Economic Reforms and Sustainability - A Conceptual Analysis & Framework

By

N. Naganna

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Please address all correspondence to:

N. Naganna
Professor
Indian Institute of Management
Bangalore-560 076
India

Phone : 6632450
Fax : 080 - 644050
E-mail: naganna@iimb.ernet.in

Indian Institute of Management Bangalore

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INTRODUCTION

Both economic reforms and sustainability havecome to thefore at the sametimein recent years. In fact, they are contradictory to each other as also their underlying principles conflict with each other. For instance, economic reforms advocate faster rates of growth while sustainability pleads for slower rates fearing that the resource-base may be depleted faster and thereby, jeopardizing the interests of future generations. This is indeed a puzzling situation which the policy making system constantly faces. An attempt is made in this working paper to resolve this conflicting situation with a view to make sustainability compatible with the economic reforms.

The paper focuses on non-renewable mineral resources because the problems posed by the renewable resources like forestry, fishery, soil fertility etc., are however, totally different requiring a different type of analysis and treatment. For the sake of brevity and precision, a number of charts have been presented to avoid elaborate explanations. On the basis of our analysis as presented here, it can be surmised that the economic reforms will largely be constrained by environmental factors and the criticalities of resource base or the sustainability.

The paper argues that sustainability can only be made compatible with economic reforms through exploration ventures and conservation programs on a continuing basis. This is perhaps the only way through which the ordeals of **doomsday** can be overcome. Therefore, the public policies need to be oriented and geared towards that end. Otherwise, sustainability will just remain, to borrow Solow's words, nothing more than a slogan or an expression of emotion.

The Hindu, 1-11-98

ALL IN THE GAME

The U.S. has lifted sanctions — our economy can be extravagant and careless once again...

Before becoming a prodigal nation largely induced by economic reforms, prudence demands that we need to take up remedial actions. The paper is an attempt in that direction.

ECONOMIC REFORMS AND SUSTAINABILITY A CONCEPTUAL ANALYSIS & FRAMEWORK[1]

N Naganna[2]

Economic reforms with their sole thrust on liberalisation, privatisation, marketisation and globalisation will have definite impacts on the country's resource base in many and varied forms. They brought out, among other things, a significant paradigm shift in the developmental strategies - a shift from government to markets, public to private sector dominance, state monopoly to market competition and so on. In fact, this paradigm shift implies some major policy shifts besides value-shifts, of far reaching consequences. On general grounds, one can suspect that the India's socioeconomic system is not institutionally (e.g., economic, sociopolitical, legal etc.) fully equipped to receive, absorb and assimilate the package of radical economic reforms. This is a major problem. Therefore, it is necessary to create the appropriate socioeconomic institutional framework to make the economic reforms successful and meaningful. The economic reforms, whatever they mean, will have to be **endogenous** to the country and its resource base; and definitely not exogenously modeled. If they are endogenous and based on the felt-needs of the people while at the same time being consistent with the known endowed resource base, then only such radical reforms will be realistic to yield the anticipated results as also muster compliance in their favour. Therefore, the economic reforms in a sense, need to be **resources-specific**.

Economic reforms alone can not ensure an improved economic wellbeing. They need to be backed up by adequate sustainable resource base. Otherwise, they do not go beyond making statements on targets, growth rates etc. Keeping in view of the role and significance of resources in the general run of the economy, the design for a minerals policy though a derived one from economic policies, is required to constitute the important elements such as a continuous appraisal of the resource base, depletion (or extraction), exploration and conservation. And, they need to be considered in an integrated manner.

The present paper is broadly divided into four sections. Section-1 explains the nature and significance of exploration in the context of increased levels of economic development. Section-2 brings out the imperative need to pursue the policy of conservation to see that growth continues over long periods. Section-3 discerns various perspectives on sustainable development as also tries to integrate exploration, exploitation and conservation with sustainability. Section-4 attempts to highlight some of the policy issues pertaining to the mining sector.

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[1] One of the major criticisms leveled against the classic study on **"The Limits to Growth"** (MIT, USA) is that it undermines the role of exploration. Keeping this in view, an attempt is made in this paper to integrate exploration with sustainability and in the process, conservation is also added to get a holistic perspective on sustainability.

[2] Professor, Indian Institute of Management, Bangalore(India).

SECTION -1

1.1 *Economic Development, Minerals, and Exploration*

Experience shows that the mineral exploration, development and exploitation are both a cause and consequence of economic development. They promote and in turn, the development strategies promote them.[3] Thus, both the mineral policy and economic policies are mutually interdependent and reinforcing. This needs to be kept in mind while formulating the economic policies. The economic reforms in effect advocate, or even otherwise result in, higher rates of extraction to meet the increasing requirements of the expanding industrial sector. In this context, it is interesting to note that:

> **"Better methods for estimating the magnitude of potential mineral resources are needed to provide the knowledge that should guide the design of many key public policies"[4]**

This implies exploration on a continuing scale. Accordingly, an attempt is made here to examine and analyse the interface between exploration and public policies. As a matter of fact, many of the key public policies are mainly geared either directly or indirectly towards promoting and facilitating the human activities to alter and use the resource base for human development or mainly the economic wellbeing. This being the case, one can suspect on general grounds that the so-called human betterment can not indefinitely continue without any physical limits. This is precisely what the famous study on **"The Limits to Growth"** advocates and in the end, prescribes a zero-growth policy. Later, it is hypothesised that the zero-growth policy can be bypassed through conservation. So to say, there are likely to be the system boundaries beyond which the human betterment (or the economic development) can not be pushed.

Conservational Dimension: It is at this juncture, the principle of conservation enters which advocates besides other things, the upper bounds to the socioeconomic system by giving a warning which says: **"thus far, no further"**. In the same vein, it is observed way back in 1910 that:

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[3] See, N Naganna (1989), "A Structural Analysis of India's Mining Sector in the context of Development Planning". **The Indian Journal of Economics**, Vol.LXIX, Part III, No.274, pp 279-306. This gives the role of minerals in economic development. See also, N Naganna (1983), "Coal and the Environment : Issues in Policy and Planning", (mimeographed), IIM-Bangalore.

[4] V.E. McKelvey, "Mineral Resource Estimates and Public Policy", **American Scientist**, Vol.60, p 32, Jan.-Feb. 1972.

> **".... may serve a useful purpose in forwarding the great movement for conservation which is more important than all other movements now before the people."**[5]

The above two propositions by McKelvey (1972) and Van Hise (1910) together would form the basic premise for the present paper on "The Economic reforms and Sustainability."

1.2 The Tripod of Sustainable Human Progress

In this context, the human progress refers to the economic or material wellbeing of the population in a sovereign state. The human progress or the sustainable human progress in the long run depends on the three basic elements, viz., exploration and development and exploitation and conservation. And they are all interconnected because of the fact that the human progress depends essentially on the known and recoverable resource base. In other words, the economic development, exploitation and conservation are together considered as a **tripod** upon which the human progress depends. From resources viewpoint, economic development largely implies a continuous rise in production, distribution and consumption of goods and services.[6] This is a highly simplistic view. Whatever it is, production systems require inputs, or factors of production, or raw materials or resources, which are in fact used interchangeably in technoeconomic analysis. Another noteworthy feature of resources is that the energy-resources transform/convert the rest of the resources into exchangeable products. In effect, all these natural resources are transformed through technology into products, which in turn gain utility and salability in the process.

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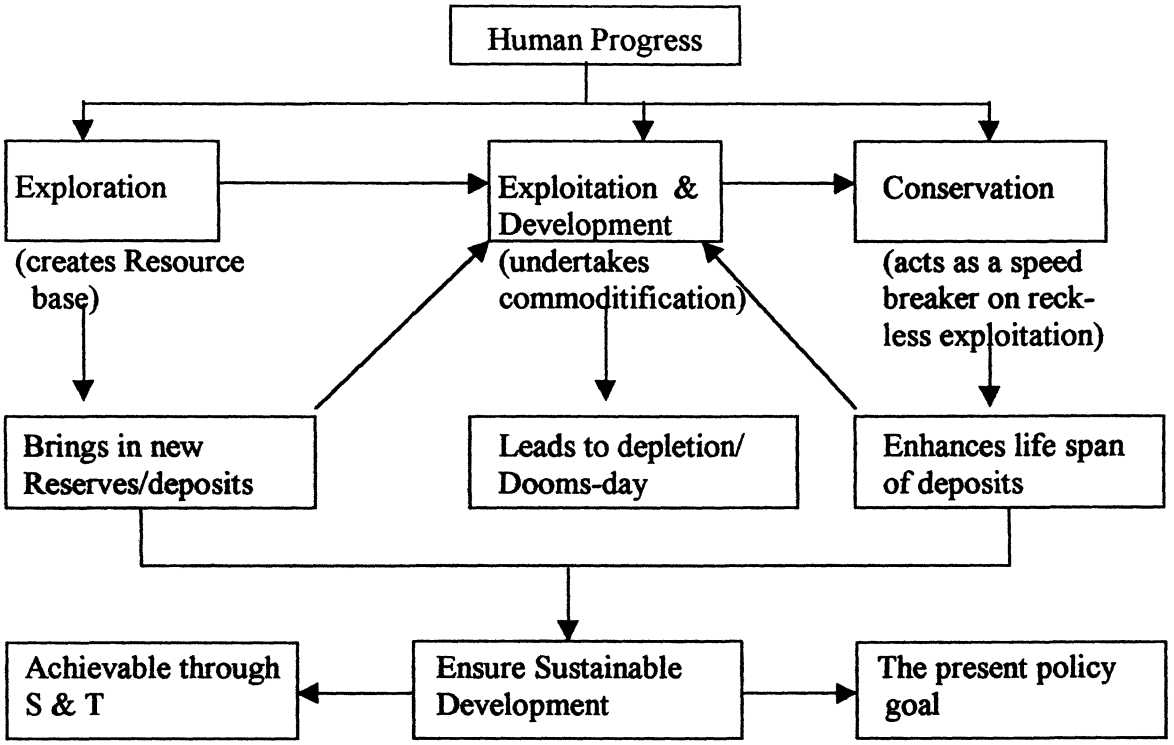
[5] Charles R Van Hise, **"The Conservation of Natural Resources in the United States"**, The MacMillan Co., 1910, pvi. See also, Norman H Dill, "Conservation of Natural Resources, a few concepts" (pp 145-149) in V.P. Agrawal and S.V.S. Rama (Ed.), **"Environment and Natural Resources"** (Jagmander Book Agency, New Delhi, 1985).

[6] James F McDivitt and W.G. Jeffery, "Minerals and the developing Economics" in **"Economics of the Mineral Industries"** (3rd Ed.) Ed. By William A Vogely and Hubert E Risser, (American Institute of Mining, Mettalurgical and Petroleum Engineers, Inc., New York, 1976)

Chart - 1 : <u>The Tripod of Sustainable Human Progress</u>



Note: One can plug in a lot of data from the plan documents, GSI, Minerals Exploration Corporation, Mining and Geology Departments of different states, ONGC, Coal India etc., to make it more meaningful and useful in policy analysis.

The above tripod (viz., Exploration, Exploitation and Conservation) needs to be studied, understood, analysed and examined carefully before any policy initiative is taken up because the resource base enters explicitly in matters relating to public policy analysis. In essence, public policy making centres on the above tripod. It is the hub of all policy-making processes.

➔ **The above tripod illustrates the extent of publicness involved in matters relating to mineral policies.**

This is nothing but **commoditification** of natural resources. The industrial organisation and management revolve around this process of commoditification in their varied forms and structures. This being the case, the economic development can be considered as nothing but the process of commoditification of resources base for the general economic wellbeing of the population in a sovereign state. Though resources occupy a central place in industry, trade, markets etc., our knowledge about them seems to be limited; definitely not in proportion to their significance and role. Therefore, a modest attempt is made in this paper towards this direction.

