Conservation & Environment: Implications in Theory, Practice and Policy

by

N. Naganna

January 2001

Please address all correspondence to:

Dr. N. Naganna
Professor (Energy)
Indian Institute of Management
Bannerghatta Road
Bangalore – 560 076
Fax: (080) 6584050
E-mail: naganna@iimb.ernet.in

CONSERVATION & ENVIRONMENT : IMPLICATIONS IN THEORY, PRACTICE AND POLICY
(with an Empirical Case Study)

N Naganna

INDIAN INSTITUTE OF MANAGEMENT BANGALORE
BANGALORE

ABSTRACT

Both conservation and environment together with exploration are the basic elements in sustainable development. The three need to be given their due space in public policy analysis. Otherwise, policy making will merely be target-fixing and slogan-driven.

The objective of this paper is to examine and analyse the issues of both conservation and environment together in the development and exploitation of mineral resources in a historical perspective. It deals both with the theory and practice of conservation which is, in fact, a part of environmental management.

At present, there is a general consensus that sustainable development implies an active role for government in efficient and equitable management of natural and environmental resources. In this context, AC Pigou wrote in 1932 that:

"It is the clear duty of Government, which is the trustee for unborn generations as well as for its present citizens, to watch over, and if need be, by legislative enactment, to defend the exhaustible resources of this country from rash and reskless spoilation".

The present paper observes that the real costs of coal in future will be much higher due to the inclusion of social costs and conservation practices. The policy of cross-subsidization at the corporate level is identified as the best possible solution to the problem of achieving conservtion in mineral resources development and exploitation. Perhaps, the very nature of resource-base requires this policy for rational resources management.

A POLICY INITIATIVE/PRESCRIPTION..........

In the context of "**Conservation & Markets**" (see p.47 of this paper), it has been observed that there is a major conflict between the level of recovery and the rate of recovery. There is yet the problem of the law of increasing costs. From these two fundamental observations and from the feel of the detailed analysis on conservation and environment as presented in this paper, it follows that the mining activity in general need to be geographically planned, controlled and regulated through state intervention. In the ultimate analysis, this implies concentration of workings/higher mining intensities in smaller geographical areas. Wide scatteration of mines over large areas with lower mining-intensities seems to be a major deterrent to conservation. Instead of opening a large number of small scattered mines over large tracts of mineral-bearing areas, it is better to open a few large mines in smaller areas. Thus the deterrent is overcome. The evaluation and monitoring parameter will be the **"mineral output per hectare of mineral-bearing area".** This is the remedial policy measure to achieve conservation/sustainability which, together with cross-subsidization, would ensure not only conservation but also more rational management of natural resources.

Operationalisation & Strategy: The implementation package for such a policy will comprise the following: i) a detailed mapping of the whole mineral-bearing area; ii) stratify/segment this area by blocks; iii) grade these blocks by their quality, quantity, mineability/recoverability and other geological factors; iv) then take up block-after-block extraction; (i.e., a new block will be permitted only when the old one is totally depleted or the last ton removed); v) regulation & control through legislation and licensing; vi) sequencing of blocks for extraction overtime, involves social choice on the basis of quality/grades, recoverability etc.

This system of block-after-block extraction would ensure better laying and utilisation of infrastructural facilities, ease of management and supervision, better public vigilance and transparency, better environmental protection planning and so on. The proposed policy initiative with an alternative arrangement of mining facilities is, perhaps, ingrained in the very nature of the resource base. It is only brought to the fore.

INTRODUCTION

Both conservation and environment together with exploration are the basic elements in sustainable development. The three need to be given their due space in public policy analysis. Otherwise, policy making will merely be target-fixing and slogan-driven.

The objective of this paper is to examine and analyse the issues of both conservation and environment together in the development and exploitation of mineral resources in a historical perspective. It deals both with the theory and practice of conservation which is, in fact, a part of environmental management. The paper tries to analyse the implications in theory and practice of conservation **(at the industry level)**, the root cause for which is the prevalence of the law of increasing costs in the extractive sector. In the process, a number of formidable conflicting situations have been identified between environment and conservation which calls for compromises. The analysis is carried through **a detailed empirical case study** on coal resources development, exploitation and management, in Andhrapradesh. It is based on field investigations/visits. An attempt (I don't know whether aborted or otherwise) is made to furnish with a wholesome analysis to contrive a policy-design for making realistic policies. It has been realised in the process that it is not only tough but painful to be analytical because of the difficulties in unriddling several conflicting situations.

Both environment and conservation are integral parts of sustainable development. It is not only difficult to define the meaning and scope of sustainable development but defies measurement by any single index. It is easier to identify policies that would contribute to achieving sustainable development than to define the term itself. There are plenty of examples on unstainable or at least inefficient or wasteful practices. The present empirical case study is a case in point.

Way back in 1908, the natural resources policy is defined as: "the use of foresight and restraint in the exploitation of the physical sources of wealth as necessary for the perpetuity of civilization, and the welfare of present and future generations". And the conservation as: "the preservation of the unimpaired efficiency of the resources of the earth" (Charles S Pearson, 2000, p.471).

At present, there is a general consensus that sustainable development implies an active role for government in efficient and equitable management of natural and environmental resources. In this context, AC Pigou wrote in 1932 that:

"It is the clear duty of Government, which is the trustee for unborn generations as well as for its present citizens, to watch over, and if need be, by legislative enactment, to defend the exhaustible resources of this country from rash and reskless spoilation". (Requoted from Charles S Pearson, 2000).

Therefore, the governments have to revitalise their role as trustees of the natural wealth/resources to see the preservation of the unimpaired efficiency (particularly the intertemporal efficiency) of the resources of the earth. The cognizance of this great role entails policy making machinery to consider sustainability encompassing environment, exploration and conservation as its core instead of periphery as seems the case now.

The present paper observes that the real costs of coal in future will be much higher due to the inclusion of social costs and conservation practices. The policy of cross-subsidization at the corporate level is identified as the best possible solution to the problem of achieving conservtion in mineral resources development and exploitation. Perhaps, the very nature of resource-base requires this policy for rational resources management.

Conservation and Environment : Implications in Theory, Practice and Policy
(With an Empirical Case Study)

N NAGANNA*

The objective of this paper is to examine the issues of both conservation and environment together in the development and exploitation of mineral resources in a historical perspective. It deals both with the theory and practice of conservation which is, in fact, a part of environmental management. The paper, however, concentrates on the coal resources in Andhra Pradesh with a passing mention of other minerals here and there.

The paper is divided into four sections. Section-I sketches broadly the developments in mineral economics as also the concept of conservation. Section-II examines the problem of conservation through the **law of increasing costs** generally associated with the extractive industries. Section-III attempts an empirical analysis (or rather the extent of urgency) of the probiem of conservation of coal resources in Andhra Pradesh which sometime back completed the centenary year of coal exploitation. Section-IV deals with conservation and environment together through a choice framework of mining systems. Further, cross-subsidization is suggested as a policy instrument to achieve conservation at the corporate level.

SECTION – I

1.1. Socio-Political Importance of Mineral Resources:

Mineral are considered to be the key of development and the foundation upon which our modern society is built. It is aptly stated that : "Mankind's progress is measured in minerals"; because minerals are considered historically as symbol of wealth, of power, of culture, of adornment, as a measure of the capacity to make war, as a basis of trade, as a tool for political gain, or international intrigue. The role of minerals is increasing over a period of time (See, Naganna 1989), particularly after the advent of modern industrialism with its emphasis on large scale production and international markets. In this context, it may be noted: "With the increasing use of metals, and more recently of fuel and energy minerals, the desire of nations or groups of nations to control supplies has grown. The economic pressures are strong today, and these economic pressures can influence the ebb and tide of war, political affiliations, international treaties and pacts". (See, McDivitt and Jeffery, 1976). This being the case, the mineral resources are to be extracted cautiously without any avoidable wastages. This implies maximum "level of recovery" from a

---

*Indian Institute of Management, Bangalore, India.

mineral deposit embedded under the geographical boundaries of a mine. Because, when once a mine is closed, it is very difficult, even technologically at times, to reopen it. With the ever increasing importance, role and demand for various types of minerals while at the same time the alarming signals of scarcities coming to the fore concurrently, the planners and the technologists together started paying more and more attention to maximise the "Levels of Recovery" from the mines by shifting to more productive mining systems with new technologies. In the past, this was ignored. The present techno-structural shift made a large dent on society, employment, labour/skill markets, environment and so on. This shift, though on a lesser scale than the occasion calls for, goes a long way in increasing the life spans of the known mineral deposits and thereby, contributes to sustainable development.

1.2. Some Comparative Developments in Economics:

In the external physical world, there are broadly three types of operating units that transform the objects of nature into consumable, usable and salable products. They are the firm, the farm and the mine (referring to all natural resources), and all of them are interconnected through various social and economic forces*. This interconnectedness is almost totally neglected both by theoreticians and empiricists resulting in independent developments in the theories of the firm, farm and the mine. The cognizance of such an interconnectedness would have given us a more comprehensive and unified theoretical framework and thus, would have resulted in a better/more rational allocation of resources. Besides, this would have also resulted in better/higher levels of conservation through better unit level planning and design on the basis of economic considerations.

Economists have so far been concerned largely with the analysis of the firm – the manufacturing unit, in regard to the development of logical structures for their inferences/generalisations on production and consumption. Such an undue concern led to the development of a full-fledged theory of the firm. This was perhaps the resultant of the phenomenal growth of trade and commerce in manufactured products ever since the advent of industrial resolution. While discussing the role of economics, Schumacher (1974) remarks that economics as currently constituted fully applies only to manufacturers. Further, he adds that it is being applied without discrimination to other sectors. One such indiscriminate application is in the area of the analysis of natural resources (or sub-soil) extraction.

The widespread recognition of the effective linkages between agricultural and industrial sectors through the laws of supply and demand, the theory of the farm was given an adequate attention particularly after the start of the growth theories and the concept of balanced growth. As a matter of fact, the development of many of the economic doctrines have their historical origins (physiocrats) mostly in the studies

---

*In this context, the concept of 'farm' is supposed to cover all the renewable resources like agriculture, fishery, forestry etc. whereas the mine refers to the extraction of non-renewable resources and the firm to the conversion of raw materials into products.

relating to agriculture. However, in the process, the theory of the mine is not given a proper attention and thus pushing the subject (i.e., mineral economics) into the no-man's land between mining engineering and economics.

