Sustainable Development : Mining and Metals Sectors

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ABSTRACT

The United Nations Conference on "Human held Environment" in 1972 has changed our perception of development. It is now recognised that development should include not only the economic well-being but should also take into account the social and environmental welfare with the creation of appropriate institutional infrastructure. The evolution of such a sustainable development is discussed along with a brief report of the activities in India. The specific case of sustainable development of the mining and metals sector is considered.

The concept of sustainable development is of recent origin. However, it has now taken root and governments all over the globe are making sincere efforts to devise suitable methods and enact appropriate legislation to ensure sustainable development. This paper reviews the concepts, methods of implementation and indicators for sustainable development. In this context, the problems and the performance of mining and metallurgical sectors are then considered.

Key Words : Sustainable development, Indian scenario, mining and metals sectors, social and environmental welfare, recycling, energy issues.

SUSTAINABLE DEVELOPMENT

Poverty in many countries arises from lack of capital, absence of human resource, outdated production methods, governments that do not provide appropriate conditions for production and political instability. Poor communities have to depend on common resources such as forests for food and fuel, and ponds and rivers for water. Inadequate replenishment of water and deforestation lead to contamination of water and exhaustion of resources from the forest. This in turn leads to decease and reduced life expectancy. Indirectly these conditions contribute to uncontrolled population growth due to fear of child mortality and because of the use of children for daily chores of collecting wood and water. A vicious circle of population growth, poverty and environmental degradation is thus set in motion. Recognising this, economists have now moved away from the traditional concept of capital and now consider capital to be made up of monetary and non–monetary components. The resources such as human-made goods and services form the human–made capital. Natural resources such as forests, water sources, mineral deposits along with biodiversity, ecological systems etc., form the natural capital. Human resource with their skills, education and health constitute the human capital, which is capable of generating products and services. Since the stability

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of the governments and political systems depend greatly on the social networks that exist, social trust, norms and networks such as cooperatives, associations, unions that help solve common problems constitute a social capital.[1]

In the earlier period, when only the first of the four types of capitals was taken into account and the importance of clean air and water, abundance of forests and biodiversity, human health and well being were neglected, economic development was lopsided. There was a total neglect of human and natural resource conservation. Humankind has so far transformed, degraded or destroyed about half of the forests and uses half of all the primary produce of the earth. We use most of the fresh water and consume the fish production of the oceans. This has affected the biodiversity very adversely and it is estimated that about 27,000 species on an island are lost annually.[1] Besides the already cited causes, human-made pollution and consequent climate changes have increased the rate of extinction of natural species. The realisation that the natural species are interdependent and that elimination and/or addition of species to the system will be detrimental to our own survival, it is now recognised that the present social organisation and the nature of technologies used are not conducive to balanced development. For example in the present social milieu, there is a growing demand for energy and rapid consumption of fossil fuels. The available technologies for the utilisation of renewable energy resources such as sunlight and wind are considered to be too inefficient for profitable use. Sections of society that are extremely wealthy consume and waste resources to the detriment of others. At the other extreme poorer sections, as already discussed, contribute to degradation of the environment by their over dependence on common resources. These considerations have called for a redefinition of development.

Thus, in the 1972 United Nations Conference on Human Environment, the concept of Sustainable Development was introduced. It was defined in the report of the World Commission on Environment and Development chaired by Prime minister of Norway Mrs. Gro Harlem Bruntland and called "Our Common Heritage"(the Bruntland Report, 1987).[2] Sustainable development is development that meets the "needs of the present without compromising the ability of future generations to meet their own needs". In other words it is " a process of change in which the exploitation of the resources, the direction of investments, the orientation of technological development, and institutional change are all in harmony and enhance both current and future potential to meet human needs and aspirations". Sustainable development is, therefore, concerned with the well being of not only the humankind but also the environment in which we exist. Human activities have to be viewed not only from the benefits that they bestow on the community but also in terms of the effect they have on the environment. These can have an impact on the environment in many ways and to different extents.[3] Human activities, including the technological ones, may cause emissions, disrupt the environment, fragment ecosystems and cause exhaustion of natural resources and species of biodiversity. The damages can be local or global. The former affects only those within the range of the event and contribute to pollution of water and air, lead to the accumulation of solid and hazardous wastes and cause scarcity of natural resources at the local level. In the category of global damages we have the