A set of broad interconnections between exploration, exploitation and conservation, and the dependence of sustainable human progress on these three basic elements, are diagramatised in Chart-1. It is almost self-explanatory. However, it is to be noted that the common objective of both the exploration and conservation is to enhance the longevity of resource availability both to the present and future generations. But the approach of the two is different though the goal is same. The ethos of both conservation and exploration is to create and maintain a long lasting and sustainable resource base. Conservation advocates the wise-use of resources by attacking all kinds of avoidable wastes on all the fronts whereas the exploration brings in new packages of resources into the domain of production stream. Thus, both conservation and exploration together would ensure sustainable development. And, there is no other way. In other words, the zero-growth policy as prescribed by the resource analysts can be deferred to a distant future.

Another noticeable observation in Chart-1 is that the "exploitation & development" leads to total depletion/doomsday if indiscriminate, unchecked and uncontrolled exploitation takes place. Therefore, the exploitation of mineral resources needs to be complemented by both conservation and exploration.

1.3. Exploration : Meaning and Scope

The two main features of mineral resources, viz., (a) Exhaustibility, and (b) Hiddenness, give rise to or rather necessitate the undertaking of exploration activity. At times, the word "prospecting" is also used interchangeably in mining parlance. The basic premise for exploration is that extraction means depletion or the depletion of a reserve under the current workings. Therefore, this calls for a continuous replenishment or replacement with new deposits to keep mining a sustainable activity. This exploration provides. It implies the conduct of search, re-search and re-re-search for various technically and economically recoverable mineral resources which have salability and utility; and which are embedded at different depths from surface; as also to gain geological and mineralogical knowledge about them. It is indeed, an INQUIRY deep into the earth's crust to gain knowledge about the valuable minerals. In the ultimate analysis, it gives us the fairly dependable clues regarding the presence or absence of mineral resources in a particular region, which is being explored. Or, it may bring in new deposits for exploitation in a mining-belt where the extraction activity is already under progress. From risk point of view, a distinction is implicitly made here between the areas

where mining is already taking place and the other areas where mining is not known (called the virgin areas). Both the cases present two altogether different situations for exploration.

The notable feature of exploration is that it is a highly risk-prone enterprise because one may touch the deposit or may not. Besides, it is also highly capital intensive. Its output is information and not any physical output. In this activity, the failures are as important as the successes. Another important notable feature is that the extent of risk element varies by the type of mineral or the mode of occurrence (e.g., placer or stratified; vein or lode etc).

Exploration is a vital activity both for fuel and non-fuel mineral resources appraisal and extraction. The objective is to **discover** the raw mineral materials for industrialisation. It is directed on the basis of our a priori knowledge about the nature of the origin and occurrence of the mineral resources. It is an integral as also inseparable part of the extraction sector. Since the minerals by nature are depletable, meaning thereby that a ton extracted is a Ton depleted; the extent of depletion needs to be replaced/replenished by new deposits to the extent possible. Otherwise, the extraction sector will come to a grinding halt. This replacement with new deposits is achieved only through exploration.

The important feature of mineral (or subsoil) resources is that they are hidden at different depths and that therefore, their quality, quantity, mineability etc., are not known to the human agent. But development requires this information in as detailed a manner as possible. It is only through exploration that this kind of information is obtained and made available to mining enterprises. Thus, exploration is a precondition to the economic development. Development follows only when the geo-technical information of the reserve position is made known to the decision-makers. Thus, exploration and development are interdependent.

Stages in Exploration Operations: The nature and the extent of known reserves or the resource base of the mining sector vary over time depending upon:

- The technology of exploration
- The extent of drilling operations and their spacing
- The intensity of them
- The geological surveys, mapping and other investigations

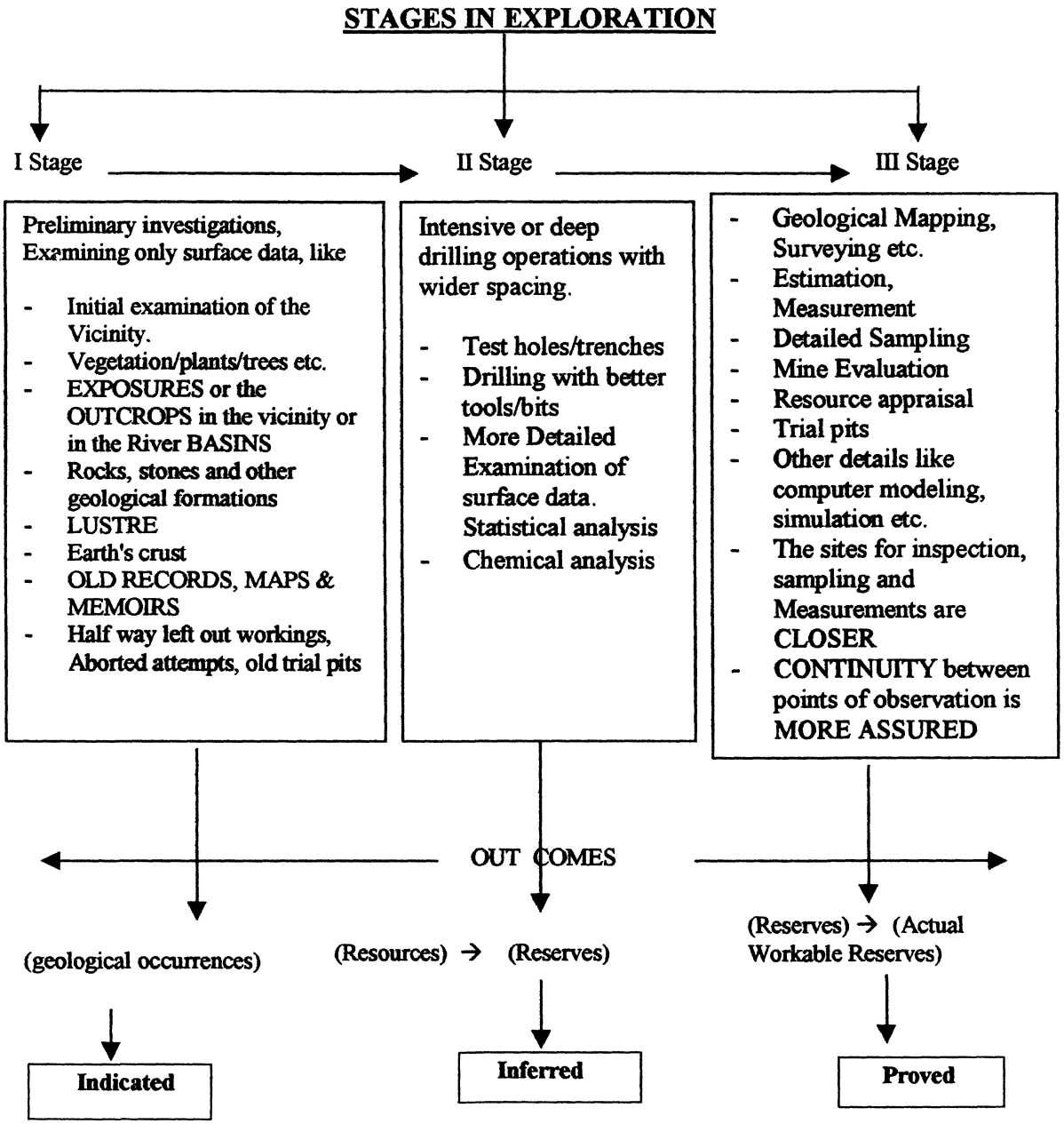
and so on. The above factors influence the dynamics of resource assessments and their shifts over time; as also determine the strategic planning of the mining sector. In other words, the output planning and exploration are inter related for a sustainable mining sector.

In Chart-2, broadly three stages have been identified in the mechanics and the processes of exploration ranging mainly from a simple suspicion (or a hunch) to the scientific confirmation; or surmise to validation. In exploration, everything starts with a hunch/surmise as to the presence/absence of a mineral below the ground. This hunch will be stretched to its logical limits by continuous scientific validation from stage to stage. It is a tedious inquiry deep into the ground to different depths. The conduct of this inquiry is broadly divided into three different but interconnected phases and is presented in the form of a flow chart (No.2). The elements that constitute each stage are also given. In a sense, each element under each respective stage can be viewed as an activity. These elements are by no means exhaustive.

The three phases in Chart-2 are arranged in an ascending order of their increasing levels of intensity of exploration operations. Each phase represent a particular process. It is a unified whole and there is a flow of information from one to the other. The first influences the rest. It may even limit the areas for further detailed exploration.

In the first phase, it may be noted that the surface data are only examined. The components of surface data are given in the flow chart. Some well established correlations or associations between/among the vegetative cover, rock formation, luster, structure of the earth's crust, soils etc., are used to get some indications about the presence or absence of a mineral. Though this is a preliminary stage, it forms the basis for further detailed investigations. This would also limit the areas in which detailed exploration is to be conducted.

Chart - 2 : Stages in Exploration Process:



During the phase-1, the outcrops or exposures play a decisive role in giving fairly reliable clues regarding whether or not a mineral is embedded. Local legends, memoirs of the earlier explorers, river basins, aborted attempts, earlier trial pits, etc., play another equally important role in furnishing some indications regarding the possibility of a mineral being present in the area under exploration.

The outcome of this phase is the information on the **geological occurrences** spread over large tracts of the supposedly mineral bearing area under investigation. Assuming continuity between the occurrences and the conventional volumetric parameters, the total reserves embedded in the area are estimated. They are only approximations. That is why, they are rightly called as the **indicated resources**.

On the basis of the outcomes of the first phase, the second phase is designed for more scientific detailed investigations. This is more intensive than the earlier one. In this phase, drilling operations with the help of rigs etc., are carried out normally with large spacings. Some sophisticated investigations like the geophysical and magnetic survey etc., are also conducted. In support of these surveys and to increase the reliability of information, a number of test holes and trenches here and there with large spaces between them are dug. The surface data are analysed more rigorously than before by using the advanced statistical, econometric and computer models. Chemical analysis of the samples obtained through trial pits/trenches is also carried out to ascertain the quality and commercial viability. Mineral estimates (reserves) are made assuming continuity between different drilling sites. **During this phase, the "geological occurrences" (or the resources) are converted/transformed into reserves.** This is the major outcome of this phase. The extent of certainty/reliability is enhanced substantially. The reserves are now almost readily available for immediate extraction since the drilling operations are found to be a more definite test. Thus, the "geological occurrences" as found in the first phase gain more "certainty" now in the second phase. This is the reason why the outcomes in the second phase are called the **inferred reserves**. In other words, the mineral resources get graduated to inferred category from the indicated type. This is a major shift.

In the final (third) stage, more sophisticated analysis is carried out to increase the level of certainty. Geological mapping, mine valuation, more drilling operations by reducing the space between the sites, more number of trial pits and so on are conducted during this final stage. In this case, **the continuity between the points of observation is more assured.**

The outcomes of the third stage are called the **proven reserves**. As a matter of fact, the inferred reserves as obtained during the second stage will be converted/transformed into actual workable/extractable reserves. Another important outcome of this phase is that the site selection for opening a mine (or the pit/mine mouth) is made ready. Of course, it may need a few more drilling operations.

1.4. Exploration Outcomes By Stages:

In the exploration processes, a number of transformations take place on resources front viz., from geological occurrences to reserves and thereafter too extractable reserves. These transformations are vital in the context of sustainable development. The outcomes of exploration by stages can be summarised as below:

Exploration Outcomes by Stages

Sl.No.	Stages	Outcomes/Transformations*	Outcomes in Probability Terms
1	Stage-I	Geological occurrences (or Resources)	Indicated Reserves
2	Stage-II	Reserves (Resources to Reserves)	Inferred Reserves
3	Stage-III	Extractable Reserves (Reserves to Workable Reserves)	Proved Reserves

***transformations are given in brackets.**

The above categorisation of mineral deposits represents the degree of probability of their occurrence in a progressive manner. That is to say, the arrangement is made from the indicated to infer to proved categories. The last one will be available for immediate exploitation. In other words, the resource base is arranged in a probability framework in an ascending order to show geologic certainty and mineability. The resources get different categorisation depending upon the intensity of exploration operations. Thus, the resource-base will always be shifting to higher levels with the discovery of new and more fertile virgin deposits as also getting higher levels of certainty for the existing resource base with regard to their immediate exploitation. This is how, **the exploration makes sustainable development a reality.**

Resource base is not a static quantity but continuously changes, or rather improves, with the progress in science and technology, exploration, development of substitutes and market conditions. Substitutes have a different role in resource analysis. They always try to replace the depleted scarce resources. Similar is the case with the mining losses, which are amenable for control through technology and mining methods. Keeping the changes and developments of sorts in view, it is necessary that the mining sector must revise its resources estimates periodically.