Economic analysis of the mineral industries may take either of the two approaches viz., production or depletion, although production and depletion are the two sides of the same coin. Because, a tonne extracted is a tonne depleted. A brief review of literature on the economic analysis pertaining to the mining sector shows that there are striking differences in approach between models in which mining is regarded as a production activity; and models in which mining is regarded as a production activity coping continuously with depletion. However, the best model would be the one that combines the elements of both. A cursory glance at the literature on the economics of extractive industries reveal the following[1]:

i) a mine is viewed more as a depleting asset rather than a producing-unit.

ii) The theory of the mine is, by and large, a logical extension of the theory of the firm though mining and manufacturing are entirely different (See Naganna, 1981).

iii) Most of the research works are either explicitly or implicitly based upon the principles of conservation rather than of production. Thus, the "economic problem" is approached not through production but through depletion. Consequently, an imbalance is created in the present analytical framework on the mineral economics. This could even harm the conservation itself.

Due to extra emphasis laid on depletion and consequently on conservation, the referents for policy, planning and resource allocation in a mine have been obscured. This does not go well from the total systems view point*. Further, the basic distinguishing feature of the mineral industries can be summarised by the statement that equal amounts of efforts (of labour, capital and management) yield unequal amounts of results (or outputs). This is the underlying problem or principle which gives rise to or runs across

---

[1] For a brief review of literature on the economics of extractive industries, see Anthony D. Scott, "**The Theory of the Mine Under Conditions of Certainty**" in Mason Caffney (ed.) "**Extractive Resources and Taxation**". The University of Wisconsin Press, Madison, 1967. See also other papers in this book. See also, William A Vogely and Hubert E Riser (ed.,) 1976.

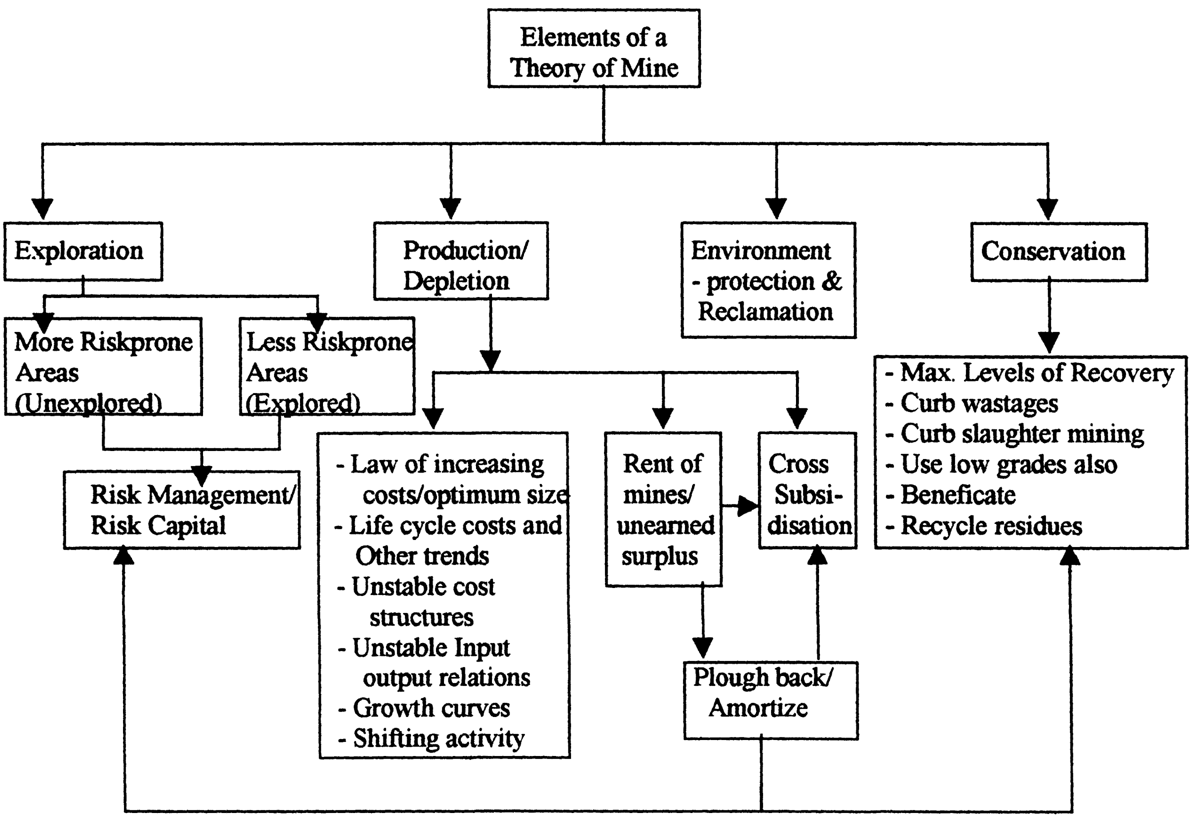
Recently, Robinson (1989) delineates in detail the historical growth of economic literature through the resources view point, particularly after examining the writings of prominent authors including Adam Smith, Ricardo, JS Mill, Marshall etc. The focus is on the conflicting views (pessimistic or optimistic) about the future availability of resources.

* This is not to undermine conservation but to highlight the fact that the over-emphasis on depletion led to making a number of **dooms-day messages** instead of achieving 'conservation & production' through minimum cost point of view. In fact, this calls for a different strategy which combines both production and depletion through an enlarged theory of mine covering the elements such as exploration, conservation, the laws of increasing costs, the life cycle cost and other trends. This type of a holistic theory needs to be constructed replacidng the present segmented approaches. It would also ensure better natural resources management.

all other related problems in conservation, depletion, pricing and so on. In fact, this necessitates a different kind of conceptual framework. The above statement is both the premise and outcome of the Ricardian rent theory which was extended to rent of mines by Ricardo himself (See, Naganna, 1974). However, this continued to remain an under-researched area in economics. It can be observed from the rent theory that the mineral economics has its philosophical origins in the conventional economic literature while its empirical origins can be traced in mining engineering.

1.3. Need for a Full-fledged Theory of Mine:

Like the theory of firm, the non-renewable resources management requires a full-fledged theory to allocate resources within a mine and to explain, predict and control the economic phenomenon. The broad elements of such a theory is presented in a chart form below. All the elements are interrelated to deduce various propositions.



Theory Building/Construction: The formulation of a theory can be undertaken either by:

a. Deduction (from general to particular), or

b. Induction (from particular to general); also called **grounded theory**

Deductive theorising requires us to come up on the basis of general principles with a theoretical formulation which will then be translated into hypotheses/surmises/contentions and subsequently TEST to find out whether the facts confirm or disconfirm the theory thus made. In short, we move from general to the specific. In the case of deductive theorisation, we have an IDEA (to begin with) of what we are going to find and then we develop a research-design to confirm or deny our suspicions/contentions.

On the other hand, in the case of inductive theory-building, we readily confess that we do not know what we are going to find until we get there. Neither the beginning nor the end is known. Instead of an idea to start with, we first find out what the facts are; and then assemble and arrange these facts into patterns that will move towards a theory. It is to be specially noted that the said patterns are to be made with reference to certain reference points (for inductive theorisation, see Naganna, 1974 or 1982).

Facts do not go wrong while logic may mislead us. Therefore, when facts and logic collide, it is usually the logic that gives way. This is a general observation. From this, it follows that the inductive theorisation is more dependable than its counter part. Hence, it will have more applied-usage and practical application in policy making. Of course, when new facts are gathered, the theory gets modified.

Keeping in view of the above two models of theory-building, a general theory for the whole non-renewable resources sector has to be constructed which will have an in-built capacity to invent explanations, understanding, prediction and control over the phenomenon; and in effect, achieve the rational use of resources. The two modes as said earlier are: **(a) Deductive reasoning:** the logical process of deriving a conclusion from a known premise or something known to be true; and **(b) Inductive reasoning:** the logical process of establishing a general proposition on the basis of observation of PARTICULAR FACTS. This is broadly the nature and scope of the two modes of theory construction. It is clear that there is a primacy of logic over empiricism in deduction while the opposite can be seen in induction. There arises the choice. Since the mining sector is notoriously heterogeneous with respect to several parameters such as the quality and quantity, mineability, geology etc., it is better to rely on the inductive mode of theory building. Our experience (See, Naganna, 1982) also confirms this preference.

1.4. Different Considerations of a Mine[2]: (OR Different Approaches)

A mine is generally considered to be a place with predetermined boundaries where a mineral resource is embedded at different depths under the earth's crust with a known and finite quantity of a reserve, and with certain known and unknown geological and mineralogical characteristics; and where the application of factors of production takes place to extract the embedded mineral deposit with little or no interruptions as also upto the **limits** jointly imposed by the commercial and technical considerations. Apart from other things, the limits would imply a certain length of life span for a mine beyond

[2] Here, a mine refers to an underground mine and not to an open cast one or a quarry.

which it ceases to yield any more outputs within commercial constraints. A mine thus brings out over its finite life span the hidden sub-soil resource for various human endeavours. This is a general view of a mine without considering specifically either production or depletion. This would also serve the general purpose of a comprehensive debate on conservation of resources from extraction view point.