phenomena of ozone depletion, greenhouse effect, climate changes brought out by deforestation etc. It is also recognised that the number of people involved in a given activity and the way the activity is carried out are equally important.[3] For example, the numbers of people using cars, the amount of fuel consumed by the car and the way the car and the metals for the car are produced have an impact on the environment. Thus a close relationship exists between human activities, needs and the environment. This interrelationship depends on population, material welfare, intensities of production and consumption and the cultural habits created by the mode of production. These and the prevailing political system, type of technology employed and public choices form the barriers for sustainable development.

As defined, sustainable development seeks to establish inter-generational equity. Future generations should not be deprived of resources and wealth because of unsustainable levels of consumption by the present generations. The available resources must be conserved and exploited to yield maximum economic benefit with appropriate management and socio-cultural performance. Consequently, progress towards sustainable development is often discussed under the broad aspects of social, natural resource, economic and institutional framework. Since we are concerned with sustainable development in the mining and metals sector, we shall confine ourselves to the natural resource aspect of sustainable development and consider the environmental issues.

The Bruntland report, which formulated the concept of sustainable development, does not speak of the means for its implementation. It recognises that there cannot be a single blueprint for its implementation. The paths will vary due to societal and political systems in place. Agenda 21 adopted at the United nations Conference on environment and development held in Rio de Janerio, Brazil in June 1992[4], states "Experience has shown that sustainable development requires commitment to sound economic policies and management, an effective and predictable public administration, the integration of environmental concerns into decision-making and progress towards democratic government, in the light of country-specific conditions, which allows for full participation of all parties concerned." Amongst many other recommendations, it urges the governments to a) make international trade and environment policies mutually supportive in favour of sustainable development and b) encourage international productivity and competitiveness and a constructive role on the part of the industry in dealing with environment and developmental issues.

METHODS OF IMPLEMENTING AND MEASURING THE PROGRESS OF SUSTAINABLE DEVELOPMENT

The concepts involved in sustainable development are:

- Equity between inter- and intra-generation
- Economic growth with equal opportunities for all
- Provision of basic needs for a better life to all citizens
- Development without destruction of ecosystems

Minimisation of the negative impacts on the environment with proper planning and with the aid of suitable technologies.

In order to achieve these objectives development policies must ensure sufficient growth in the per capita, increase the export potential of the goods manufactured, generate jobs, power, provide basic amenities and control population and urbanisation. Governments must consider environmental aspects of all development activities, conduct environmental impact assessment of all major projects, minimise generation of waste, promote technologies that are eco-friendly and conserve /enhance the resource base. In the broader sense, sustainable development requires approaches based on putting people at the centre and taking long-term view about the safeguarding of the interests of future generations. Decision-making has to be based on the interaction between economic growth, social justice and environmental protection. The definition of environment itself needs to include not only our physical, chemical and biological surroundings but also our economic, social and cultural spheres.[5]

In order to assess the progress of a country's efforts towards sustainable development, it becomes necessary to define several indicators. Chapter 40 of Agenda 21[4] calls upon the governments of signatory countries and non-governmental organisations to develop such indicators. It also stresses the importance of harmonising such indicators to enable development of a set of common indicators, which can be made globally available and updated regularly. In 1995, the Commission of Sustainable Development approved the programme of work on such indicators. The indicators have to fulfil several criteria such as the following:

- Should address all the three dimensions of sustainable development – environmental, social and economic
- Should enable quantification of progress made
- Should be capable of being applied at regional, national or global levels
- Must convey sufficient information for the decision makers
- Should be easily understandable to the common man

These indicators once again encompass the social, economic infrastructure and natural resource aspects of sustainable development.