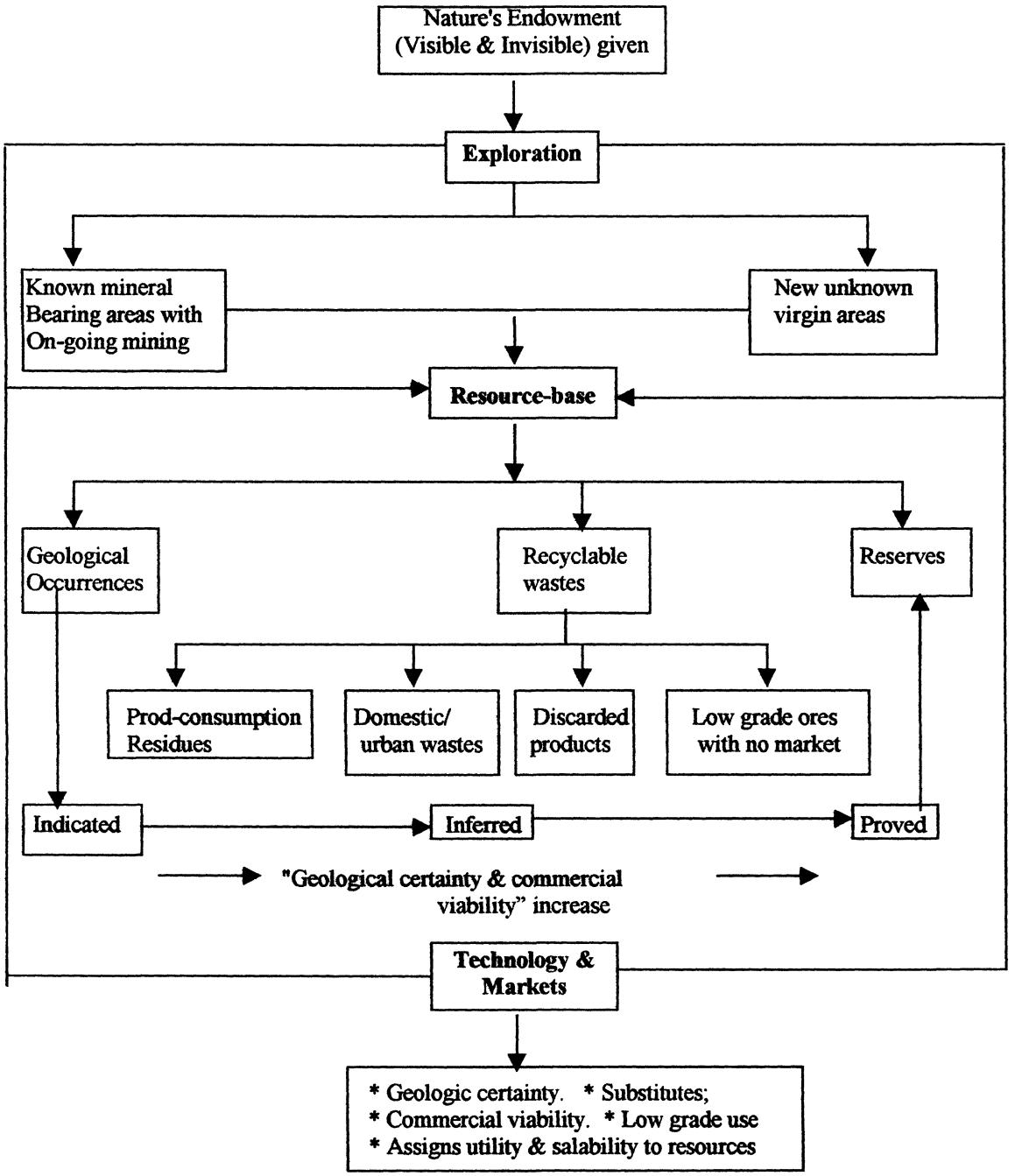
1.5. Interconnection Between Exploration, Technology & Markets And Resources:

The interaction and interconnection between exploration, technology & markets, and resources assume special significance in the context of sustainable development because of the fact that the resource-base has to keep pace with the ever-increasing requirements of developmental strategies. As said earlier, development implies essentially the process of commoditification of the endowed resource-base through technology into various usable products (see Chart-4). Since development is built upon the resource-base, and since resource-base is exhaustible, the concept of sustainable development obviously requires a sustainable resource base solely through continuous exploration operations to replace the depleted stock. For the sake of brevity, this underlying principle of sustainability through exploration is presented in the form of a simple flow chart (No.3). It is to be specially noted that the "recyclable wastes" enter as a

component of resource base in Chart-3. This is because of the fact that waste is said to be wealth. In a sense, Chart-3 simplifies the whole gamut of processes involved in the conversion of nature's endowment into various products for the material wellbeing of the people.

In Chart-3, it can be seen that there is "exploration" at one end of the spectrum and the "technology & markets" at the other end. In between these two process boundaries, the dynamics of resources appraisal operate. It is to be emphasised that the Resource-base is a joint product of "exploration" and "technology & markets", or in other words, exploration coupled with "technology & markets" produce resource-base from a given nature's endowment. It is, therefore, rightly said that the "**resources are not ..... they are made**". In the same vein, it is again rightly said that the human wisdom/intelligence is the supreme resource.

Chart - 3 : Interconnection Between Exploration, Technology & Markets, And Resources



1.6. Recyclable Residues as Resource-base : A Digression:

Several decades ago, the great economist Frank H Knight observed that the word "consumption" is a misnomer in economics because we don't consume anything but only make use of the utility element in the products over their useful life after which they are discarded and normally thrown into the open environment as wastes/residues.[7] Thus, all the products in the end become discarded or residuals/wastes. They can be designated as the **Consumption Residues**. Similarly, all the inputs/raw materials can not be totally converted into outputs without generating the process-wastes in the production process. They can be called the **production residues**. Thus, the wastes/residuals are the inevitable outcomes of the production-consumption streams. In a sense, production/consumption means generating wastes/residuals. Or, to put it differently, it can be said that today's production is tomorrow's waste. Similarly, there are extraction or mineral residues at the mine sites arising mainly out of the benefication process.

The flow **Chart - 4** delineates various stages involved in the generation of waste's/residues in the production-consumption processes in a given society. The nature, the composition and the type of wastes (i.e., gaseous, liquid, solid, hazardous, toxic etc.,) generated varies from stage to stage. Accordingly, the collection, treatment and disposal (including recycling) systems also vary. This needs to be kept in mind. The Chart - 4 has a two-fold dimension, viz.,

a) environmental implications pertaining mainly to the assimilative capacity of the environment to receive, absorb and assimilate the wastes and

b) Waste as Wealth : Most of the wastes/residuals are recyclable back into the production stream.

The first one lies outside the scope of the present paper. The second one is our concern. The Chart-4 traces the origins of the resources and delineates the course they take to become products and thereafter in the end, wastes/residuals. These wastes or the **extraction-production-consumption residues** are mostly recyclable to bring them back into the production stream. Therefore, it is rightly said that **waste is wealth** because they tend to become part of the resource-base. They are the potential reserves. For instance, in some of the advanced countries, the recycling of metallic wastes contributes significantly to their total metal requirements. Thus, recycling acts as a **substitute to extraction.** This has far reaching implications in terms of environment, depletion, conservation and so on. Recycling also implies better/wise use of scarce resources and consequently, it has become an important element of conservation. That being its importance, it has to be made as an integral part of the production processes. It should not be considered in isolation; and it should not be treated as a discrete activity separated from production. But it has several problems. Apart from the problems of costs, lagging technology, collection, pricing, subsidies etc., the major problem is that:

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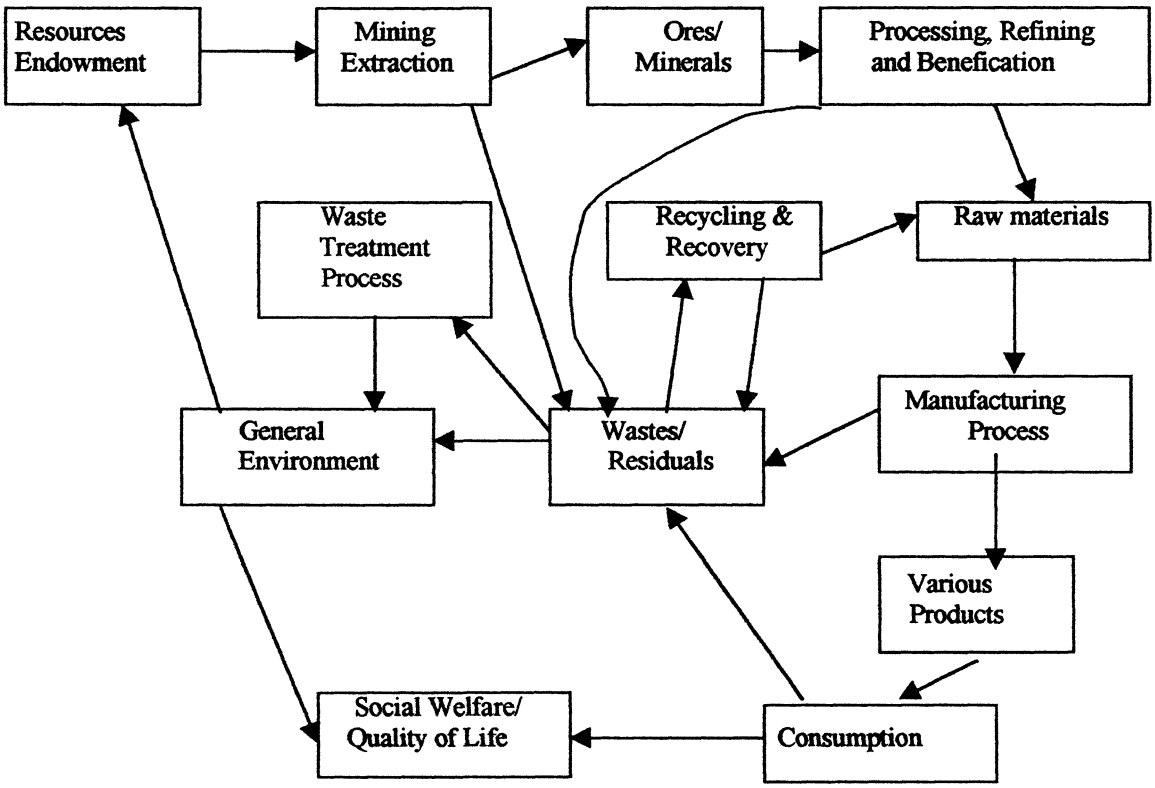
[7] See, Allen V Kneese, **"Economics and Environment"**, Harmonds Worth, Penguin, 1977. This is the classic work of its kind on this issue.

➔ **The society is not institutionally fully equipped to deal with the problems of wastes and their recycling.**

The society needs to recognise the wastes as wealth or as part of the resource base.

Yet another important feature in Chart - 4, though implicit, is that it reveals the whole range of stages/processes involved in undertaking the "Commoditification of nature's endowment".