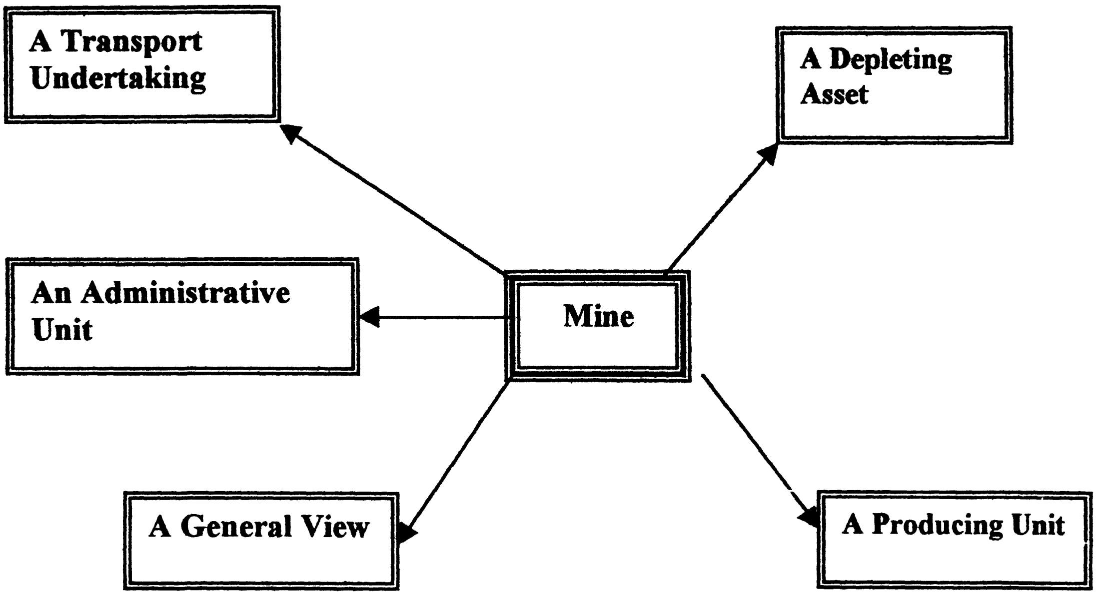
From a different stand point, it has been observed in the case of coal mining that "the colliery is, first of all, a transport undertaking" (See, the United Nations, 1961). By a critical examination of production costs, it can be noticed that a coal mine looks like more a "transport unit" than an extraction one because the sum of transport (hauling) related costs in a coal mine is found to be forming as high as 40 to 45% of the total per tonne pit head costs (See, Naganna 1974, 1984). This may be true even in the case of non-coal mines. A mine tends to become a "transport undertaking", if it is considered through the cost structure point of view. This kind of consideration would be of help in the formulation of principles of mine planning.

In addition, a mine can also be viewed as:

- a depleting asset (or a wasting asset), or
- a producing asset

In both the cases, production enters in a very different way. The former view leads to the principle of conservation while the latter to output planning/production economics. Similarly, the former leads to the problem of royalty while the latter to that of rent (Ricardian). Thus, the two (or three) different approaches to a mine yield different analytical frameworks. In these and in the other, the "economic problem" enters in a very different way. The literature on mineral economics views a mine mostly as a depleting asset. However, the best approach would be a combination of the two which will solve simultaneously the problem of extraction through minimum cost point of view and the problem of optimal levels of recovery (or the conservation) over a period of time for a given deposit (See, Section-II of this paper).

Dimensions of a Mine



Policy Implication: The policy analysis and design for the mining sector are required to explicitly specify the way in which a mine is going to be viewed/framed. Because, this will have an influence on the rest of the steps in policy formulation and the general approach to the issue on hand. As a matter of fact, the "framing" of an issue/problem for reddressal through the policy measures depends mainly the way in which a mine is viewed or the dimension chosen. This analysis on the multiple dimensions of a mine together with the **three-way relation** (viz., age-size-cost relation) as delineated in Naganna, 1982, would give an integrated approach to mine planning, pricing and a more rational allocation of enterprise-resources on which **a policy** has a direct dent. In fact, this is an important element of policy design.

The kind of frame work as presented here would improve the understanding of the operational processes of a policy or how a policy is likely to work to deliver the intended effects. In a sense, it epitomises the policy analysis for the mining sector.

The knowledge about the divergent views on a "mine" would help understand, perhaps in a better way, the problem of conservation (or the maximum level of recovery from a given known deposit) in its entirety. Each view generates a particular approach to mine management. The choice of approach depends upon the broad resource conditions and the historical phase of development. For instance, under scarcity situations with undue pressures from population growth and industrialisation the approach of depletion becomes more important and relevant. Different socio-economic compulsions give rise to different approaches to natural resources management.

There is yet one more dimension. The ownership pattern of resources limits the generality of the concepts. In other words, the concepts that are developed in market economies (or under private ownership) need not necessarily hold good under public ownership. For instance, the public ownership follows the policy of cross-subsidization (See, Naganna, 1974). This policy refutes the well accepted theory of depletable resources (or the Ricardian Rent Theory) which predicts low cost resources will be exploited first and an array of cost-differentials asserting that the higher cost (above price) mines leave the industry. As a matter of fact, the Indian coal industry under public ownership exploits both high cost (above price) and low cost coal resources (mines) simultaneously through the above policy. Later, it will be shown that the public ownership is more conducive to conservation of mineral resources than its counterpart.

1.5. An Overview of Historical Developments in Mineral Economics:

In what follows is not a literature survey as such but a brief sketch of the important developments that took place in the construction of economic knowledge pertaining to the minerals extraction sector. The broad purpose is to identify some major shifts in this context. As stated earlier, mineral economics is the neglected branch in general economic science which assumes broadly that resources are given and are readily available just for asking in required quantities/qualities for the firm. Ever since the start of the principles of economics with Adam Smith, there are always crucial references to the natural resources extraction to explain the main body of economic principles. Somehow, they were always fit into the main body either logically or perceptually, but never empirically. As Adam Smith was "never exclusive" in his approach, he could not devote adequate or exclusive attention towards the problems of natural resources extraction. There could not, however, emerge a unified theory of natural resources extraction till Ricardo formulated his rent theory. It was David Ricardo who has laid the foundations for this subject (i.e. mineral economics) in his famous book on the **Principles of Political Economy and Taxation**. For the first time in the history of economic thought, it was Ricardo who treated the economics of mining explicitly. Ricardian theory of rent, though contrived mainly as a complementary one to lend credence and support to the theory (Ricardian) of value, can be considered, in a broad sense, as a theory of natural resources extraction. This can further be substantiated by the fact that Ricardo has added a small separate chapter on **"Rent of mines"** in his famous book. For Ricardo, **mining is also agriculture** because he felt that both are guided by and adhere to the same set of economic and natural laws (See, Ricardo, Chapter III, pp.108; see also, Ghosh 1977, pp.52-56). However, his major concern was on the cost of gold mining to explain the value of money under "gold standard". Later on, his disciple JS Mill followed the same path, but gave more emphasis to the problem of royalties than to rent. This gave rise to a distinct body of literature on the Taxation policies of mineral wealth/mineral extraction. In Mill's treatment of the subject, for the first time, **the problem of depletion entered explicitly**. This has no significant place in Ricardo. In Ricardian analysis, mine enters as a "producing asset", while in Mill's it enters as a "depleting asset" and thereafter it continued to be so with a different thrust. Marshal did not give much emphasis to the theory of the mine, but placed more on the theory of the firm. His famous comparison of natural resources with a "water-reservoir" (or Nature's-reservoir) for pumping-out purposes led to the concept of constant returns to scale in extractive industries (See, Marshall, **principles of economics,** BK IV, Chapter III, Section 7). As a matter of fact, this could have, more appropriately and meaningfully, resulted in the development of the concept of a "total life cycle costing model" for a mine (Naganna 1974, 1984, Kauffman 1969; Harvey Graham 1976). This approach would have given us a better mine planning to achieve higher levels of conservation of mineral resources while at the same time ensuring the least-cost outputs. A major shift took place in the development of mineral economics with the advent of conservation of mineral resources while at the same time ensuring the least-cost outputs. A major shift took place in the development of mineral economics with the advent of conservation movement which was started in the initial years of the present century in the USA (See the classic work of Charles Richard Van Hise, 1910). Harold Hotelling (1931) gave a theoretical framework to this great movement. This created an imbalance in the growth of mineral economics by giving more importance to the problems of depletion at the cost of ignoring the production aspects. Ever since, this imbalance persisted. The club of Rome Study **(Limits to Growth, 1972)** is a case in point. Mineral economics, therefore, even today centres largely around the problems of conservation rather than production. Recent articles/papers in the reputed journals testify this. Later in 1987, one more shift took place. The concept of conservation ultimately took the garb of **sustainable developmentin** the Report (1987) of the World Commission on Environment and Development, popularly known as the Brandtland Commission, 1987. Since then, **sustainability** has become a benchmark against which all the economic development policies are to be assessed (See Naganna, 2000).

1.6. Concept of Conservation:

Conservation is generally associated with the mineral and other natural resources[3], and more particularly with the exhaustible minerals whether they are scarce or otherwise. The mineral resources are considered to be the stored-up wealth and some thinkers consider them to be the Nature's capital (Schumacher, 1974). They are prominently characterised by:

- Exhaustibility/depletable
- Nonreplenishability/nonrenewable
- Hidden or unknown with reference to their quality, quantity, mineability etc.
- Finite/fixed or fund-reserve or Nature's reservoir.
- Both present and unborn future generations have equal right over them. Intertemporal efficiency of resource base.
- Extremely variable or heterogeneous in terms of their quality, geological properties, reserve-position, etc.
- Unlike others, mining is essentially a "**shifting activity**" with multiple-operating units in a mine.

---

[3] Some natural resources like forestry, fisheries, soil fertility etc., are renewable or replenishable by human choice and action. In this case, the streams of replenishment can be so arranged that they match with the growth of consumption. Thus, these types of resources may be perpetuated almost indefinitely. Here, the concept of conservation may mean differently to cover largely the replenishment programmes. These aspects lie outside the scope of the present paper.

These distinguishing features give rise to different approaches to resource extraction for the material well-being of mankind. In the ultimate analysis, it can be shown that **conservation tends to become a logical imperative and a practical concern of economic planners mainly because of the above features.** Besides, they also provide the ethical (value) foundations for the concept of conservation. Had there been no such features (as above), there would not have been any concern for conservation. It can be argued easily to show that conservation imposes limits to growth.

More importantly, the above cited properties form the inherent traits on the basis of which the natural resources can be classified under different heads such as, soils, water, forests, minerals etc. Though all of them are useful, they are not, however, comparable in terms of availability, utility, endowment, replenishability etc. For instance, in the case of minerals, a tonne extracted is a tonne disappeared almost forever because earth takes several millions of years in their regeneration. So to say, they have only one-time use. While others like forestry are replenishable even in short intervals. In view of these differences, conservation may mean different things to different classes of natural resources. Further, the types of minerals such as the vein and stratified types; major and minor; strategic and non-strategic; scarce and abundant etc., will also influence the meaning, scope and operationality of the concept of conservation. The present paper is primarily concerned with the problem of conservation of mineral resources with special reference to stratified ones.