SCIENCE FOR SUSTAINABLE DEVELOPMENT

Chapter 35 of Agenda 21[4] stresses the importance of science in the management of environment and development of humanity. The international conference on an Agenda of Science for Environment and Development into the 21st Century (ASCEND 21) identified the following areas:

a) Strengthening the scientific basis for sustainable management,

b) Enhancing scientific understanding,

c) Improving long-term scientific assessment,

d) Building up of scientific capacity and capability.

Growth and development in these areas will ensure sound management policies that are well founded in science and capable of flexible response to changing situations.

Further additional knowledge will be acquired towards assessing the Earth's carrying capacity and identifying processes, which could either impair or enhance its ability to support life. Such studies will also enable the application of new analytical and predictive tools for the assessment of the influence of human actions on Earth's natural systems. Besides, it will be possible to estimate the human dimensions of the consequences of environmental change such as global warming. It is also expected that there will be greater international cooperation and coordination in establishing data banks on developmental and environmental issues, which will enable the statistical interpretations and projections for the future. Agenda 21 calls upon all the member states to take adequate steps to create such databases and promote "the education and training of scientists to develop an ability to identify, manage and incorporate environmental considerations into research and development projects."

SUSTAINABLE DEVELOPMENT PROGRAMMES IN INDIA

India has made significant progress towards sustainable development and has implemented a number of plans and programmes.[6] The ministries of Environment and Forests, Agriculture, Water Resources, Finance, Industries, Rural Development, Non Conventional Energy Sources and External Affairs are involved in decision making for sustainable development. Many inter ministerial committees and Core groups coordinate the making of legislations and policies. To-date nearly twenty legislations have been passed. From the point of view of the present discussion, the following are relevant:

The Environment (Protection) Act, 1986
The Water (Prevention and Control of Pollution) Act, 1974
The Air (Prevention and Control of Pollution) Act, 1981
The National Environment Tribunal Act, 1995
Hazardous Wastes (Management and Handling) Rules, 1989
Ozone Depleting Substances (Regulation) Rules, 2000
New Biodiversity Bill-2000
The Prevention and Control of Pollution (Uniform Consent Procedure) Rules, 1999

The Central Pollution Control Board (CPCB) oversees the implementation of the Environmental Protection Act, 1986. The Board has established a number of monitoring stations across the country and has identified several severely polluted areas of the country such as Vapi in Gujarat, Howrah in West Bengal, Udyog Mandal, Dhanbad in Jharkhand for special attention. In addition, the Ministry of Environment and Forests has brought forward many policy initiatives to cover a wide spectrum of environmental issues ranging from vehicular pollution to bio safety. India introduced Environmental Impact Assessment (EIA) as early as in 1978 in order to assess the environmental compatibility of any proposed project in terms of the efficiency of the technology in resource utilisation, recycling, suitability for the proposed location etc. From 1994 onwards, EIA is a statutory requirement for the mining, irrigation, power, transport and for 25 other categories of developmental projects.[6]

As stated already, environment is a multidisciplinary subject requiring varieties

of inputs and information. Keeping this in mind the government of India has established an Environmental Information System as a plan programme. A large number of nodes called the ENVIS Centres cover several different areas of environment. ENVIS also implements UNDP's Sustainable Development Networking Programme. Establishment of the Indian Centre for Promotion of Cleaner Technologies is another step in this direction.

The measures discussed above are regional and country as well as process specific. The phenomena like greenhouse effect and ozone depletion are global in nature and need concerted action by all countries. In appreciation of this need, India has signed a large number of international treaties/agreements in the field of environment. A few of these that are relevant to the present discussion are:

Vienna Convention for the Protection of Ozone Layer
Basel Convention on trans-boundary movement of hazardous substances
Framework Convention on Climate change
Montreal Protocol on the substances that deplete ozone layer.