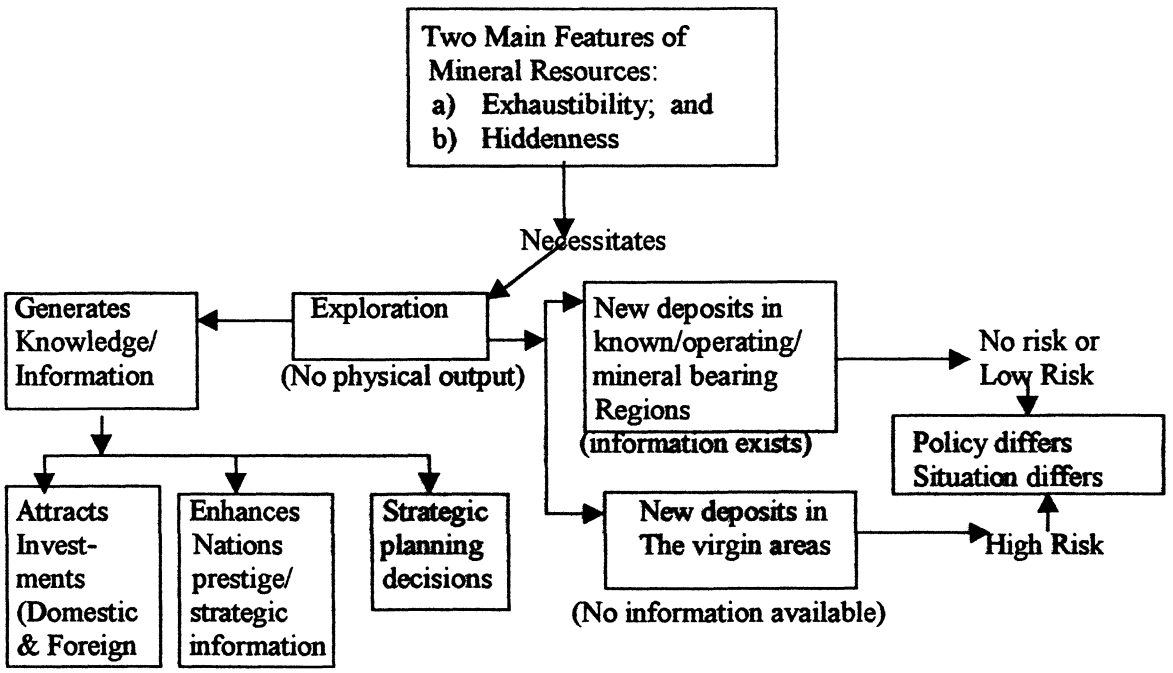
Chart - 4: The Flow Diagram of Resources Use : The Inevitability of Wastes/Residuals:



1.7. Some Policy Issues in Exploration:

Though exploration is vital for the general economic development, it has several problems, which need to be addressed, by the state. The major policy issues involved in exploration have been presented in a summary form in **Chart - 5**. It is widely known that both exploration and exploitation are risky ventures as also highly capital intensive. The following are some of the broad implications arising out of the risk element.

Chart - 5 : Some Issues in Exploration Ventures



Some Policy Issues:

a) Can MNC's be allowed in this sector?
b) Secrecy of information?
c) Costing and Financing of exploration projects whose output is not physical? Who should bear the costs? Present vs. future. Historical cost?
d) How to take care of "Risk"? How to deal with it? Consider the answers in the context of privatisation.

→ If knowledge/information is the output of explorating, THEN:

i. Is it storable? Dissemination? How to price it and sell it?
ii. What right the public has on it? Right to information?
iii. Can we maintain secrecy? Is it ethical? Can the patent rights be applied? Who should own and manage the information?

→ In exploration, both "successes" and "failures" are equally important. Then:
How to deal with "failures"? How to price it?

→ If exploration is a precondition for sustainable development, then:
How to promote it? What policies are needed? How to formulate the national strategy?

a) The promoter has to assume the risk on his own resources as along as **no workable** deposit has been assessed.

b) Exploration is like a big gamble, where, in the end, the best player wins. Similar is the case with exploration provided elaborate techniques are used. However, the number of successful prospects is **very small** compared with the number of failures where money and labour have been spent **in vein**. Consequently, miner must have sufficient resources (i.e., time, space, know-how, etc.) to conduct this job and spread his risk.

c) The prospector must be given irrevocable assurance that he will get the full reward for his work and of his possible findings, and that he will be granted the mining rights (and its renewal) to exploit the newly found deposit on the sole condition that he will comply with the legal requirements.

d) Contrary to the general impression, many mining enterprises operate with a small profit margin.[8] The popular observation is that one single successful venture overshadows the numerous less fortunate ventures or **earlier failures** in various mining projects.

On the whole, it can be said that the mining industry is highly capital intensive and risk prone which finds it increasingly difficult to attract capital and skilled manpower. Keeping in view of the risk factors not only in exploration but also in extraction, it is necessary to formulate a comprehensive policy by the government to encourage exploration, development and exploitation of resources in the general public interest.

1.8. Exploration and Depletion : A Longrun Perspective:

It is necessary to note that depletion is a corollary to extraction because a Ton extracted is a Ton depleted from the finite (known) stock of reserves under workings. Depletion is the inherent feature of mineral resources. If extraction continues without the depleted reserved getting replaced/replenished by exploration through the discovery of new deposits/virgin-areas, then the mining enterprise will have to face the imminent doomsday; or in other words, it tends to cease to exist or even face extinction due to the inevitable danger of facing the total exhaustion of the deposit under workings. Therefore, to make the mining sector exist continuously for fairly long periods and save it from facing the doomsday sooner, there must be timely exploration operations with adequate

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[8] This is a general observation which could perhaps be due to some inherent features of mining operations like the life cycle cost and other trends, the law of increasing costs, high overheads and so on. The mining enterprises will have to take into account these inherent features while making the strategic plans. Another reason could be the negligence of timely initiation of exploration by the mining enterprises to replace the less economic (or less profitable) depleted stock by bringing fresh deposits.

investments to bring in new deposits/virgin areas through new discoveries. Since the main objective of exploration is to replace/replenish the depleted stock, it is to be considered as complementary to extraction. It is essentially a precondition for a sustainable mining sector which in turn, a precondition for sustainable development. Thus, exploration is a driving force for a sustainable mining sector.

➔ Keeping n view of the role and significance of exploration, it is proposed that the mining enterprise is required in the interest of its sustenance, to create an **exploration-fund** like that of the depreciation fund in the manufacturing enterprise. Both the funds are having comparable commonalties in several respects because they deal with a depleting capital stock - one with the Nature's capital and the other with man-made capital. The revenues thus collected through exploration fund can be spent in replacing the depleted stock.

If accepted in principle the proposed fund, then the accounting procedures can be worked out accordingly. The premise is that the resource base has all the qualities to be considered as the capital stock (plant and machinery) to claim for depreciation. There is no such provision at present in the mining legislation or policy.

Longrun Growth Combined with Depletion:

After examining a continuous time series data on output for about 100 years from the very start of a coal mining company which registered a tremendous growth from a meager 10,000 tons per annum during the initial period to about 25 million tonnes per annum in recent periods, it is conceptualised that the longrun growth curve for the mining sector at the macro level takes a **step-wise raising trend** with a small sprouting decline at the peak of each step.[9] It is to be noted that the **extraction-cycle**[10] underlies this longrun growth curve as presented below:

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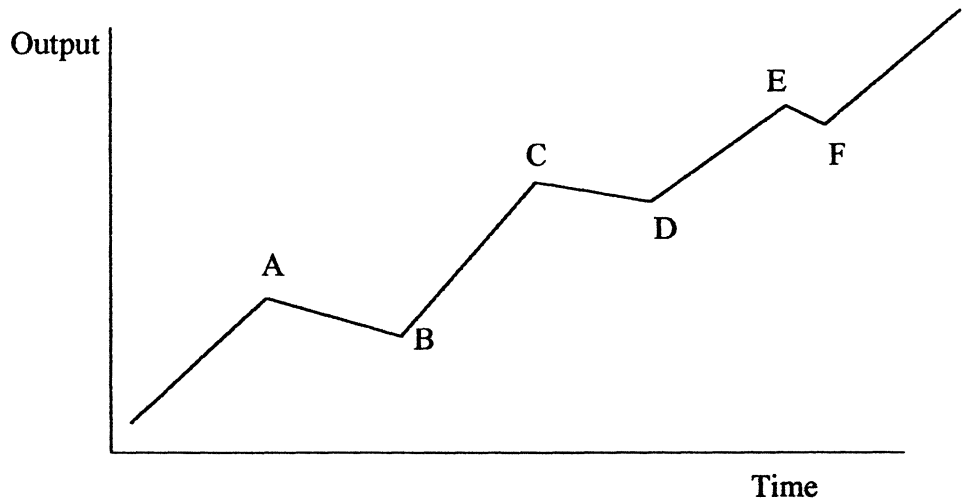
[9] That aside, the process of conceptualisation is mainly based on our several field visits during past couple of decades to both coal and non-coal mines and mining enterprises in India and the educative/informative lengthy discussions we have had with several mine managers; as also based on our field visits to several coal mines in UK, USA and Thailand. Thus, the conceptualisation on the long run growth curve is mainly through **induction** or rather **experience-driven**. However, it stands to the test of logic and reason.

[10] See, N Naganna (1984), "Structural Composition of Costs in Coal Industry : New Perspectives", **The Indian Economic Journal**, Vol.2, Dec.1984, pp.104-132.

Diagram-1 : Longrun Growth Curve Combined with Depletion



The special feature of the above diagram is that the growth is combined with depletion to get some policy guidelines on investment decisions. Achieving growth and maintaining (or sustaining) the growth are two different phenomena. The later can take place through exploration while the former is achievable through the application of more capital and labour. The peculiar feature of the mining industry is that it is in the business of a constantly depleting-asset. **Hence the mining industry has to achieve growth while at the same time constantly coping with depletion**. This growth curve gives.

It can be observed from the above step-wise growth curve that each growth phase is followed by a step (or a flat peak) with a mild sprouting decline represented by AB, CD, and EF points. The reason could be due to the aging mines (or the extraction cycle) and the consequent depletion at each step. At these points, the investment decisions regarding exploration work to add new workable deposits, opening of new mines, developing the new mining fields etc., need to be made. In other words, the growth-oriented or the capacity-creating investment decisions need to be taken at these points. The declining flat peaks (viz., AB, CD, EF) at the end of the respective growth phases, give signals for the likely on-set of depletion and hence, the need for generating additional capacity to keep the mining activity on an increasing straight line. If investments do not take place in time, then that will be the definite beginning for a definite end of the mining activity. Thus, the long run growth curve incorporating depletion summarises the growth path of the mining sector along with the required timely investment decisions for exploration and development. Consequently, this would also help achieve the sustainable mining sector.

SECTION - 2

Like exploration and in equal measure, conservation also achieves sustainability but through an altogether different route. Exploration increases the resource-base by new discoveries of reserves and virgin areas, whereas conservation attacks **'wastes'** of all kinds on all fronts through 'science & technology' as also vehemently advocates the parsimonious/wise-use of resources as against the indiscriminate and reckless exploitation for extravagant consumption. The goal is same but the means differ. Thus both are equally important and necessary in achieving the goal of sustainable development.

2.1. A Policy Framework For Conservation:

Since the general environment in the country became **"balded"**[11] due to various exploitative and other stresses, there is no other alternative except to follow the rigorous policy of conservation across all the sectors of the economy. In this context, the Seventh Five-Year Plan states that the basic approach to all economic decisions would be one of sustainable development in harmony with environment. This is the generally accepted policy. For the sake of simplicity and brevity, the policy framework for conservation is presented in the form of a flow Chart (No. 6). This summarises various forces that led to the general acceptance of conservation as a policy goal by the policy-making machinery because of the fact that the environmental resources impose stringent constraints on policy making.