Conservation Explained: Conservation movement was started with an objective to arrest, curb, avoid, minimise, control and regulate mainly the damages caused to or inflicted on the precious natural resources due to unhealthy, unscientific, and selective (or slaughter) mining practices; and thereby increase the natural resources availability to our posterity (See, Anthony D Scott, 1955). Thus, it can be viewed as a set of remedial policy measures to reduce or minimise various types of avoidable "wastages" in extraction and utilisation of natural resources and "save" (or leave) more to the posterity or the future. It is essentially a great movement against all types of avoidable wastages. In the initial stages, it was more an ethical/moral concept than an economic or technological one. Later, particularly in recent years, it has become more than an economic concept getting extended into environmental protection, pollution, material sciences and so on. **The principle, of conservation, in essence, preaches not abstinence from but parsimony in natural resources use for human benefit.** It means the following:

i. It does not preach abstinence from consumption of natural resources but a meaningful restraint on it. It does not, however, imply tightening of our belts. It discourages emphatically the ostentaneous and wasteful consumption as seen in the west (See, Meadows, 1972; see also, David Novick, 1976).

ii. It advocates wise-use of resources as also appropriate replenishable programmes wherever they are applicable either directly or indirectly. This would imply the substitution of exhaustible scarce resources through their opposites to deliver the similar benefits/services. Eg.; energy fuels by solar and other renewable sources of energy.

iii. It involves optimal rates of recovery from known deposits over their life span. It implies the maximisation of the life span of deposits with a pre-determined set of consumption norms. The general guidelines to determine approximate consumption norms can be derived from the geographical area, population, resources endowment, minimum needs and the like. (See, Frederick M Peterson & Anthony C Fisher, 1977).

iv. The concept of conservation is totally against wastages both in utilisation and recovery of natural resources. Among other things, this implies more importantly the maximum levels of recovery from the given known deposits. As a matter of fact, this is to be considered as the crux of conservation from an important technical sense. Moral angle is a different issue altogether.

v. Its ultimate goal is to leave maximum possible benefits of (or from) natural resources to posterity, from effecting "savings" by avoiding all possible types of "wastages" both in consumption and production processes. This means the making available of maximum possible supplies of resources to posterity after meeting **all the legitimate** present consumption needs. It gives a special attention towards the problems of non-replenishable and non-renewable resources.

Keeping in view of the above explanation, conservation can be defined as an approach (or a method) to achieve continuing reductions in avoidable "wastages" in the recovery, processing and utilisation of natural resources for human benefit such that it saves more and more for the posterity. Thus, its domain is enlarged to cover the areas like politics and public policy, science and technology, economics and moral/ethical codes (or values). Indeed, its scope is too vast to consider it as a generic concept.

As the principle of conservation has an ethical/moral value around it, it could get a widespread acceptance from all the circles—political thinkers, economists and technologists alike.

Conservation and Extraction:

Mineral economics has then become a part of the economcis of conservation. One of the two major logical consequences of conservation theory is the minimisation of wastages in the process of natural resources extraction; while the other being the curtailment of current high extraction rates to the minimum possible levels such that there will be a maximum balance between extraction and exploration which will enhance the life span of the mineral deposits. In this case, the determination of current extraction rates involves, in the ultimate analysis, value judgments. There is no rational method/model to tell us how much to extract annually from a given known deposit. In the former case, it implies that a part of the conservation problem involves solving the production problem i.e., optimum rate of annual outputs through least cost point of view. Then the wastages from extraction can be minimised and the life span of the deposit can be enhanced. All this leads to the adoption of scientific methods of mining on the one hand, and optimum rates of recovery (i.e., the optimisation of mining operations) on the other. This can be achieved only through a proper production planning system with an objective to recover maximum amount of mineral output from a given deposit. This will hopefully satisfy the principles of conservation.

In this context, one should see the interconnection among depletion, exhaustibility and conservation and its long term policy implications as discussed extensively in Chandler Morse, 1976. This is in fact a classic study of its kind. In the present context, this study of Chandle Morse observes that the output in a steadily growing state can not be used in ways that promote or induce increasing pressure on aggregate resources and the environment. (p 266). Further, the study also observes that conservation can not be handled solely in terms of conventional benefit-cost analysis (p 267). As a matter of fact, these two statements run as implicit working premises all through this present empirical study.

A Real Life Situation/Example:

The above analysis can be substantiated in a way from the past experience on India's coal industry. Our ancestors followed unscientific and slaughter mining methods through rat-hole (tiny) mines with no production planning worth the name[4]. Consequently, huge quantities of coal deposits of high quality are being locked up in the form of pillars, barriers etc., under the closed/abandoned mines several decades ago in the Eastern Coal Fields. This is a loss/wastage which could have been easily avoided by proper planning. These coals are deprived to the present generation. This deprivation is referred to as loss/wastage attributable to wrong extraction practices. This the conservation opposes.

Now, it has become a major engineering challenge to reach those locked-up coals under abandoned mines for renewed extraction. The abandonment took place long ago. However, no solution is found so far due to some critical technological limitations. Besides all this, there is even a strange proposal to shift the Dhanbad City bodily to extract the high quality coals underneath the city. All these problems are the legacy of the past. If our ancestors were to follow the principles of conservation, we would not have inherited those problems. Similar kinds of avoidable wastages in extraction process can be observed in the case of other minerals like Cuddapha slabs, barytes, ochres etc. The net effect of such slaughter mining practices will be the loss of resources and a consequent reduction in the life span of the mineral deposits. Posterity will pay the price for our wrong doings. The conservation principle advocates the avoidance of such avoidables damages to resources in the extraction process. There is, however, an avoidance-cost.

I hope the above would serve as a real life example which will give credence and clarity to the ideas presented in this section and elsewhere.

---

[4] The phenomenon of small-sized mines (rat holes) is the logical consequence of the Law of Increasing Costs (to which the coal industry is subjected to) under competitive conditions with private ownership (See Naganna, 1974 or 1982; 1980; 1984). This was the case before Nationalisation. See also, Section-III of this paper.

1.7. A Brief Review on Conservation:

The classic work of Hise (1910) made a significant dent on the then thinking on natural resources. The fact that this book underwent an immediate reprint in just three months after its publication explains its importance. Here, conservation started as a moral principle. It is worth quoting a few passages from this great work.

"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" (Hise, 1910)

"Bringing an appreciation of the importance of conservation to the foreground of human consciousness is a work which can not be done by one man or one organisation in one year, or by many men and many organisations in many years. It 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 in preventing further wanton wastes. This must be done if our descendants are to have transmitted to them their heritage not too greatly depleted"(Hise, 1910)

"The great movement for conservation.... is more important than all other movements now before the people"[5] (Hise, 1910)

To this great movement, Hotelling (1931) gave rationalisation through mathematical modeling. Scott (1955) gives a historical as well as analytical content. Carlisle (1954), Herfindall (1955), and Schumacher (1974) contributed significantly to the understanding and appreciation of the problem of conservation of mineral resources. Morse (1963) highlighted the problems of scarcity of resources in the growth process. More importantly, the problem of resorting to inferior deposits after the fertile ones are exhausted along with its cost implications is also highlighted. It implies increasing real costs for achieving economic development with a given resource-base of varying grades/quality. This took an alarming shape in Meadow et.al. (1972) which influenced a great deal on present day thinking on resources. Here, conservation enters as a limiting factor to growth and prescribes less material/energy intensive lifestyles, zero growth etc. This induced a new branch in materials science. In Wilson (1980), the concept undergoes a significant change to become an immediate substitute to production. Thereafter, this led to the development of a new subject called "Energy Auditing" in which conservation enters mainly as a **cost-saving device**. The turn is due to the fact that the energy-costs are increasing much faster than others in several industries. Thus, the faster rising fuel prices gave few dimensions to the conservation concept*. These developments in recent

---

[5] One can make out a strong case on the imperative need for this movement for India of today.

* The recently held Ingternational Conferences on **environment and Development** pursued the same philosophy of conservtion but arranged in the garb of sustainable development. Now, **sustainability** has become a national policy objective or a guiding principle in several countries including India. The dterm **sustainable development** is popularised in the 1987 report of the World Commission on Environment and Development.(Brundtland Commission). Thereafter, sustainability has become a benchmark against which all the economic development policies are assessed and evaluated. Thus conservation became a guiding principle in policy formulation but in the name of sustainability.

years mainly due to oil-crisis and partly due to other considerations, converted the original moral angle into a technological one. The whole history of technology and its development, in one important sense, is the history of conservation. Because, the underlying principle in technology development is always the cost-effectiveness either in reducing the material-intensities or substituting the scarces resources by abundant ones, or both. This refers to production, conversion and extraction processes.

In recent years, conservation in the name of sustainable development became the policy objective or the guiding principle in the developmental planning and policy.

On the other hand, the moral principles that place various kinds of restraints on wants, desires etc., through adoring austerity, simplicity etc., culminate in preaching, practicing and achieving conservation of resources. Thus, conservation is the root of all the morals in consumption process in society like the curbs on ostentaneous and other wasteful forms of consumption.

The current studies, mostly interdisciplinary type, focuses more on the practice of conservation covering those aspects such as the administrative, implementational, legal, technical etc. (See, David Pearce, et.al, 1989).

In conclusion, it can be said that the principle of conservation underwent significant changes over time in terms of its meaning, content, importance and relevance. However, experience shows that the conservation movement is subjected to "issue-attention-cycle" as seen in public policy making. In recent years (See, David Pearce, et.al., 1989), the concept of conservation has taken a different shape, or rather a different name, in the concept of "Sustainable Development". The content of these two, however, remains more or less the same. Thus, **conservation got directly linked to the processes of development.**

Achieving Conservation:

Conservation can be achieved on different fronts viz.,

- production end;
- consumption end;
- mineral processing; and
- extraction end.

The approach to conservational measures and practices in all these cases vary significantly. Each one will be different from the other, though the end result may be the same. In the case of production/processing, the approach would be to introduce technological improvements through R&D efforts such that it results in lesser and lesser material-intensities. On the other hand, consumption can be regulated through various direct and indirect policy controls/instruments to see that conservation takes place. In both these cases of production and consumption, conservation can be achieved by competitive marked forces through relative price movements/adjustments and other market signals. Historical experiences in different countries give ample credence to this trend. But, in the case of extractive industries, the market mechanisms and other market signals do not operate effectively to induce the conservational measures in this sector mainly because:

a. there is no direct demand for minerals;
b. the nature of the industry is different;
c. the market signals have to take complex paths to reach this sector.

Consequently, conservational measures in the extraction sector are to be inducted either through state intervention or through direct regulatory controls. The whole issue of conservation becomes complex because of the fact that this sector is subjected to the Law of Increasing Costs. This will be examined in the next section.