ENVIRONMENTAL DEGRADATION AND SUSTAINABLE DEVELOPMENT

Rapid industrialisation has resulted in depletion of natural resources, generation of waste and discharge of pollutants into the environment. For a long time, the smoking chimneys of industries were considered to be signs of development and economic well being. The concept of sustainable development has negated such ideas and has stressed the importance of the need for newer technologies, which are energy efficient, zero waste based and least polluted. Until all the countries are able to adopt such newer technologies, it becomes necessary to concentrate on abatement of pollution from the existing industries. Pollution prevention involves the use of processes, practices or products to minimise the discharge of pollutants and wastes into the environment. The reduction can also be effected through the adoption of technologies that either minimise the use of raw materials or the energy required for the process. Several different strategies are adopted worldwide.[1,7] These are discussed here.

Fixing Emission Standards

The maximum concentrations or quantities of pollutants are fixed and compliance is demanded. For example, the Central Pollution Control Board, New Delhi, has now fixed the level of solid particles per cubic meter for the operation of iron foundries at 150mg/m^3. Similarly, limits have been set on the composition of the exhaust from automobiles.

Command and Control Regulation

In this approach the type of pollution control device to be used is specified. For example, the pollution control devices may be dry or require the use of water. The discharge of the water used may lead to pollution of the water sources and hence the use of wet pollution control devices may be banned.

Emission Offsets

It is very common to see the growth of a particular type of industry in a given geographical location due to availability of raw materials, power and other resources. The clustering of foundries at Howrah, Rajkot and Batala or the growth of tanneries in Kolkata and parts of Tamilnadu are examples of such a phenomenon. If a new unit is to be established in the vicinity of the existing ones, it may be asked to help in the reduction of pollution from the existing unit(s) before being given permission.

The Bubble

Unlike in the case of emission standards, which fix a ceiling on each of the pollutants, a ceiling is placed on the total pollutant concentration.

Banking of Emissions

Under this system, a firm may perform beyond expectations and achieve a low level of pollution in a given period. It will then be allowed to bank the performance and be permitted to exceed the levels fixed to the extent their performance has achieved lower limits earlier.

Polluter Pays Principle

In this method, prevalent in some of the developed countries, the polluter is allowed to pay charges to secure the right for discharging pollutants into the environment. By making the polluter pay, an incentive is provided to reduce the quantum of pollution. This method has some inherent drawbacks. It is not always possible to identify the polluter. The pollutant may actually cross international borders as well. For example, a large fraction of acid rain over Canada is thought to be due to the emissions from the industry in the United States. Norway attributes the acid rain over its territory to emanations from Great Britain and Germany. Besides, those responsible for the pollution and depletion of the resources are not those who bear the consequences. Imposition of charges/penalties will mean that the consumer pays the price indirectly and such a situation with respect to essential goods is not desirable.

Precautionary Principle

In the Rio Declaration on Environment and Development, it is stated " where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation". This principle recommends erring on the side of caution for the prevention of damage. It requires assessment of costs and benefits of action and transparency in decision-making. With respect to use of freshwater, collapse of global fish stocks, issues related to climate change etc., it is difficult to lay down safe limits. Precautionary action is a better option.

Integrated Resource Management

Since resources are often non-renewable, one has to consider the demands made on them by several interested parties or users. The most deserving user has to be given priority after considering various social, economic and environmental factors. Scope for review should exist in the decision made.

Ecosystem Approach

Organisms and the specific external environment around them form an ecosystem. It is a system in which there is considerable interdependence upon and interaction between the organisms and their environment. Ecosystems are complex entities. All attempts should be made to keep them intact. In order to ensure their integrity it is necessary to consider all ecological processes, physical and biological components, human activities and the landscapes.

These methodologies offer the possibility of integrating environmental, social and economic considerations with decision-making. These are still evolving and are being pursued at different levels and in different combinations by various governments across the globe.