Because of various stresses **(See Chart - 6)** inflicted increasingly on environment in recent years, the environment is getting incapacitated or debilitated significantly to render its basic functions effectively besides creating a number of formidable environmental problems like soil erosion, pollution, deforestation and so on. This degraded environmental status is described by the acronym "balded" which, in fact, necessitated an increasing concern on conservation and sustainability. This being the case, the crying need for conservation came, in deed, from the growing environmental concerns. In this context, it is rightly observed that:

"The new ethic of conservation of exhaustible resources has grown as concern for the environment has grown, because much of our environmental quality is itself a nonrenewable resource"[12]

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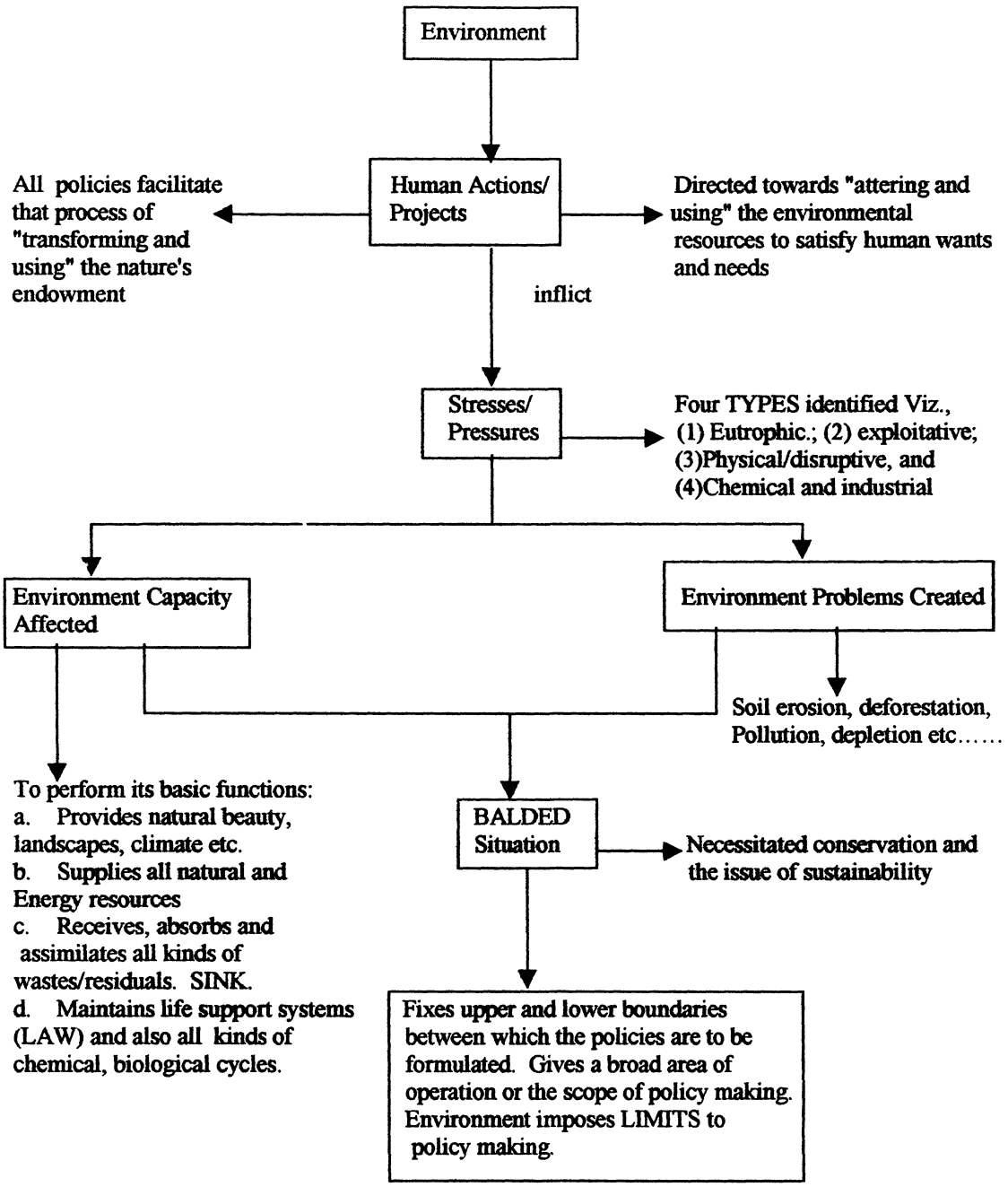
[11] This is not a common word but an acronym coined to describe the present status of environment in our country, where : B = Billion lot (i.e., population explosion); A = Increasing levels of aspirations resulting in more energy and material intensive lifestyles; L = Life expectancy; D = Deforestation; E = Effluents (or wastes) of all types resulting from extraction-manufacturing-consumption system; and D = Depletion of all kinds of natural resources.

[12] R.K. Jain, L.V. Urban and G.S. Stacy, **"Environmental Impact Analysis : A New Dimension in Decision Making"**, Van Nostrand Reinhold Company, New York, 1977, p1.

Chart - 6 : A Policy Framework For Conservation when Environment Became "Balded"



Note: Balded is an acronym, where B = Billion lot (i.e., population explosion); A = Increasing levels of aspirations resulting in enhanced energy and material intensive lifestyles; L = Longevity or the life expectancy; D = Deforestation; E = Effluents (or wastes of all kinds); D = Depletion.

In point of this fact, some people talk about, in the context of developmental concerns, the environmental sustainability where, in fact, they mean resource sustainability. However, both have almost become interchangeable in common parlance.

2.2. Meaning, Scope and Significance of Conservation:

The philosophy of conservation underwent significant shifts with respect to its meaning, content, scope, significance and above all, in its applied usage. So to say, its original meaning went on expanding to encompass the changing socioeconomic conditions, needs and values. In recent years, it has become almost a policy goal or even a terminal-value in several countries though stated in not-so-clear terms. Way back in 1910, Charles R. Van Hise (**op.cit, p 14**) in his classic work on the Conservation of Natural Resources in the USA has observed that : "It (conservation) is a campaign of education, which will extend through generations. But losses have already been so great that the movement should be carried forward as rapidly as possible, especially preventing further wanton wastes. This must be done if our descendants are to have transmitted to them their heritage not too greatly depleted". These words of wisdom have become more significant and relevant today than before. A large number of public movements, lobbies, agitations etc., all over the world would justify the imperative need for a holistic national, perhaps global, policy on conservation. The fact that a separate chapter on "Promoting Sustainable Development : Challenges for Environment Policy" is included for the first time in our "**Indian Economic Survey - 1998-99**" gives credence to the dire necessity for a holistic policy on conservation.

Charles Van Hise (op.cit., p1) considers conservation as: "The natural resources limited in quantity should be conserved. By their conservation is meant that they should remain as nearly undiminished as possible in order that this heritage of natural wealth may pass in full measure to succeeding generations". This principle applies to mainly renewable resources like forests, water, fisheries etc., and partly to non-renewable resource base.

The principle of conservation does not, however, preach abstinence but parsimonious use or wise use of natural resources for human benefit. Abstinence or non-use of natural resources is not the central theme of conservation because it is ridiculous to think of a situation where man just looks on the stock without touching. However, the full accomplishment of conservation of our limited natural resources is not possible. With reference to water, forests, fisheries and other renewable resources, it may be possible to perpetuate their stock in full measure to pass on to the succeeding generations but not the soils and minerals. In this context, the above author (p2) rightly observes that:

"The mineral fuels, when taken from the ground and used, are gone. Thus it is impracticable, indeed impossible, to transmit to our descendants all the fuel which nature has granted us, except upon the basis of non-use and this **no one would advocate**".

In the distant past, when the population size was small with limited needs/wants and the resources plentiful, every one was getting resources for the asking. People thought that land and other resources were infinite and illimitable in their supplies. Accordingly, the socioeconomic systems including the law and customs were adapted to the perceptions of plentiful resource base. Scarcity or otherwise of resources is mainly relative to the population size, demands/markets and technology. For various reasons like the population explosion, rapid industrialisation, ever increasing aspirations, science and technology, ever expanding markets etc., the situation on resources are proved totally incorrect and that therefore, the socioeconomic systems need to be adapted accordingly. The present situation is that the aspirations have become unlimited with limited resource base. The gap between the two is widening continuously resulting in various socioeconomic problems as also the sustainability becoming more critical.

It has been widely appreciated that the minerals and fuels are not infinite and illimitable in their supplies and hence, the need to conserve them. The principle of conservation exhibit different aspects with reference to different types of natural resources like the renewable, non-renewable etc. In our considered view, it can be defined as an approach (or method) to achieve continuing reductions in WASTAGES of all kinds in the recovery, processing and utilisation of natural resources for human benefit such that it saves more and more of resources to the succeeding generations. It is a dynamic concept. Its domain is enlarged over a period of time to cover the areas like politics & public policy, science & technology, economics and moral/ethical codes. The major elements of this approach of conservation include:

a) A careful preservation and protection of something, especially planned management of a natural resource to prevent over exploitation (or over use), destruction, or neglect.

b) Preservation of resources through prevention of loss, waste, damage etc. This is central to conservation.

c) It does not preach abstinence from consumption. No tightening of belts. No non-use advocated. On the other hand, it advocates parsimonious or wise use of natural resources. It directly attacks the "slaughter mining" practices or the "skimming the deposits". More importantly, it encourages maximum levels of recovery from the deposits under working.

d) It attacks the wasteful, extravagant, conspicuous and ostentatious consumption. In other words, it attacks consumerism.

e) Advocates reduction in material intensities of the products or dematerialisation of products through science & technology.

f) Replenishment of the depleted stock through new discoveries and minimisation of wastes in extraction.

g) Reduction in the current rates of exploitation through recycling and recovery. In the same way, it encourages the development of substitutes to both products and scarce resources. Or substitution of scarce resources by more plentiful ones.

h) Most important of all, is its advocacy for less energy and less waste-generating technologies along with less material and energy intensive life styles. Its motto is three Rs (viz., Reduce, Reuse and Recycle).

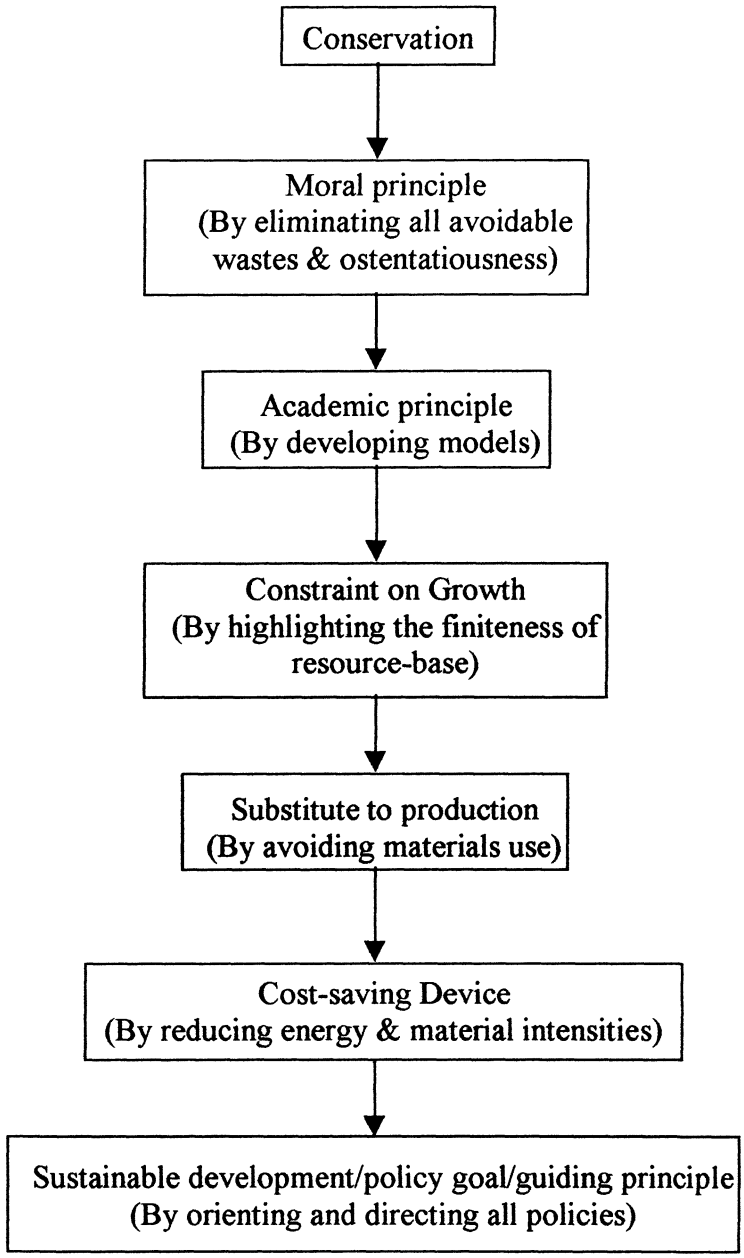
All these above elements of conservation suggest that its goal is to make maximum possible supplies of resources available to posterity after meeting all the legitimate and reasonable present consumption needs. It gives special attention to the non-renewable and scarce resources. Science & technology has a vital role to play in achieving conservation.