Rate and Level of Recovery:

In this context, Carlisle (1954) makes a distinction between the Rate of Recovery and the Level of Recovery from a mineral/ore deposit. Further, he discusses elaborately the issue of alternative optimum rates and levels under different conditions by using different kinds of interest and discount rates to present and future earnings under private ownership. He also considers the effects of the grades of ores, risk and uncertainty, monopoly power and price changes on the rate and the level of recovery from a mineral/ore deposit. This distinction has significant implications in conservation.

Rate of recovery refers to the annual rate of mineral extraction from a deposit given the wage rates and prices, while the Level of recovery refers to the total Quantity of mineral body that can be extracted from a given known deposit over the life span of a mine at the available technology, mining methods and market prices. The level of recovery is more relevant to conservation. In fact, the thrust of cosnervation is to maximise the level of recovery from a deposit because this would ensure minimum "loss/wastage". The present paper gives focus on the level of recovery in the coal industry under public ownership. However, in the earlier studies which are mostly of non-empirical in nature, production economics receives very less attention while financial considerations like interest and discount rates play a vital role. In this sense, the present paper is a departure.

Conservation and Sustainable Development:

As observed earlier, the concept of conservation is gradually moulded into the form of sustainable development, particularly after the Brundtland Commission (1987) report. In several respects, both the concepts are very similar having the same objective of providing an undiminished resource availabilities/supplies to the succeeding generations. Both aim at achieving the unimpaired intertemporal efficiency of resource-base. Therefore, the conversion of conservation into sustainability is only a terminological replacement without altering its meaning and scope. Since 1987, sustainability has become a benchmark against which all the public policies are required to be assessed and evaluated.

With its multiple and often ambiguous definitions, sustainable development defies measurement by any single index. (See, Table-5). In this paper, an attempt is made to make an empirical assessment of sustainability with reference to mineral resources.

It is easier to agree on policies that would contribute to sustainable development than to define the term itself. Examples of unsustainable or at least inefficient or wasteful practices are numerous. (Eg.: Poor irrigation practices to water logging and salinization of soil resulting in loss of land productivity; water-intensive crops in scarce-water conditions; timber and deforestation; slaughter mining practices and over exploitation, resource damages; industrialisation and pollution; chemical-intensive agriculture and environmental degradation etc.) Thus the term sustainable development can better be understood by its negative connotation rather than by its positive contents. For various meanings, scope and perspectives on sustainability, see Naganna, 2000 and 2000b. its main thrust and concern is on natural resoruces, both renewables and nonrenewables. Natural resources are central to sustainability. Sicne they are said to be the common property resources, it requires appropriate public policies in regard to their exploration, development, exploitation and conservation. Accordingly, **way back in 1908**, the natural resources policy is defined as:

"The use of foresight and **restraint** in the exploitation of the physical sources of wealth as necessary for the perpetuity of civilisation, and the welfare of present and future generations". And the conservation as: "the preservation of the unimpaired efficiency of the resources of the earth". (Charles S Pearson, 2000; p 471).

Role of State:

At present, there is a general consensus that sustainable development implies an active role for government in efficient and equitable management of natural and environmental resources. In this context, A.C. Piguou wrote in 1932 that:

"It is the clear duty of Government, which is the trustee for unborn generations as well as for its present citizens, to watch over, and if need be, by legislative enactment, to defend the exhaustible **resources of this county from rash and reckless spoliation".** In this context, it may be noted that there is no substitute or alternative to this duty of government. It is its primary duty like the law and order or the protection of property. In the later case, there could be alternative arrangements by the private agencies whereas such a thing is not possible in the former case of exhaustible resources. Thus sustainability is the rediscovered duty of state.

Sustainability is a dynamic concept. It is relative to the extent of exploration and the explored/unexplored area. Also, relative to S & T. It is primarily relative to the extent of endowed resource-base and the magnitude of population.

It is to be specially remembered that we don't have a licence to "rash & reckless spoliation" of our resource base. This the conservation attacks.

SECTION - II

In this section, the nature of size-cost relationship in the coal mining industry is presented which has a significant bearing on or implications in conservation particularly through mine-size and the consequent slaughter mining practices. In other words, the impact of size-cost relation on cosnervation is explored in this section.

The Law of Increasing Costs and Conservation:

The size-cost relation in coal mining industry has been investigated under two phases (See, Naganna, 1984, 1974 and 1982). In Phase-I, the total annual output of a coal field is taken as size while in Phase-II, the annual output of a mine is taken as size. In both the cases (with five coal fields and 21 coal mines), it was found that the coal industry is subjected to the law of increasing costs[6]. The underlying forces, along with a brief review of literature, were also investigated. This positive relation between mine-size and per tonne costs stood to the test of logic besides being fit into the existing theory. It can be reproduced in a graphic form as in Figure-I.

This being the case, the logical outcome of such a relation is the smallness in size of operations or the prevalence of rat hole type of mines under competitive conditions with private ownership. Keeping this relation in view, the size distribution of mines in Indian coal industry was examined. It was found (See, Naganna, 1974 and 1980) that the Indian coal industry was characterised by an overwhelmingly large number of small mines before Nationalisation. The fact that the GOI appointed an Amalgamation Committee (1956) to amalgamate all the small contiguous mines, confirms this. They brought out the demerits of such small units. Among other things, these small mines go against the principle of conservation because:

- They do not adopt scientific mining methods
- No scope for mechanisation
- Low levels of recovery
- Slaughter mining practices.

This is to show that both theory and practice are interwoven. In fact, theory is a **hub** around which a variety of divergent practices emanate. A rational policy design is required to take implementable policies*.

---

[6] In this case, the size through minimum cost point of view becomes indeterminate. See Naganna, 1974 or 1982 for a discussion/solution on optimum size of a mine. This could also be true in the case of other minerals

*If theory is ignored in policy making, then we should know that we are subjecting ourselves to the **tyranny of numbers.** Ignoring theory means ignoring the theory of causation without which the exercise of control, regulation and monitoring (the core of policy) is not possible. Therefore, a good policy design should enable us to safeguard ourselves from the despotic empirical assertions of numbers. This is an implicit message in this section on **policy design.**

These rat-hole type of mines, as they are called in mining circles, are extremely detrimental to conservation practices. Their prevalence is justified, as said earlier, on economic grounds (Law of increasing costs). They inflict disasters on resources because they pick-up the best selectively near the pitmouth and leave the rest which can not be easily exploited later. This is the loss/wastage. To put it differently, the level of recovery is so low that they really become a menace to scientific resources management. The threats caused to the resource by the tiny mines is represented in Figure-2. In fact, this is too naïve a presentation.

The problem of locked up coals in Eastern Coal Fields, as brought out earlier, is largely due to the rat-hole type of mines in large numbers under the erstwhile competitive coal industry which is again due to the Law of increasing costs. The menace of rat-hole mines was tackled by Nationalisation of coal industry. As a matter of fact, one of the two objectives of Nationalisation is to achieve conservation through scientific mining practices.

Implications in Theory and Practice:

From purely conservation point of view, the small-sized mines are detrimental and hazardous to conservation practices because the level of recovery is very poor in them. On the other hand, the large sized mines are conducive to conservation because the level of recovery will be high which is due to a larger scope to undertake mechanisation programmes. On general grounds, it can be stated that large mines with mechanisation are extremely conducive to conversation (See, Chart-2). Experience confirms this. In the same vein, it can also be inferred that the public ownership of resources is more conducive to conservation and scientific resources management. By using price and other instruments, the scale of operations can be enhanced to introduce mechanisation and thereby, the level of recovery. Further, they can also adopt a cross-subsidization policy to combat the niggardliness of nature to achieve conservation. Thus, the sequence of "increasing costs $\rightarrow$ rat hole phenomenon $\rightarrow$ resource damages" can be broken. The resource damages or non-conservation is logically inherent to the mining sector under competitive conditions with private ownership. The issue of achieving conservation can be resolved through public ownership to a significant extent.

Then, what about other minerals? Yes, the other minerals like slabs, limestone, iron ore, ochres, mica and a host of other minerals (particularly the minor minerals/ores) which are under private ownership with a near competitive conditions are also subjected to the general law of increasing costs and the consequent small-sized mines/quarries. The same logical analysis (as was seen in the case of coal) holds good here also. Therefore, conservation assumes special dimensions in these minerals. Resources are getting damaged alarmingly in several ways such as the slaughter-mining practices, low levels of recovery resulting in "loss"/"wastages" and so on. Any one who visits these mines in any of the mineral-bearing districts can observe these and many more atrocities committed on the precious resources. This calls for an immediate solution like the case of coal, or the direct controls by the State through legislation or any other public policy to promote conservation by curbing the "wastages" and other unhealthy mining practices. This is a more important **policy issue** than all others now before the political agenda. Otherwise, the society has to face the ordeals of "Dooms Day" as predicted by Meadows et.al. (1972).

Inherent Feature:

Depletion leads to increasing Hauling distances below the ground which in turn increases costs of extraction (See, Naganna, 1982). These rising real costs generally go against achieving conservation of a resource like coal, irrespective of ownership. Since, "depletion" is inherent to all the mineral resources, non-conservation (or the tendency on the part of the miners to "waste") is also inherent. Thus, non-conservation is ingrained in the mining system itself. These inherent distortions in the mining sector can be checked and controlled by the state intervention through appropriate policy measures and effective implementaion (See, David Pearce, 1989). Thus, the problem of conservation can be overcome either by public ownership or through direct state controls and regulations on mine-size, levels of recovery, mining methods and so on.

Conservation and Development:

Economic development ultimately results in the consumption of natural resources in some form or the other. In fact, development means conversion or transformation of natural resources into consumable, usable and salable goods and services for human benefit. Therefore, it appears that Development and Conservation cannot go together. Conservation does not, as stated earlier, preach (or advocate) abstinence but wise-use of resources. In this context, conservation refers to the Rate of recovery (or the annual rate of extraction), not to the Level.

The concept of conservation, as observed earlier, got directly connected with development through sustainability. In the ultimate analysis, the conservation principle advocates in this context a production system with lesser material and energy intensities along with an overall diminution in the generation of "residuals" both in the production and consumption streams (See, Alan V Kneese, 1977). This may not imperil much the future availabilities of resources to the succeeding generations, besides it would also ensure a greater balance between exploitation and exploration. Thus, the solution for the conflict between conservation and development lies mostly in the discoveries and designs of suitable and environmentally sound technologies, and partly in devising a package of policy measures to control and regulate the ostentaneous and wasteful consumption over and above the legitimate consumption needs.

