Trends of Poor Countries

Despite vast geological resources, including minerals, African countries, for instance, have not been able to take advantage of their mineral resources for their own socioeconomic development because of financial and technological limitations. It has been an old refrain that African governments are not utilizing their local geological experts. Here, and in most countries, the main reference institution in the mineral industry is the geological service. Most African geological surveys are not doing what they are supposed to. They are not mapping and 95% of their geological reports are old and based on old geological concepts. Almost all these institutions have budgets that are far too small to run their geological activities.

The Geological Society of Africa (GSAf) has initiated a partnership between the industry, academia, and government institutions dealing with the mineral industry. Its objectives have been redefined, so that emphasis shifted to solving societal problems. The new objectives include provision of sufficient earth resources, such as water, energy, and minerals, to African communities. GSAf also deals with quality education and research in geosciences and environmental issues.

During the 1990s, the GSAf started updating the geological maps of Africa by publishing articles and maps in its official journal, *The Journal of African Earth Sciences*. Training workshops are being conducted in different parts of the continent to disseminate modern concepts and techniques in the mineral industry. International bodies such as UNESCO and UNEP have been approached for collaboration in one of several major projects on sustainable development and management of African earth resources. The response has been good and projects are being undertaken in different regions of the continent.

Africa has the world's largest reserves of strategic minerals such as chromium, with 82% of the world's known reserves, cobalt 54%, manganese 52%, and uranium 29%. Africa also has 76% of the world's phosphates and 39% of industrial diamonds. South Africa alone produced 23% of the world's gold output in 1995. Africa produces 7800 thousand barrels daily of oil and 129.5 billion m^3 of natural gas.

The main problem in developing these resources in Africa is represented by lack of capital and market access for their products. Africa does not have the appropriate technology, experience, and capital to inject into the mineral industry. The market also faces the problem of powerful monopolies; for example, the diamond business is controlled by De Beers, while gemstones have no reliable pricing and markets. However, these problems could be solved if multinational companies got involved in the tapping of Africa's earth resources and African governments made sure that their countries benefited from these multinational companies.

It is expected that Africa's earth resources could contribute substantially to the rapid and stable economic growth necessary for the eradication of poverty on the continent. About 40% of the continent's population falls into the category of absolute poverty. This means that these people are earning less than a dollar a day, according to UN classification. The economic growth of most African countries in 1999 was about 2–4%. Economists argue that an economic growth rate averaging 5–7% a year is necessary to reduce

poverty among African nations.

In addition, agriculture—the main occupation in Africa—is not performing well. The industrial sector is in its infancy and is not competitive. Consequently, the earth resources of Africa are the key to sound economic growth and eradication of poverty on the continent.

Geological authorities expect that the GSAf has a special role in ensuring the full involvement of earth scientists in the development of the mineral sector. First, its objectives have been redefined to be relevant in this millennium. Second, it has a good communication network for dissemination of information among grassroots members in different parts of the continent. There is a journal, *Africa Geonews*, which is published twice a year. The official scientific journal, *The Journal of Africa Earth Sciences*, is internationally recognized. A website has been established and can be accessed at <www.elsevier.nl/locate/gsa>. Third, international and regional meetings and training workshops have been organized in different parts of Africa. Thus, the active grassroots members are fortunately aware of the new developments in geosciences and in the mineral industry in Africa.

There are considerable mineral and energy resources in East Africa. These deposits can be easily understood if placed into age brackets. Those terrains that are 2500-million–3000 million years old are endowed with gold and base metals such as lead, copper, and zinc and are found around Lake Victoria—Mwanza, Musoma, Tarime, Migori, and Kisumu. There are diamonds in the 65-million–145-million-year-old kimberlite pipes, most of these in Tanzania. The 1600-million–2500-million-year-old soils contain gold, lead, zinc, chromium, nickel, titanium, iron, manganese, copper, arsenic, and antimony. These are found in southwestern Tanzania around Lake Tanganyika. The 900-million–1600-million-year-old terrain in northwest Tanzania and southwest Uganda is rich in cobalt, nickel, copper, tin, tungsten, niobium, and tantalum. The 550-million–900-million-year-old terrain is ubiquitous in eastern Tanzania, northeast Uganda, and southeast Kenya. The longest portion of this belt is in Tanzania and that is why Tanzania is the leading producer of gemstones in East Africa.

The three East African governments have managed to attract major multinational companies, putting in place conducive investment environments. However, it is still necessary to improve the means to attract more capital investment, including resuscitation of national geological surveys and establishing reliable databanks. Africa currently accounts for 17% of the world's exploration expenditure, which was about US$610 million in 1998.

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