In India, clean technologies and processes are promoted through a variety of means. Environmental clearances are to be obtained before setting up industries producing petrochemicals, cement, thermal power, drugs, fertilisers etc. In some cases (eg, asbestos and products based on it, paint complexes, bulk drugs, foundries etc.) clearance from the environment angle is mandatory irrespective of the investment level. On the other hand government provides subsidies, tax incentives and 100% depreciation allowance for the establishment of non-conventional energy generating units.

India has taken a lead in setting environmental standards for products and processes besides introducing environmental impact and life cycle assessments, eco-labelling and environmental audits. The Ecomark Scheme, Green rating and ISO:14001 certification are some of the visible outcomes of the efforts. The environmental impact assessment programme is intended to eliminate problems in the integration of trade and environmental issues. In the area of relevance to the industry, Government has been adopting both preventive and promotive methods. Fiscal incentives are provided for the installation of pollution abatement equipment in the form of customs duty exemption and soft loans. Legal actions and closure are the punitive measures adopted.[6]

MINING, MINERAL AND METALS SECTOR

The mineral metal sector is characterised by several unique features. Some of these are[7]:

- Mineral deposits are naturally occurring and we have no control on their location,
- The probability of a mineral exploration programme leading to an economically viable mineral deposit is low and expensive,
- Every venture of exploiting a mineral resource will eventually be economically unviable as the resource is depleted,
- Since the properties of the extracted metal are independent of the mine from which it has been extracted, the process of mining and metal extraction has to be internationally competitive,
- The technologies involved are often complex requiring trained work force, heavy investment and long periods of time for lucrative return on investment,

- Minerals become industrially important only when appropriate uses are found for them, and
- Synthetic materials also compete against naturally occurring minerals.

Even though the minerals are often considered to be non-renewable resource, it has to be recognised that only a fraction of the total reserves in earth have actually been explored. In this context, the case of the Sigma mine in Val-d'Or, Quebec and the Dome mine in Timmins, Ontario are interesting. They have been functioning for over 50 years with the annual projections predicting availability of the mineral over the next 2 to 3 years only[7]! Nevertheless, the sustainability of mining industry is greatly dependent on exploration and prospecting which lead to the location of new mineral resources. Exploration is therefore essential for sustainable development of the mining industry. As and when a typical mine resources get exhausted, several human problems arise due to closure of the mine, loss of jobs and the decline of the township associated with the mine. Such a situation is fast emerging at the Hindustan Copper Limited, Ghatsila Works and associated mines. It is also noteworthy that not only the closure of a mine leads to human problems but also its establishment in the first place. The beginning of mining activity is associated, very often, with deforestation and displacement of people owning the land. These social aspects need to be addressed for sustainable development of the mining sector.

Mining and mineral beneficiation require relatively large amounts of energy and water. Mining also leads to significant pollution of the water resources around the mines and beneficiation plant sites. It is recognised that man-made tailing ponds and dams are amongst the largest structures constructed by man. They may contain as much as 100 million tonnes of slurries. There are about 3500 such dams.[8] The main effects of mining on the surrounding water bodies have been listed by Balkau.[9] These are:

- Suspended solids and sediment from runoff and processing operations,
- Acids from various processes,
- Acid mine drainage during and after operation,
- Heavy metals leached from waste and tailings,
- Sulphate, thiosulphate, polythionate etc., from acid drainage,
- Mercury from the process are from ores,
- Arsenic from oxidised mine waters,
- Cyanide from leaching processes,
- Oils and fuels from ancillary operations.

While mining operation itself may not cause pollution, the interaction of tailings and acid drainage etc., with the water bodies is the most serious environmental hazard. Other important environmental issues related to the minerals and metal sector are mine reclamation, metals toxicity, metals recycling and energy efficiency. Some of these are briefly discussed.