The choice is not between development and conservation but for a judicious combination of the two, subject to two overriding constraints as below:

a) An upper-bound : beyond which Development can not be pushed without facing the ordeals of "Dooms Day" (or the near-depletion of scarce resources)

b) A Lower-bound: below which the concern for conservation should not be pushed[7]. This is given by the poverty levels, basic human needs, etc.

That judicious combination will be the reflection of collective social choice based on the existing social priorities/preferences. The resource endowment, the extent of geographical area, population size, level of development etc., help choosing an appropriate mix of development and conservation. However, it can also be seen as a matter of judgment because of the conflicting views on the present versus future generations.

[7] In this context, conservation is restricted only to the rate of recoveries or depletion. However, the levels of recovery, avoidance of wastages etc. stand.

SECTION - III

Empirical Assessment of Conservation:

An empirical assessment of conservational practices both directly (intended) and indirectly (unintended) as practiced by the mining industry is carried out in this section. For this purpose, a case study method is chosen. The case in question refers to the coal mining industry in Andhra Pradesh. The broad framework as developed in Sections I and II is used to analyse the empirical analysis of conservation with special reference to coal resources in AP. The source of data is the longitudinal field investigations. Due to these repeated visits with long intervals, we could get a long time series data, particularly the output data, for more than a century since the very start of coal mining operations in A.P.

The whole literature on mineral economics is replete with models, mostly mathematical and econometric, focussing mainly on the optimal exploitation or the optional rates of recovery and the long run resource depletion; and thereby, giving a variety of doomsday messages and red signals on the sprouting awesome scarcities and the endangered future availabilities of resources[8]. And, most of the studies are theoretical in nature with little or no empirical analysis particularly at the industry level. This is where the present paper makes a **detour** into the critical issue of increasing the levels of recovery instead of rate (optimum or otherwise) of recovery from the existing and known mineral deposits. Because, the core of conservation is the level of recovery while the rate of recovery enters only when we discuss the intergenerational equity over the resource accessibility or the long run availability of resource supplies to sustain the current levels of development and consumption. How long is the long run, is in fact a matter of social choice/judgement. Whether or not the mathematical modeling can solve this question is again a matter of opinion and analysis.

The central concern of this Section-III is to examine and analyse the practices of conservation in the industry both intended and unintended within a theoretical framework. The lessons from this analysis can be of use in making a policy-design and formulation. Since such policies are derived from empirical analysis, their implementation will be more effective and fruitful. There are not many empirical studies of this nature.

---

[8] An exhaustive survey is given in, Frederick M Peterson & Anthony C Fisher, "The Exploitation of Extractive Resources - A Survey", **The Economic Journal**, 87, December 1977, pp 681-721. Also a similar survey in. Anthony C Fisher & Frederick M Peterson, "The Environment in Economics : A survey", **Journal of economic Literature,** Vol.14, March 1976, pp 1-33. The whole literature largely centres around 'scarcities', optimum rates of extraction, preservation of environment etc., through mostly mathematical modeling at the cost of ignoring what is being perceived and practiced at the industry level. In the context of over reliance on mathematical modeling, see the classic paper and the subsequent debate in, David Novick, "Mathematics : Logic, Quantity and Method", **The Review of Economics and Statistics,** Nov. 1954, pp 357-386

3.1. Coal Resources in Andhra Pradesh : A Historical Perspective:

Andhra Pradesh is amply endowed with coal resources spreading over four districts, viz., Adilabad, Karimnagar, Warangal and Khammam districts. The Andhra coal fields are also called the Godavari Valley Coal fields. The Singareni Collieries Company Ltd. (SCCL) is the sole lessee of all the coal fields in the state. It is charged with the responsibility of playing a vital role in the exploration, development and exploitation of the coal deposits endowed in the state. The SCCL is the oldest public sector coal company in India with the share capital being owned both by the state (51%) and the central (49%) governments. Sometime back, this company celebrated the centenary year of successful mining operations.

Historical records/evidence from the State Archives of AP show that the exploration (drilling) operations were taken up in October 1872 by an order from the HH, the Nizam Government to ascertain as accurately as possible the extent of the coal resources in the Singareni Coal fields of the Thelangana region. In November 1872, the prospecting operations were commenced. In 1875, a report (Henan's Report, 1875) was submitted which estimated the total coal resources embedded in the Singareni Coal fields will be of the order of 46.5 million tons of which 19.5 million tons of coal was considered to be of first class quality and decidedly equal to, if not better than, any coal as yet discovered in India. On 7th January, 1886, the Government of Hyderabad granted a mining concession to Mr. John Stewart and William Clarence Watson of London. A Limited Company called the Hyderabad (Deccan) Company Limited was duly registered and incorporated under the Company's Act of 1883 on the 29th July 1886. The company started raising coal from the Singareni Coal fields on the 7th August 1886. Thus, the coal mining industry in Andhrapradesh was started in the year 1886 with an annual output of about ten thousand tons. Thereafter, the output has grown in astronomical figures despite the year to year mild fluctuations. In the year 1888, a couple of years after the start, the output was a meagre 13 thousand tons and it reached to a little over one lakh tons by the year 1890. From this humble beginning, the SCCL at present is raising about 30 million tonnes of coal annually by operating 69 mines (including 11 opencast mines) with an employment of about 115,000 workers. And, it is aspiring to reach a 40 million mark by a few years from now. The SCCL is one of the most progressive companies constantly looking for modernisation and growth. The important noteworthy events in the long history of over a century of mining operations are given below:

⇒ Discovery of coal	: 1870
⇒ Confirmation of coal deposits	: 1872
⇒ The Hyderabad (Deccan) Company Ltd.	: 1886
⇒ Commencement of mining operations	: 1886
⇒ Starting of SCCL	: 1921
⇒ SCCL became a public sector undertaking	: 1961
⇒ Commencement of opencast mining	: 1979
⇒ Mechanised longwall face	: 1983
⇒ Commissioning of drag line	: 1986

The major sources or the drivers of the phenomenal growth of coal industry in AP are:

⇒ Tehnological change/mechanisation programmes
⇒ Shift in mining systems
⇒ Geographical diversification
⇒ Increased mine size, and
⇒ Exploration.

Not only growth, but sustainable growth over a fairly long period of time could be achieved through these factors without facing the ordeals of depletion.

The Unique Location: The striking feature of coal resources endowment is that there are no other coal fields, other than the AP coal fields, in the whole of Southern India to meet the ever increasing demands for energy and coals (See the map). Therefore, the locational position gives a unique status to the AP coal fields. Since coal transport is energy intensive as also high cost one, the Southern states have to increasingly depend on AP coal fields due to their proximity to various consuming centres in the south. These coal fields have to meet not only the coal needs of its own state but of the whole southern region. This is the special feature. Hence, this lcoational feature calls for a special attention on conservation of these coal deposits because when once these coals are depleted at faster rates our succeeding generations will have to pay a heavy price in paying for longer hauls (or higher transport costs) of coals from far away regions.

The major coal consumers from these coal fields are the thermal power stations, cement factories, railways, fertilisers and others. Among them, the demand from the thermal power stations is the highest.

The locational aspect has two distinct but inter related implications. One is in conservation/faster rates of depletion as mentioned above and the other in growth. Both these features are clearly reflected in the comparative growths of the SCCL, the CIL and the all-India coal sector in recent years particularly since nationalisation. In this context, the focus is laid on the SCCL and the CIL while the total period is divided into two phases. The SCCL registered a significant rise to 16.53 mil.tonnes in 1986-87 from a mere 5.31 mil.tonnes in 1973-74, showing a substantial rise of 212% (or an annual growth rate of 16.3%). See, Table 1.B. On the other hand, the CIL could muster a growth in output to 142.6 mil.tonnes in 1986-87 from 69.8 mil.tonnes in 1973-74 exhibiting a rise of 104.3% (or an annual growth rate of 8.0%). See Table 1.B. Thus the growth of SCCL is double to that of the CIL during the period (1973-74 to 1986-87) immediately after nationalisation of coal mining industry.

More or less, the same trend of faster rates of growth in SCCL than the CIL continued (See Table 1.B) during the second phase i.e., 1987-88 to 1997-98. However, the growth rates are found to be lower during this period than in the earlier period though the production levels remained high. This could be due to the change of base-year or due to the increasing levels of interfuel substitution. However, the fact remains that the

SCCL mustered higher growht rates than its counterpart (the CIL). The Table 1-B shows that the SCCL achieved an average annual growth rate of 7% while the CIL achieved 5.8% during the period between 1987-88 and 1997-98. This needs to be understood, assessed and evaluated keeping specially in view of the unique geographical position of the A.P. coal fields.

Consequent upon the higher comparative growth rates in the SCCL, its relative position in the all-India coal output has gone up significantly. The SCCL was contributing about 5.0% to the all-India coal output in 1964-65 (See Naganna, 1974) which increased to about 7.0% by the year 1974-75 and thereafter to about 10.0% in 1985-86. Subsequently, its relative position in the all-India coal sector continued to remain at about 10.0%. In one sense, this implies that the SCCL could achieve not only growth but the **sustainable growth.** This is the striking feature. The underlying factors of this success story are mainly the comfortable resource-base, the continuing exploration operations to replace the depleted stocks and to some degree, the conservational practices. In this paper, an attempt is made to investigate these factors in as detailed a manner as possible.

3.2. Coal Resource-base of the AP/SCCL:

The issue then becomes one of whether or not the AP coal fields have adequate resource-base to maintain and sustain the phenomenal growth in output as observed earlier. Among other things, this implies primarily the issue of sustainability or the carrying-capacity of the resource base to achieve, maintain and sustain the immensely impressive growth rates.

The company's published documents show that the coal bearing area of the SCCL extends over a stretch of nearly 350 kms. In the Godavari valley with an areal extent of about 15,000 sq.kms. This coal bearing area contains the coal reserves as below:

a. Indicated reserves	: 1112 mil.tonnes
b. Inferred reserves	: 3543 mil.tonnes
c. Proved reserves	: 6201 mil.tonnes
Total Coal Reserves	**:10,856 mil.tonnes**

The major coal fields are located at Kothagudem, Yellandu, Manuguru, Ramagundam, Mandamari, Ramakrishnapur and Bellampally. The district-wise and depth-wise breakup of coal reserves in the AP/SCCL coal fields as also for all-India are presented in Tables – 2,3 and 4. For the ease of reading, these data are given in the form of pi-diagrams[9]. These tables are self explanatory.