Till recently, the conservation and production were considered as independent, separate and distinct entities while in fact, they are not so. This is the gravest mistake unparalleled with any other one in the history of human thought, knowledge and skills. The need of the day is therefore to integrate and combine these two into one with in-built mechanisms to achieve the elements of conservation as listed above to the fullest possible measure.

2.3. Shifts in the Philosophy of Conservation:

On the basis of a quick scanning of literature on conservation, one gets the impression that the principle of conservation underwent a few clearly discernible shifts in its philosophy and applied usage. The original meaning, which was too simplistic and restricted, went on expanding to encompass the changing socioeconomic conditions, needs and values. These shifts are summarised in the form of a flow chart below:

Successive Shifts in the philosophy of Conservation[13]



[13] Charles Van Hise (1910) op.cit.; Harold Hotelling, "The Economics of exhaustible Resources", **Journal of Political Economy**, 39, April 1931, pp 137-175; Anthony D Scott, **"Natural Resources : the Economics of Conservation"**, University of Toronto Press, 1955; Harold J Barnett and Chandler Morse, **"Scarcity and Growth"**, The Johns Hopkins University Press, 1963; Meadows D Et.al., **"The Limits to Growth"**, Universal Books, New York, 1972; Robert Solow, "On the Intergenerational Allocation of Resources", **Scandinavian Journal of Economics**, vol.88, No.1, 1986. David Pearce, et.al., **"Blue Print for a Green Economy,** (Earth Scan Publications Ltd., London, 1989, pp 173-185).

The shifts that took place over time in the focus and philosophy of conservation are self explanatory. All the shifts are nothing but different variants of the same central theme of conservation i.e., save for the future generations not by abstinence but by the wisest use of resources and by avoiding all kinds of conceivable wastages in the extraction-production-consumption processes. The shifts reflect broadly the fast changing socioeconomic and market conditions. The underlying reasons for such shifts could be mainly:

i) Cognizance of the increasing scarcities in resource availability

ii) Faster rates of depletion due to rapid industrialisation and the lagging exploration.

iii) The need to improve the living standards and the poverty alleviation programs coupled with population growth.

iv) Developments in science & technology; increasing knowledge on the criticalities of the resource-base.

v) Expanding markets and increasing competition.

The reasons could be many and varied. But the fact remains that the principle of conservation got transformed gradually from a simple moral principle into one of a **supreme policy goal** i.e., the sustainable development. The increasing realisation/awareness through aggressive selling (or advocacy) strategies on the imperative needs of protecting the environmental resources made, in effect, the conservation/sustainable development as a major guiding principle of all the activities in all the sectors of the economy.

2.4. Achieving Conservation:

It is a difficult task. It can be achieved by both science & technology as well as by bringing attitudinal changes towards extraction-production-consumption processes. A three-pronged approach to achieve conservation is presented in **Chart - 7**. It has to be achieved at three different levels, viz., extraction and mineral processing; production & distribution; and consumption.[14] This is the only way through which the goal of sustainable development can be achieved. Towards this end, the public policies need to be oriented and directed.

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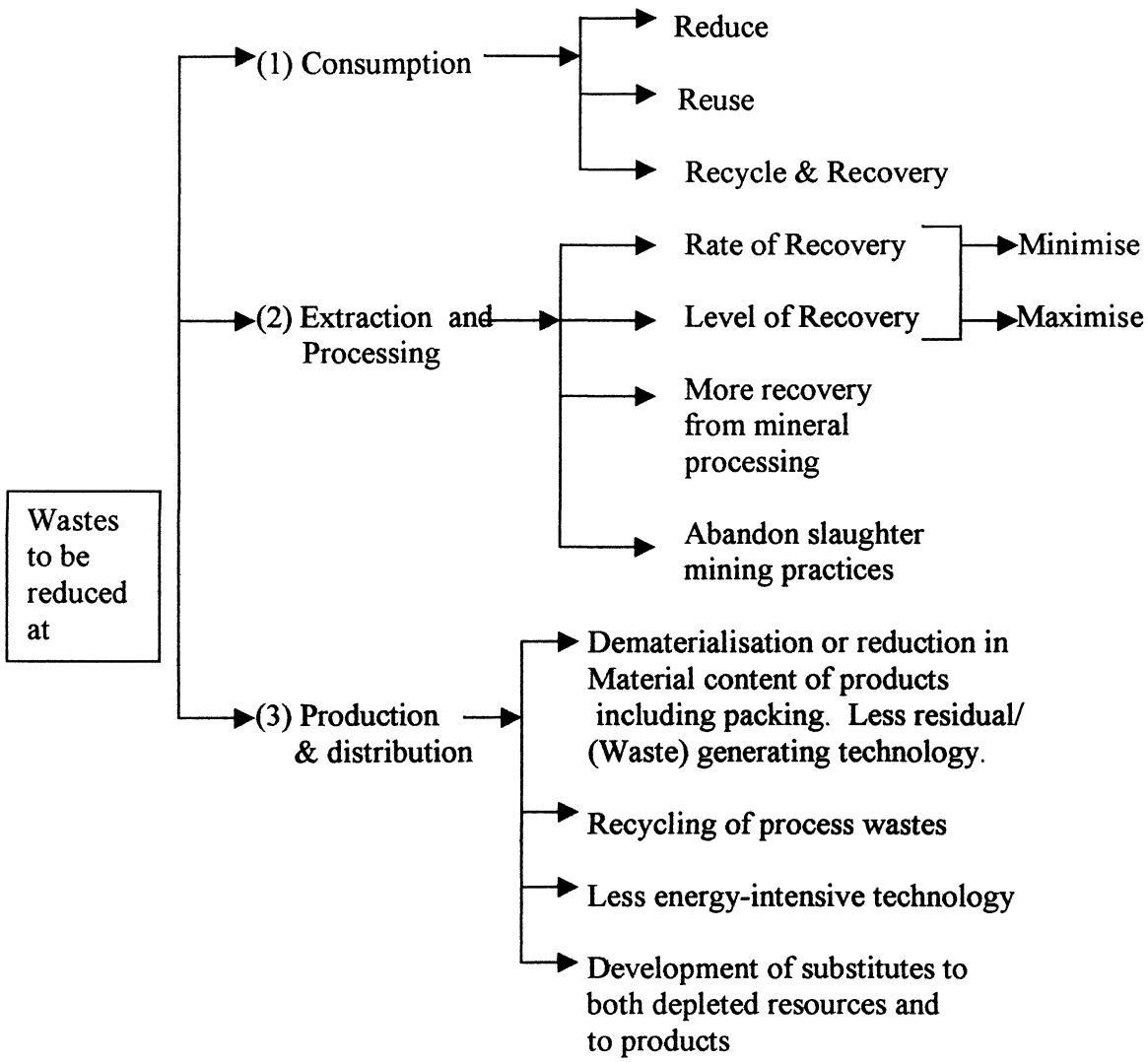
[14] It has been observed that significant results can be achieved in conservation by just improving the simple 'house keeping practices'. This is a zero-cost measure.

See also, N Naganna (1990), **"Conservation and Environment in Mineral Resources Extraction : The Case of Coal in Andhrapradesh"**. (A paper presented at the Eighth Conference of the Andhrapradesh Economic association (APEA) held on Jan.20-21, 1990). An attempt is made in this paper to achieve and integrate both the environmental protection and conservation of mineral resources through the framework of the choice of mining systems.

Chart - 7 : A Three-Level Approach To Achieve Conservation



Interface with Resource-Base: In the ultimate analysis, conservation through its three-pronged approach enhances the life span/longevity of the resource-base by parsimonious use[15] and thus maximise the resources availabilities to the succeeding generations. Besides this, it also reduces significantly the adverse impacts of depletion on the mining sector.

SECTION - 3

In this section, an attempt is made to integrate exploration and conservation with sustainability in the context of economic reforms. At the outset, it is to be noted that the economic reforms, in effect, will have definite impacts on the resource-base because the rates of exploitation (or its corollary, depletion) will have to increase at much faster rates than before to keep pace with the envisaged rates of development. Among other things, this raises the question of sustainability. Therefore, necessary policy initiatives need to be taken up to cope with the rising demands of economic reforms and thereby, to make them sustainable.

3.1. Meaning and Scope of Sustainability (or Sustainable Development):

In recent years, sustainability has become the primary concern of all public policy making, particularly those policies relating to the industry, trade and economic development. The issue of sustainability is considered in so broad a term that it also encompasses the environment. In fact, the vice versa is true. However, the dictionary gives the meaning for the word "sustain" as: Keep from falling or sinking; keep up; maintain. The same meaning is applicable in the context of resources management.

All the discussions and debates on economic development in general implicitly assume that there is some sort of "**capacity-limits**" for the resource-base to sustain the level and pace of economic development as envisaged by the policy makers. However notional it may be, the concept of "sustainability" is entering explicitly as a new dimension into the decision-making processes on economic affairs. Pushing the developmental concerns beyond the sustainable-limits of the resource-base is not a wise policy because it implies the sacrifice of long-term interests in favour of short-term gains. In other words, the failure to account for sustainability **erodes the capital base** for future development. Consequently, the "sustainable development" has become an important **policy goal** for many countries, including India. Accordingly, the governments have also

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[15] Michael E. Porter and Class Van der Linde, "Green and Competitive : Ending the Statement" **Harvard Business Review**, Oct-Sept., 1995, pp 120-134. This is the best paper of its kind which justifies that the companies that adopt the resource-productivity frame work will reap the greatest benefits. In other words, this paper exhibits from the industry's point of view that the practice of conservation is economically and commercially a viable proposition.

See also, Michael E Polter, "American Green Strategy **"Scientific American**, April 1991, p 168. In this paper, the author argues that the distinction between environmental protection and economic competitiveness is in fact a false dichotomy.

accepted the responsibility for promoting the sustainability of development because the "growth-inducing" and "output dominated" economic policies are primarily linked to the resource-base.[16] The policy concern, therefore, is to maintain the stock of productive assets and resource-base intact over time to the extent possible. At the outset, it may be noted that this can be possible only through a continuous program on exploration and the development of substitutes to replace scarce resources wherever possible. But the problem is that most of the resources are complementary rather than substitutes (e.g.: coal and iron ore). In what follows is a brief account of various perspectives or viewpoints on the concept of sustainability or the sustainable development.[17]

(i) Sustainability is said to be:

"Current decisions should not impair the prospects for maintaining or improving future living standards"

(ii) "The development that meets the needs of the present without compromising the ability of future generations to meet their own needs"

(iii) "Sustainable development - development that is likely to achieve lasting satisfaction of human needs and improvement of the quality of life"

"In general terms, the primary objective is reducing the absolute poverty of the world's poor through providing lasting and secure livelihoods that minimise **resource depletion**, environment degradation, cultural disruption and social instability".

(iv) "Sustainable development implies using renewable natural resources in a manner which does not eliminate or degrade them, or otherwise diminish their usefulness for future generations..... Sustainable development further implies using non-renewable (exhaustible) mineral resources in a manner, which does not unnecessarily preclude easy access to them by future generations..... Sustainable development also implies depleting non-renewable energy resources at a slow rate so as to ensure the high probability of an orderly societal transition to renewable energy sources.....".

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[16] See Eighth Five Year Plan document. Also see, **"The Indian Economic Survey**, 1998-99", pp 155-165

[17] David Pearce etal., **"Blue Print for A Green Economy"**. (Earth Scan Publications Ltd., London, 1989; pp.173-185). Most of the definitions or perspectives on sustainability or the sustainable development are taken from this book (pp 173-185). In these perspectives, the major drawback is that they do not provide any space for exploration and conservation, and their impacts on resource-base and its longevity. An attempt is made towards the end of this section to remove that drawback and thereafter, to place the rate of extraction in the sustainability framework.