Mine Reclamation

Mineral exploration and mining disturbed the environment and mine reclamation aims at restoring the original status to the extent possible. In the present day context, the strategy for mine reclamation is built into the plans for exploitation of the reserve discovered at the very beginning of the venture. Many countries do not permit abandonment of mines after recovery of the valuable mineral.

Metals Toxicity

Metals are naturally occurring in the environment in the form of chemical compounds. Only a few metals are found in their native state. Man-made activity of extracting metals from ores disturbs the environment by redistributing, concentrating and modifying their natural occurrence. It is also known that the human body has several metals, albeit in microgram concentrations. These metals help activate several essential enzymes. While all metals are not accumulated in the human body, mercury and lead are known to be bio-accumulative. When such an accumulation occurs, it leads to toxicity and consequent health hazard. In some of the advanced countries, both competition between materials and regulatory governmental action have resulted in substitution of metals like lead. In India, for example, a law has been enacted recently to regulate the sale of lead-acid batteries.

Metals Recycling

In the course of metals production, different types of wastes are generated. These may be classified under the following heads:

- Production wastes – The raw material left after the extraction of a valuable part. This waste will not measure up to the needs of the primary activity but may be useful in another field of manufacture or consumption after some treatment.
- Consumption wastes – This refers to worn out products and materials, which cannot be reclaimed economically.
- Salvageable wastes – These are a part of production and consumption wastes that can be reclaimed for utilisation as primary or secondary source material in some manufacture. The use may be immediate or potential.

Some of these wastes are potential candidates for the reclamation of metals through secondary process. For example, 38 to 40% of copper used in electrical, electronic and telecommunication equipment is recoverable while about 10% of it can be recovered from general engineering goods. In the advanced countries, close to half of the steel consumed arises from scrap. The concept of recycling metal bearing wastes has thousands of years of history and is a statement of sustainable development in spirit. The industry is also highly competitive and most matured. Recycling directly leads to conservation of natural resources and energy conservation. For example, the energy requirements for the production of primary and secondary aluminium are 270 GJ/t and 16.5 GJ/t respectively. Thus, over 90% of the energy needs for aluminium extraction from bauxite can be saved through recycling.

One of the difficulties in estimating the life cycle of metals up to the point of recycling is the long lifetime of metals. It is therefore difficult to predict the recycling rate of several metals such as copper, which may last as long as 50 years in electrical applications. Prediction of the lifetime is easier in some of the short-term applications such as life of lead in lead-acid batteries. In such cases, it is easier to estimate the rate of recycling and also to ensure environmentally friendly processing of the lead recovered from the batteries through the enactment of appropriate laws. Some times there are also technological problems in recycling metals in so far as the impurities that are brought into the new product from the scrap. Besides, the Basel Convention (signed in 1989 and made effective from 1992) imposes restrictions on the trans-national movement of wastes, which include many metal recyclables. These restrictions cause difficulties in procuring recyclable metal wastes by developing countries, which have been processing them earlier.

Energy Efficiency

Economic and social development greatly depends upon energy. The production of energy through thermal power plants entails the emission of greenhouse gases and discharge of solid waste such as fly ash. About 75% of world's energy is produced from fossil fuels viz., oil, coal and natural gas. The balance of energy is derived from hydro and nuclear power. The pattern of energy production in India matches this world scenario. Of the 1,00,000 MW of installed power capacity in the country, 71% is from thermal sources while 24% is from hydro, 2.9% from nuclear and the rest is from wind mills.[6] Nuclear power while not releasing any gaseous emissions has the problem of disposal of radioactive waste. Since CO_2 emissions lead to global warming, there is an all round effort to both find alternative sources of energy and reduce the consumption of energy through innovative technologies.

The production of many metals is energy intensive. Notable amongst them is aluminium. It requires 270 GJ/t as against figures of 184, 39, 61 GJ/t for copper, lead, zinc respectively. Energy can significantly be saved by greater reliance on secondary metal production as discussed in the previous section.

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