[9] For a detailed resource analysis and classification, see N Naganna, **"Public Expenditure Programmes, Natural Resources & Public Policy"**, Working Paper No.161, IIM-Bangalore.

The all-India Coal Industry:

Table-5 summarises the reserve position by states and also give the reserve-output ratios for each state. It can be seen from this table that the AP is endowed with only 5.5% of the total all-India coal reserves while it contributes disproportionately about 10% to the all-India coal output. Similar is the case with Maharashtra. Incidentally, their reserve-output ratios are the lowest among the coal producing states in the country. From this analysis, a startling observation follows which reveals that the rates of depletion in relation to their respective resource endowment in both AP and Maharashtra are much higher than the other states. This calls for conservation. Both these states are distinct in their own way—A.P. by its geographical location and Maharashtra by its extent of industrialisation.

There is one more observation. Table-1 reveals the major structural trends/changes that are taking place in India's coal sector. To overcome the difficulties of the poor quality of coals (low BTU's) and the unevenness in geographical distribution of coal resources and the consequent high transport costs of coals, the Indian coal sector undertook the major geographical diversification programmes. It has far reaching implications. By this approach, the primacy of Bengal and Bihar in coal sector is gradually reduced and replaced by the expansions in other coal fields of MP, Orissa, AP and Maharashtra. For instance, Bengal-Bihar coal fields together contributed as much as 80-85% to the all-India coal output in the earlier periods, say around 1950. This domination is gradually reduced by developing other coal fields, and these structural changes are clearly reflected in the average annual growth rates of output in different states (See, Table-1).

The geographical diversification in the growth of Indian coal mining industry reveal some significant implications in terms of conservation. It enabled and promoted the extraction of low grade coals by making it a viable economic proposition through reducing the overall transport costs. Thus the skimming of coal deposits at the macro level is avoided to a significant measure. (See, Naganna, 2000). Further, the very reduction in the overall transport costs of coals to the widely scattered consuming centres adds to conservation.

Exploration at the SCCL: To meet the challenges of growth arising out of the unique location and the unique role assigned to the AP coal industry, the SCCL undertook large scale exploration programmes in recent years to search and find out new virgin coal bearing areas/coal deposits to replenish the continually depleting stocks at faster rates than ever before. Exploration is undertaken on a larger scale than before to keep pace with the expanding coal markets. Otherwise, the industry will have to face the ordeals of `doomsday'. The meterage drilled and the reserves found, increased substantially from year to year, and consequently the **proved** coal reserves have shoot up to 6201 mil.tonnes by 1999 from about 2000 mil.tonnes in 1970 and the geological total coal **resources** to 10,856 mil.tonnes by 1999 from about 4000 mil.tonnes in 1970. Thus the resource base increased substantially to cope with the expanding coal markets. In fact, this is an important note-worthy feature.

Since extraction means depletion, exploration alone can make the growth sustainable (See Naganna, 2000). Table-8 gives the data on the extent of exploration and the reserves proved for the period from 1973-74 to 1998-99. This is indeed the most vital information in the analysis of resource base upon which the survival of the industry depends. It was reported that the extent of exploration undertaken before 1973 was only on a very limited scale with a few personnel. The meterage drilled was only a few thousands a year. The country's declared coal-based energy policy (1973) gave impetus to exploration activity in the SCCL. In recent years, the meterage drilled reached a peak of one lakh eight thousands (in 1993-94) and it is consistently high between the years 1985-86 and 1998-99 (See Table-8). Correspondingly, the extent of proved reserves annually is also found to be consistently high all through the period. Thus, it is evident that the exploration operations not only provide comfortable resource base constantly replenishing the exhausted stocks but help to achieve the sustainable growth. This aside, it also helps to achieve conservation in the sense that the future generations are not precluded from an easy access to coals.

3.3. Resource-base : A Critical Appraisal:

As it stands, it appears that the resource-base in the AP state seems to be quite comfortable and rosy. That does not however mean that all the coal resources are totally extractable from all the coal fields consisting of about 60 blocks spreading over an area of 400 to 450 sq.kms. The extent of exploitation from a given reserve/deposit depends upon several complex factors which are not known before hand and which can not be planned for manipulation and control. The role of "unknown unknowns" is very critical in matters relating to exploitation. In this context, it is worth noting an observation from Watkins (1944) who says:

> ***"Even after the discovery of a `vein', a `pool' or a `seam', its extent and richness can only be determined by actual extractive operations. And these estimates remain nothing more than estimates until these operations are completed and the deposit exhausted".***

This classic statement summarises the whole matters of risks and uncertainties relating to the deposits and the extent of their recovery. The extent and richness of the embedded deposits are, so to say, inherently unknowable and so, unestimatable. The very concept of a reserve then is really deceptive. It is therefore true that all the `deposit' can not be extracted. The level of recovery from a given deposit depends mainly on `luck' factors. Apart from the uncertainties, it also depends to a large extent upon the formulation of more productive mining projects.

On general grounds, it can be said that only about a half (or 50 to 60%) of the deposit can be exploited after giving adequate allowance for mining losses, geomining uncertainties, surface land protection and so on. The level of recovery from a deposit, however, varies also by the type of mining system adopted (See, Chart- 2). The lowest can be seen in "Bord & Pillar" method while the highest in the opencast mining The choice of mining systems has thus significant implications in achieving the goal of conservation or maximising the level of recovery.

Empirical Assessment of Resource-base:

On general grounds and on the basis of available literature on conservation/mineral economics and more importantly, on the basis of our field experiences in the mining sector, it can emphatically be said that the **theory and practice** of conservation are inscribed in the empirical evidence exhibited in Table-7. And, an equally important one is Table-8. This issue will be taken up later.

The broad empirical assessment of resource-base is presented in Table-7. In this exhibit the concept of **geological reserve** is used which is slightly different from the concepts of `resource' and `reserve'[10]. It may be noted that the quantification of geological reserve lies in between the `resource' and `proved reserve'. To be more specific, its quantity will be below the resource and above `proved reserve' category. (See Naganna, 2000). This is the reason why there is a seeming discrepancy in the data presented in Table-7 and Table-3. However, the discrepancy is not factual but conceptual.

Table-7 reveals that the AP coal fields have altogether a comfortable resource-base at 7095 mil.tonnes of proved geological reserves while the geological resources are estimated to be 10,856 mil.tonnes (see Table-3). It is evident that there is a long journey before a resource gets converted into the status of an extractable reserve; and the journey is ridden with several uncertainties at each stage. In Table-7, the known coal deposits are classified under two broad categories viz., reserves under working mines and reserves under virgin areas; and again under this bifurcation, a few more categories are made. They are mostly self-explanatory. This classificatory system is industry specific. It is to be noted that there are losses (called mining losses or geological impediments) in between the two categories. Thus the extractable reserves is the net of these losses among which some are avoidable and some unavoidable. Consequently, the **extractable reserves** in the AP coal fields gets drastically reduced, after providing allowance for mining losses, to only 2700 mil.tonnes from a high of 7095 mil.tonnes of proved geological reserves. Thus, the extractable reserves forms only 38% of the total proved geological reserves and most part of the remaining reserves except the consumed reserves, is wasted in the process. **The concern of conservation is with these mining losses and practice of conservation is to increase the extractable 38% (in this case study) to the maximum extent possible.** On the whole, the empirical evidence given in Table-7 confirm the fact that the extent and richness of deposits can only be ascertained by the actual extractive operations. Therefore, the concept of resource-base is highly misleading and deceptive too because it raises false hopes resulting in reckless and unaffordable consumption levels/patterns besides giving rise to several complexities in planning and policy making. Accordingly, it is to be specially noted that the resource analysis/resource estimates needs to be used with utmost caution.

---

[10] For a detailed conceptual analysis of resource-base, see N Naganna, "Public Expenditure Programmes, Natural Resoruces and Public Policy". November 2000, Working Paper No.161, IIM-Bangalore.

3.4. The Alarming Growth Trends:

Keeping in view of the resource-base analysis as carried out in the earlier section, the growth of coal mining industry in AP needs to be examined. The growth of output by coal fields and its trends for a period f 110 years from the very start of mining operations in AP are presented in Table-6. Also, a graph is made out of this data. Since the break up of output data are deliberately given by field-wise, it implies that the SCCL could achieve the immense growth mainly through geographical diversification, followed by mechanisation, exploration, shifting to better mining systems and so on[11].

The growth in the coal sector of AP is in fact unparalleled with any other sector in the economic history of the state. The recorded (SCCL) coal mining operations in AP started with a meager 0.6 lakh tonnes in the year 1889. And, after a century it increased to as high a mark as 164 lakh tonnes per annum by the year 1987-88 and then it raised still further to 273 lakhs in 1998-99. The growth indeed is astronomical. From a mere 0.6 lakh tonnes in 1889, the output increased to 4.7 lakh tonnes by the turn of the century in 1900. Thereafter, it reached a high of 6.7 lakh tonnes by the year 1920. Then, there was a stagnation for about 15 years from 1920 to 1935. The output did not register any growth but maintained the base (1920) year output. Then, there was a significant rise to 11.0 lakh tonnes by 1947 from 6.7 in 1935 (or 65% rise). After independence, the growth is enormously high. The coal output made a significant jump to 25 lakh tonnes in 1960 from 11.01 in 1947. Again, the output made a further jump to a new high of 40.5 lakh tonnes by 1970-71. From this new heights, it registered a **four-fold rise** to 164 lakh tonnes by the year 1987-88. Thus, it is evident from Table-6 that the growth in coal output during the century (1889-1988) is indeed enormous or rather alarming. This alarming trend further continued to reach a peak of 289.4 lakh tonnes (or 76% rise) by 1997-98.

The linear growth rates by using the simple equation, $Y = a+b_t$ have been computed for different segmented periods during the century under study. The values of the linear growth rates thus computed are presented in Table-17. It is specially to be noticed that the growth rates are found to be much higher after the advent of economic planning in 1951. Different periods mustered different growth rates (See Table-17). As a matter of fact, these growth trends have pushed the relative position of AP coal industry to higher levels in the all-India coal sector. (See tables-1A, 1B and 5). This indicates that the AP coal fields bore a larger brunt of industrialisation in comparison with the all-India industry. In other words, this implies that these fields are exploited more extensively than others as also more intensively with respect to its endowment (See Table-5). This implies that the depletion rates are much higher in AP fields than the rest, resulting in higher diminution rates in the life span of these deposits. Hence this justifies the imperative need for stringent conservational measures to maximise the level of recovery from the deposits by minimising the mining losses (See Table-7). **"Extract the Last Tonne"** from a mine, can be figuratively the guiding principle in all matters relating to the exploitation of mineral resources.