(v) The guidelines for a responsible natural resources policy to include:

"....activities should be considered that would be aimed at maintaining over time a constant effective natural resource base. This concept....implies not an unchanging resource base but a set of resource reserves, technologies and policy controls that maintain or expand the production possibilities of future generations".

(vi) "The sustainability criterion requires that the conditions necessary for equal access to the resource base be met for each generation"

"....sustainability could imply use of environmental services over very long time periods and, in theory, indefinitely".

The underlying idea to this perspective is the intergenerational equity.

(vii) In utility terms, sustainability is defined as:

- ➔ "Non-declining utility", in other words, "it is the discounted present value of utility that should not decline"
- ➔ "...sustainable development will be non-declining per capita utility - because of its self evident appeal as a criterion for intergenerational equity".

In this case, utility or well being depends on the consumption of goods and services and on environmental quality.

(viii) Some resource economists are of the view that sustainability:

"**Refers to replacing depleted natural resource stocks**" For instance, Robert Solow proposes that:

"**An appropriate stock of capital - including the initial endowment of resources - be maintained intact**"

Solow further says: "If sustainability is anything more than a slogan or an expression of emotion, it must amount to an injunction to preserve productive capacity for the indefinite future. That is compatible with the use of non-renewable resources only if society as a whole replaces used-up resources with something else".

What is being advocated is that we can meet our obligations while at the same time being fair to the next generation by leaving them an inheritance of wealth no less than we inherited.[18] If each generation thinks in this way, then the future generations need not worry.

Most of the propositions assume unlimited substitutability between resources. This appears to be untenable.

(ix) In the same vein, sustainable development is considered as:

"In principle, such an optimal (sustainable growth) policy would seek to maintain an `acceptable' rate of growth in percapita real incomes without depleting the national capital asset stock or the natural environment asset stock". It continues to say:

"It makes no sense to talk about the sustainable use of non-renewable resources (even with substantial recycling effort and reuse rates). Any positive rate of exploitation will eventually lead to exhaustion of the finite stock"

(x) There is another similar perspective which observes:
"This does not mean that sustainable development demands the preservation of the current stock of natural resources or any particular mix of human, physical and natural assets. As development proceeds, the composition of the underlying asset base changes".

Agreement: "There is broad agreement that pursuing policies that imperil the welfare of future generations, who are un-represented in any political or economic forum, is unfair".

Thus, the above brief review though selective reveals that different authors consider sustainability in different ways. Development is not a one-time affair. It is now considered as a continuing process into the foreseeable future as also with multiple dimensions. It is also considered as a process of commoditification of resource-base by making products with utility and salability to satisfy the market demands. It is thus essentially resource-dependent. In developmental policies, time was not considered from resource-supplies/availability point of view till recently. Resources were just assumed to be there in right quantities and qualities, and in right places. But that assumption is being questioned now. For various reasons, a paradigm shift took place in recent years towards giving a due space and cognizance for resource base in developmental strategies. This is the reason why the concept of sustainability came to the fore. Then, the issue comes out to be:

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[18] Robert Solow, "On the Intergenerational Allocation of Natural Resources", Scandinavian Journal of economics, vol.88, No.1, 1986. See also, Myron W Watkins, "Scarce Raw Materials : An Analysis and a Proposal", **American Economic Review**, 1944. T.J.C. Robinson, **"Economic Theories of Exhaustible Resources"** Routledge, London, 1989.

➔ Is continued economic growth compatible in principle with the longrun resource sustainability?

This needs to be addressed before deciding the developmental strategies and policies.

Whatever the perspective that we take on the sustainability or the sustainable development, the future or the interests of the foreseeable future generations enter explicitly into the current decisions on the developmental concerns. Further, it implies primarily the maximisation or the maximum enhancement of the longevity or the durability of the resource-base. Recent debates recognise the fact that the known resource-base has a finite capacity (not infinite) to sustain only a particular level/pattern of development.

3.2. A New Dimension of Sustainability:

The perspectives on sustainable development as presented above reveal that an undue stress is laid on the reckless exploitation of resources without showing due consideration for the future generations. Another drawback is that they do not give an adequate space for exploration and conservation without which, mere taking about exploitation do not mean much. After considering critically the various perspectives, the sustainable development can be defined or rather considered as the resource-specific developmental strategy coupled with a parsimonious social system in a sovereign nation which is determined endogenously and definitely not exogenously modeled; and which is constantly complemented by exploration and conservation programs between which lies the rate of exploitation of non-renewable resources. (This will be diagramed later in this section). This kind of developmental strategy is hoped to achieve a long lasting productive capacity to satisfy the human needs and wants without jeopardizing, to the extent possible, the interests of the future generations. Because, it is ridiculous to think of total abstinence from consumption in the name of leaving them (the future generations) an inheritance of wealth no less than we inherited. Thus, the new paradigm will integrate exploitation with exploration and conservation through science & technology with a view to take care of the genuine interests of both the present and future generations by creating a lasting or non-declining resource-base. In a sense, it implies the management of growth over long periods.

Since this is a laudable concept, most of the countries including the developed countries have now accepted the sustainable development as their **policy goal**. It has indeed emerged as a terminal goal (policy) towards which the rest of the policies are oriented or even directed. But the question is as to how the sustainability to be achieved without sacrificing the current needs.

3.3. Interface Between Sustainability and Exploration:

After having seen various perspectives on sustainability and its historical origins, one can, on general grounds, see a clearly discernible relationship between exploration and sustainability. As a matter of fact, the later shades off into the former. Because the issue of sustainability, in the ultimate analysis, leads for its redressal to a critical evaluation and appraisal of resource base in its varied forms and uses, which really belongs to the domain of exploration. In other words, the sustainability can be quantified and operationalised only through resource appraisal. In this frame work thus contrived, both exploration and sustainability tend to become the two sides of the same coin. Both become inseparable in the context of sustainable development.

Development, as said earlier, is nothing but the process of commoditification of natural resources, including minerals. This being the case, development requires the exploitation of resource base both for domestic consumption and export earnings. The extraction of resources obviously depletes the resource stocks because a ton extracted is a ton depleted. In other words, any positive rate of exploitation will eventually lead to the exhaustion of the finite stock. In point of this fact, we can not achieve development, which is compatible with sustainability. Following the earlier statements on the nature and scope of sustainability, we can not in fact achieve the following elements[19] in economic development:

- **Non-impairment** of future living standards.
- **Without impeding** the ability of future generations to meet their own needs.
- **Lasting satisfaction** of human needs and improvement of the quality of life.
- **Without diminishing** their (resources) usefulness for the future generations.
- **Without precluding** easy access to them (resources) by future generations.
- **A constant** effective natural resource basic; or an **unchanging** resource base for future.
- **Resources availability** over very long periods, or in theory, **indefinitely.**
- **Non-declining utility** or the non-declining per capital utility or the intergenerational equity.
- **Replacing** the depleted natural resource stocks.
- An appropriate stock of capital is maintained **intact.**
- Leaving them (to the future generations) an inheritance of wealth **no less than we inherited.**

This is to show that development is not compatible with sustainability unless otherwise it is complemented by exploration. All of the constituent elements of sustainability as listed above can be achieved to a significant measure by continuously undertaking the intensive exploration programs on an increasingly large scale to bring in new deposits and virgin areas to replace the depleted natural resource stocks; or to maintain the resource base intact for future generations. It can, therefore, be inferred that:

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[19] They are all the elements of sustainable development as enunciated earlier.

"If depletion is a corollary to extraction, then exploration is complementary"

Exploration constantly replenishes the depleted stocks to see extraction continues over very long periods. Otherwise, the "dooms day" will be reached. Thus, exploration essentially achieves sustainability or the sustainable development by:

- replacing or replenishing the depleted resource stocks
- by maintaining the resource base intact
- by preserving the future living standards without impeding the ability of future generations to meet their own needs
- by providing an unchanging or non-declining resource base for the future
- by ensuring resources availability over very long periods

and by leaving to the future generations an inheritance of wealth no less than we inherited. Development is thus made compatible with sustainability. Therefore, it follows that the sustainability or the sustainable development can be achieved through exploration coupled together with the conservational practices at all levels/fronts. As noted earlier that conservation also enhances the life span of resource base though from a different route. Both have the same goal of achieving sustainability.

3.4. The Asymptotic Limits:

Exploration can not go on indefinitely yielding results in terms of discovering new deposits and virgin areas. A time will come when the whole geographical area including oceans will be fully explored. The whole lot of geo-technical information on resource base is made available. In other words, exploration will reach the asymptotic limits on some day or the other when it can not add anything new to the existing stocks. At this point, two things are likely to take place to achieve sustainable development. They are:

a) Primacy of conservation over exploration by vehemently attacking all types of wastes in the production-consumption streams, and by reducing the material-intensities of the products, (including recycling), and also manipulating the current rates of extraction by better mining systems.

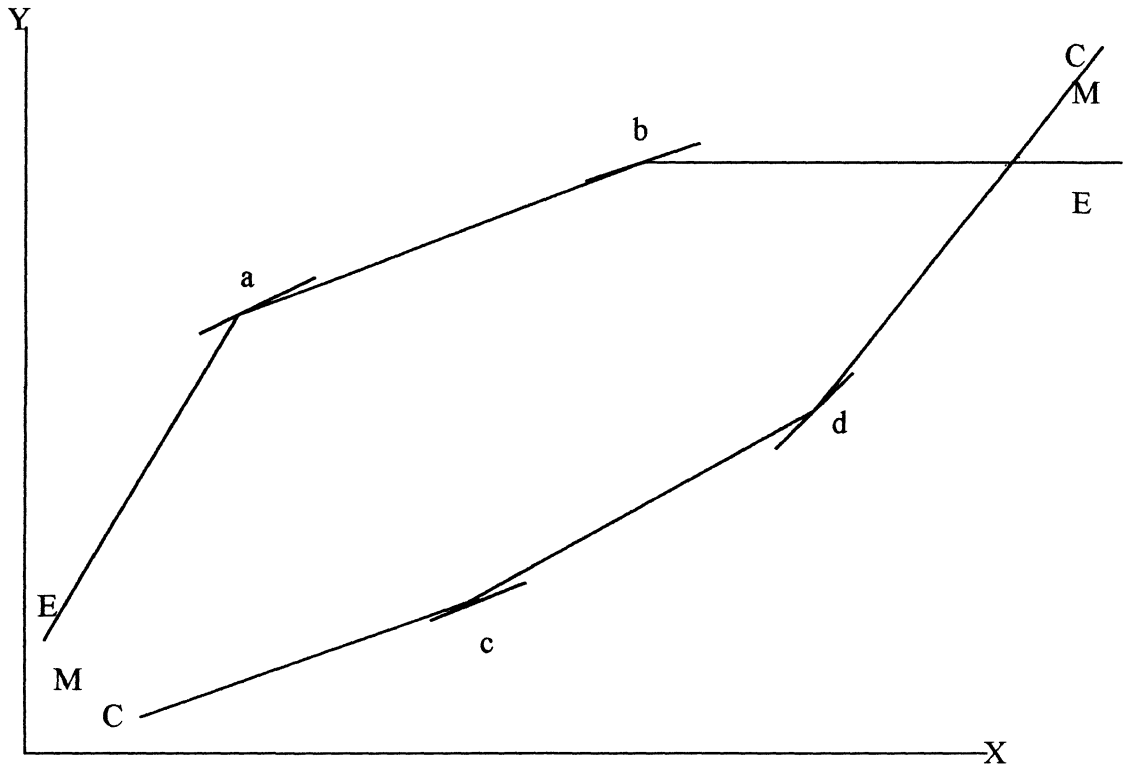
b) Science & technology will assume greater role in developing substitutes to both products and depleted resources; as also achieving better levels of recoveries from mines/resources.

It is necessary to rely on non-exploration and conservation to achieve sustainability or sustainable development - the supreme policy goal. However, their relative roles may be changed in the longrun in the sense that there will be the primacy of exploration over conservation before the geographical areas get fully explored and thereafter, there will be the primacy of conservation over exploration.

3.5. Long run Trends and Sustainability:

By definition, the sustainability or the sustainable development refers to the longrun trends in resources availability or the supply side of the developmental strategies Although, forecasting in these matters is a difficult and complex exercise, it needs to be taken up to get some surmises or even advance information on the basis of which, policy modifications and future investment decisions can be made The issue is one of generating surmises or the conjectures about the future patterns of sustainable development in an exploration-exploitation-conservation framework, which underlies behind the sustainability The conjectures thus generated will have immense use in making long range planning and in evolving a policy design for the mining sector It gives, among other things, the preparedness to the economic system The longrun trends in exploration, exploitation and conservation underlying the principle of sustainable development can be conceptualised through diagrammatically as below

Diagram - 2: Longrun Trends in Resource base and Sustainability



This is only an attempt to conceptualise the longrun trends in resource base with reference to sustainability EE curve represents exploration, MM curve exploitation and the CC curve refers to conservation. On the X-axis, the exploration, exploitation and conservation activities are represented In this context, it may be noted that conservation is considered in broad terms so as to include the attacks on wastes of all kinds on all fronts, reduction in material intensities of products, more recoveries from the resources and the mines etc , such that the life span of deposits (or resource availability) increased And on the Y-axis, the discoveries of new deposits, virgin areas, resources base etc , are

represented to show mainly the supply side of the economic system. It may be noted that conceptually both conservation and exploration add to the resource availability/resource base as also increase their longevity. Both are driven by science and technology, and both are continuing processes over long periods.

The above diagram shows that the outcomes of exploration reach the asymptotic limits. This state is a crucial one. It shows that new discoveries can not increase the resource base since the whole area is fully explored. The resource base becomes static with no likely foreseeable reserves getting added to enhance its longevity with current rates of exploitation remaining constant. This being the case, the forces of sustainability will have to come from a different source (i.e., conservation, and science and technology). On the other hand, conservation takes a different path without any asymptotic limits. It continues indefinitely though with different intensities and growth rates. This is the difference between the two. After exploration reaches its asymptotic limits, the primacy of conservation over exploration takes place. This turning point is represented by 'A' in the diagram. In fact, this is not a point but a period, which can take place any time after exploration, reaches its limits. Therefore, it is to be understood that there exists a period (the point 'A' in the diagram) during which a transition to the primacy of conservation over exploration takes place (including the development of substitutes to depleted resources and to products). This means that the resource base will be maintained more by "science & technology" rather than by new discoveries. This can also be considered as a paradigm shift from exploration to conservation. In other words, policy shifts are likely to take place during this period in favour conservation.

After the exploration reaches its asymptotic limits, there will be an increasing role to science & technology, and the market conditions. The developments in technology may bring the hitherto technically inaccessible and uneconomic deposits into the commercially viable category, implying thereby that the resource-base is increased. Similarly, the depletion and its consequent scarcity resulting in rising mineral prices may also add significantly to the process of converting the hitherto uneconomic deposits into profitable reserves. This trend will also lead to the development of substitutes to overcome scarcities. The extent of market expansions may also cause similar positive effects on resource-base. All these techno-economic changes will have implications in sustainability. Thus, sustainability is a dynamic concept as it varies with resource-appraisal.

Another interesting observation is that the rate of exploitation always lies in between the rates of conservation and exploration. Otherwise, the result will be the "dooms day" or the sustainability can not be attained. In this case, depletion will have an overriding influence on resource base, which will be exhausted soon due to lack of new discoveries. However, conservation being what it is, may counter this trend to enhance the durability of resource base. This is the reason why the rate of exploitation will have to lie in between conservation and exploration. In effect this is to be considered as a necessary condition for sustainability while the sufficient conditions being the adequate public investments on conservation and exploration.

It is to be noted that the shapes of the curves and their slopes, the inflexion and intersection points etc., in the diagram depend upon several factors like the extent of potential resource-base and the mineral bearing areas, rate of development; investment patterns, population size, status of environment and so on. As a matter of fact, one can easily identify broadly three phases in diagram-2 during which exploration and conservation register different patterns of growth rates implying different meanings and policy recommendations.

The above diagram serves as a tool to analyse and understand the broad implications of long range policy and planning with a view to achieve sustainable development. Sustainability or the sustainable development implying a sustainable mining sector requires that the MM-curve will have to lie much below the EE-curve till it reaches the period of asymptotic limits and thereafter it has to lie below the CC-curve. A number of variants or a combination of different scenarios can be worked out depending on the analytical needs and the policy decisions. In other words, a set of different long-range scenarios can be worked out on the relative positions of exploration, exploitation and conservation in the domain of resource base and its utilisation. On the basis of this analytical framework, public investment decisions and priorities are to be made.[20] **This is what is required in policy making if sustainability is to be anything more than a slogan or an expression of emotion** as Solow observed earlier.

Three Propositions: One can derive broadly three propositions on resource utilisation from diagram-2. They are:

Proposition-1: Sustainable development or sustainability requires that the rate of extraction will have to lie always somewhere in between the rate of exploration and the level of conservation. This is a necessary condition. As a corollary, it can also be surmised that the doomsday and its consequential zero-growth policy can be escaped for long periods by this approach.

Proposition-2: For any reason, if the rate of extraction is pushed above both exploration and conservation, then the doomsday is imminent and that too, sooner than expected.

Proposition-3: If the rate of extraction lies below the exploration and conservation, then it can be inferred that there is under exploitation of resource base implying thereby a large potential for sustainable growth.

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[20] In this frame work, it may be noted that sustainability does not advocate for a reduction in the current rates of exploitation to increase the life span of the resource base. Because this implies, in effect, a reduction in living standards. On the other hand, sustainability implies the sustainable maintenance of current rates of exploitation over very long periods while at the same time keeping the resource base intact by continuously undertaking exploration, conservation and the development of substitutes to replenish the used-up or depleted resources and to the products with different materials and intensities. Accordingly, the public policies need to be directed towards this end.

SECTION - 4

In this section, an attempt is made to bring out some broad policy implications of sustainability or even policy initiatives particularly in the context of the on-going economic reforms. Sustainability is in fact the public concern because it is a campaign for the protection of the interests of future generations. And, its counter parts viz., conservation and exploration are also equally concerned with the future generations. In point of this fact, the public policies need to be oriented towards achieving sustainability or the sustainable development.

4.1. Economic Reforms and Sustainability:

Economic policy reforms need to be endogenous and resource specific for their successful implementation, compliance and anticipated outcomes. Whatever the form, the speed and phasing they take, the economic reforms will have definite impacts on the resource base as they envisage faster rates of development than before. Since this obviously implies faster rates of extraction/depletion, the issue of sustainability comes to the fore. In fact, the later implies the management of growth. The policy issue is therefore one of making sustainability compatible with economic reforms. On the other hand, the mining sector in general has to respond to the new economic policies without any frictions and bottlenecks.

The faster rates of depletion resulting from the new economic policies obviously imply the imperative need for undertaking exploration/prospecting ventures on an increasingly large scale and thereby, to update the resource stocks and replenish the depleted or depleting resource base by newly discovered deposits. In other words, the need is a critical and thorough reassessment of mineral resources periodically to sustain the impacts of the economic policy reforms. The policy initiatives are to be taken up to make sustainability compatible with economic reforms through exploration and conservation.

Policy Shifts: Another important policy implication is that the economic reforms induced concomitant shifts in mineral policies to keep pace with the demands of new economic policies. All these policy shifts changed the whole policy-making environment in the country. Before the introduction of economic reforms in 1991, the mining policy was mainly geared towards facilitating and encouraging the domestic exploitation of mineral resources mostly under the public ownership while at the same time ensuring safety and conservation.[21] Exploration work was carried out by the central and state governments through various agencies like the GSI, Minerals Exploration Corporation, State Departments of Mining and so on.

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[21] The mining policy and legislation in India before economic reforms are given in the paper on **"Mining Legislation and Administration in India"** (pp 113-136) in the **"Proceedings on the Seminar on Mining Legislation and Administration"** (Mineral Resources Development Series No.34; United Nations, 1969). This gives a cross-country comparisons on mining policies and ownership patterns. Also brings out a case for private sector participation in mineral exploration and development.

After the economic reforms, the mining sector is opened up to both private and foreign enterprise participation in the areas of exploration, development and exploitation of mineral resources.[22] In the process, conservation got lesser concern while environmental protection entered explicitly and in a significant measure, in the new mining policy. This is a remarkable feature in the recent policy shifts. However, conservation and exploration need to get their due space in the new mining policy.

4.2. Policy Implications of Exploration and Conservation:

As said earlier that there are broadly two policy modes viz., exploration and conservation, through which the issue of sustainability can be made compatible with economic reforms. Chart Nos. 5 and 7 identify a number of policy implications on exploration and conservation respectively. In the same way, the diagram-2 explains and integrates the relative positions of exploration, conservation and exploitation in a sustainability framework. Similarly, the diagram-1 integrates growth with depletion as also give timely signals to take up exploration ventures. Although the generalisations contained in them are in nascent stage, they have wider policy implications. They also suggest that the ordeals of doomsday can be mitigated by timely decisions and prudent planning.

Since exploration is a capital-intensive activity coupled with high risk, the private enterprise does not seem to be enthusiastic to enter into this area though the new mining policy allows private participation.[23] Another problem is that the exploration work does not produce goods with readily available markets but only information for which the buyers are very limited in number. In addition, exploration is a highly heterogeneous activity yielding different results in different places with the same technology and skills. The probability of potential discoveries vary drastically from place to place. There is yet the problem of spreading and costing the risk element.[24] All these issues, in effect, make the costing and pricing of geologic information a formidable task which impedes the private sector participation. The costs of exploration are a critical issue to deal with.

Since exploration has a large social-benefit angle, the state participation appears to be inevitable in this vital area. The state can introduce an exploration-cess on mineral outputs to collect revenues from the existing mining industry and the revenues thus collected can be spent on exploration ventures to replenish the depleted stocks by new discoveries. These investments need to be made on highly risk-prone virgin areas. Sustainability is thus built into the mining system. In other words, the risk capital on exploration is internalised. In addition, the state may have to create favourable conditions and incentive schemes to attract risk capital for exploration ventures from the

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[22] See, **The Hindu**, "New Mining Policy" dt.: 2.8.1995; **Business Line**, dt.:31.12.1995; **Financial Express**, dt.: 27.12.1995; **Economic Times**, dt.: 30.12.1995.

[23] See, **The New Indian Express**, dt.:20.8.1999.

[24] Alan Gersten, "International Risk Management : Case Study - Eastern Exposure", **Journal of Accountancy**, August 1999, pp 53-58.

private sector. The state can also encourage the foreign direct investment in this area by providing various incentives and guarantees. Because, increasingly more reliance needs to be placed on the capital intensive exploration techniques to achieve and maintain high growth rates in the mining sector.

As against exploration, conservation is a very vast area covering the whole gamut of extraction-manufacturing-consumption streams. It has to be made, as an integral part of all these processes as also needs to be internalised by all the decision-making systems in the society. Conservation should become the guiding principle in public policy making. It is a two-fold campaign, the first being waged against all the conceivable wastages while the second advocates "savings" of resources through all the conceivable means. Through education, it is to be made as a way of life. This is perhaps the only way to save the country from becoming a prodigal nation.

Conclusion:

One of the major impacts of economic reforms will be on the extraction sector resulting in faster rates of depletion than before and thus making the sustainability a critical issue. To keep pace with the increasing demands of economic reforms, significant shifts were made in mining policy allowing both private sector and foreign enterprise participation in exploration, development and exploitation of mineral resources. All lead to faster rates of extraction than before. In effect, over-exploitation may result in total depletion of scarce mineral resources and thereby, depriving the future generations with adequate mineral deposits to maintain their production levels. It is argued that the issue of sustainability can be made compatible with economic reforms through undertaking exploration ventures and conservation programmes on a continuing basis. The public policies are required to be oriented towards this end. Otherwise, sustainability will have to remain nothing more than a slogan or an expression of emotion.