---

[11] N Naganna, **"Management Responses to Growth : A Case Study"**, Working Paper No.151, April 2000, IIM-Bangalore.

Some Contributory Historical Events: During this period of 110 years under consideration, several events of far reaching consequences took place such as: The two world wars, Political independence, Economic planning & Industrialisation, AP state formation, Green revolution, The energy (oil) crisis, Coal-based energy policy declaration, and so on. All these events in an historical perspective made their respective dents on the growth of coal mining in AP. This is also reflected in the graph. The growth of coal industry is by and large correlated though not in the causal sense, with the growth of industry and agriculture in Andhrapradesh. This the history unfolds.

The Issue of OVER-EXPLOITATION: There is no doubt about the fact that the growing rates of extraction are indeed alarming or even awesome. At the outset, it may be noted that the issue of over or under exploitation is mainly a matter of opinion and judgement though rationality can be applied on the basis of the extent and richness of the deposits. However, in the ultimate analysis, the issue depends on the tastes, values and needs of society

The growth rates are found to be much higher in recent times than ever before due to the expanding demands for coal and energy. This raises the important question on whether or not there is over-exploitation in the AP coal fields. On the other hand, this also justifies the imperative need to conserve, not by abstinence, but by better methods of extraction to maximise the levels of recovery. Appropriate policy measures are required to promote conservation not only in the coal sector but in the mining sector at large Since conservation involves economic costs, it has to be examined in relation to the extent of resource base and its recoverability. It has to be considered in its totality, not in isolation as an ethical norm, because it is connected with several factors like the socioeconomic needs, values, tastes, resource base, social perceptions and so on. As a result, the adherence to conservation at times may be diluted under pressing socioeconomic compulsions. The iron ore export agreements is a case in point.

The issue of over-exploitation and conservation are interconnected They are not independent because the later comes to the fore when former takes place. However, the issue of over-exploitation or otherwise, is a matter related to our needs, values, tastes, perceptions and resource base. The concern can not be independent of our present needs However, on the basis of empirical evidence given in Tables 5 and 7, we are inclined to state that the AP coal fields are found to be subjected to the phenomenon of over-exploitation This we claim as a rational judgement. And this calls for remedial measures

3.5. Empirical Assessment of Depletion: (Or The Life span of Coal Deposits in AP):

Since extraction means depletion, it is necessary to make an empirical assessment so that the outcomes can be utilised in identifying the appropriate policy initiatives. The alarming depletion levels can be summarised as below: (See Table-6)

a Just one year output of today (i.e , 1998-99) is **more than** the cumulated total outputs of the first 50 years

b. The sum of two years output of today (i.e., 1997-98 & 1998-99) is more than the sum of the first 70 years output.

c. Just one and a half year output of today is more than the total sum of coal outputs extracted before independence.

d. The sum of the last thirteen years output is more than the sum of the earlier 100 years output.[12]

As a matter of fact, this is the amazing reality. Reasons are obvious. Depletion/exhaustibility is taking place in recent years at much faster and higher rates than ever before. It is an eye-opener; and is the time to wake up and respond urgently in a manner that suits. The amazing depletion levels are seen not only in the case of coal sector but can be seen across the mining sector in general. This calls for immediate attention of the policy-making machinery to see that the interests of the future, or the succeeding generations, do not get jeopardized in a manner that their productive capacity gets adversely affected. (See, Naganna, 2000).

Extent of Depletion: The total cumulated outputs so far extracted since the start of mining (See Table-6) are summarised below by the succeeding decades in sequence. This gives credence to the argument for an immediate policy initiative.

Sl.No.	Decade No.	Period	Total Output in the decade ('000 tons)	% Variation over the previous decade
1	1	1889 to 1898	2164	-
2	2	1899 to 1908	4310	**99.1**
3	3	1909 to 1918	5568	29.2
4	4	1919 to 1928	6427	15.4
5	5	1929 to 1938	7995	24.4
6	6	1939 to 1948	10,671	**33.5**
7	7	1949 to 1958	14,764	38.4
8	8	1959 to 1968-69	34,755	**135.4**
9	9	1969-70 to 1978-79	62,559	80.0
10	10	1979-80 to 1988-89	136,204	**117.7**
11	11	1989-90 to 1998-99	241,239	**77.1**
Grand Total			**526,656**	-

It is clear from the above evidence that the SCCL has extracted a cumulated total sum of 526.7 million tonnes since the beginning of its operation in 1889. In other words, the total cumulated depletion unitl now is found to be 526.7 mil.tonnes. Needless to say time and again that the depletion rates in recent years are much higher than before.

[12] The output figures for the first three years (i.e., 1886, 1887 and 1888) obtained from the historical records are given in the text. It is around ten thousand tons per annum.

Life Span Of Coal Deposits In A.P.: The fast increasing growth rates in recent times will have definite impacts on the longevity of the total coal deposits in the state. In other words, the depletion reduces the life spans of the known deposits. As said earlier, the total known proved geological reserves are estimated to be 7095 mil.tonnes as on March 1999 (See Table-7). The element of risk and uncertainty associated with the extraction of these reserves are well known or rather notorious. As a result, NOT all the declared (or known) reserves whether proved or otherwise can be exploited fully. In other words, 100% level of recovery is just not possible though it varies by the mining system chosen. See Chart-2. A large part of the deposit, perhaps a significant part, will have to go as a "mining loss/wastage" in the form of:

a. Locked up coals in the form of pillars and barriers to protect the surface land, property etc., from subsidence.

b. Inaccessible or difficult-to-access seams, or seams at large depths or seams which are difficult to extract. These are not commercially/economically viable seams though technically recoverable.[13]

c. Risk and uncertainty due geo-mining conditions (like roof and side falls, gas out bursts, faults and dykes, etc) resulting frequently in closure of some sections in a mine or even mines.

d. Bad seams with irregular and unpredictable behaviour.

No doubt, these factors refer mostly to underground mining system but the opencast mining is not totally free from the mining problems. However, due to these and several other reasons, all the estimated potential quantities in 'reserves' can not be exploited fully. Therefore, the net amount will be much less than the estimated potential. This analysis refers to the 'level of recovery' connoting the extent of a reserve that can be exploited under the known technology and mining conditions as also within the commercially viable limits. Therefore, the net amount of "commercially and technically" recoverable reserves will always be much less than the 'proved' or 'inferred' reserves. Keeping this analysis in view, the Table-7 is accordingly prepared. It is the **most important** table of all. It gives the present status of coal reserves in AP coal fields as on March 1999 by summarising **the course** that the geological resources/occurrences take before they reach the status of an "extractable reserve".

Table-7 gives the break up of reserves under different categories and by different coal fields. There are in all 12 coal fields or coal bearing areas under the jurisdiction of the SCCL. It is estimated that all these 12 coal fields together have 7095 mil.tonnes of proved **geological** reserves out of which only:

⇒ 2700 mil.tonnes are estimated to be readily available for extraction (or available extractable reserves).

---

[13] In fact, the quality of coals in the bottom-most seams are generally found to be higher than in the top seams. But, the extra cost of mining such seams seems to outweighs the benefit of their quality.

Or, this is to say that only 38% of the total proved geological reserves are treated as the "available extractable" reserves at the present levels of market price and known technology. In other words, this is the net amount (2700 mil.tonnes) of reserves that are available for future exploitation from now on. This is the most striking feature in the resource analysis. These extractable reserves are classified as below:

a. Extractable Reserves under Working Mines : 1020.41 m.t.
b. Extractable Reserves under Virgin Areas:

i. Projectised --------------------	: 232.363 m.t.
ii. Un-projectised --------------------	: 1448.00 m.t.
Total	**: 2700.00 m.t.**

The above analysis confirms the fact that all the geological reserves (See Table-7), proved or otherwise, are not extractable at the present level of market price and known technology. That is why, it is said earlier that the concept of reserves is generally misleading and deceptive too, because it raises false hopes.

On the basis of the known/proved **extractable reserves**, the life span of the coal deposits in AP state can be estimated as below:

a. At an annual rate of extraction of 30 m.t. $= \frac{2700}{30} = 90$ years longevity.

b. At an annual rate of extraction of 40 m.t. $= \frac{2700}{40} = 67$ years longevity.

In this way, a number of scenarios can be generated. Whatever be the scenario one develops, the extractable reserve will last for about a century. On general grounds, one can intuit that the coal deposits in AP may last for about 80 years. This near-depletion point will be reached much before the rest of the coal fields (Bihar, Bengal, MP, Orissa). This is a notable point.

At the current rates of extraction of about 30 m.t. per annum, the life span of the deposits in AP can be estimated to be less than a century. But, with the rising prices of coal/energy and better mining methods and technology and with more intensive exploration operations, more and more reserves from the category of geological reserves can be brought under the immediate "extractable" reserves. As a result, the longevity of the deposits is likely to go up. But there is one problem. That is about the per tonne costs. Due to the exhaustion of more fertile deposits, the per tonne **real costs** of future coals will be high. And to this extent, the economic interests of the future, or may be of the succeeding generations, will be geopardized. In fact, this is precisely the concern of sustainability. This needs to be tackled.

In this context, a bit of explanation about reserves is called for. (See, Naganna, 2000b; see also, Chandler Morse, 1976). The resources are classified differently by different countries/agencies and also varies within the same country. In this context, the reserves are classified under (See Table-7):

⇒ Proved geological reserves (equivalent to resource-base)
⇒ Available geological reserves
⇒ Available mineable reserves
⇒ Available extractable reserves

These reserves are arranged in an ascending order of their probabilities of getting from the earth's crust. In a limited sense, this categorisation is similar to the one by indicated, inferred and proved (See, Naganna 2000). Like the resource-base, the proved geological reserves give the ultimate supply potential particularly when exploration outcomes reach the asymptotic limits; or in other words, when the whole suspected mineral bearing area is fully explored. All these categories are the outcomes of exploration and the classification is made on the basis of the intensity (technology; spacing; depth etc.) of exploration operations. As the intensity goes up, the reserves (or resources) get assigned higher probabilities of getting exploited and accordingly, they are classified. In that sense, the available extractable reserves show that they are immediately available for working commercially and technically. Such reserves are estimated to be 2700 m.t. (or 38% if geological reserves) which may not last for more than a century. Needless to say that the future is much longer than a century and the resources are finite. Therefore, this calls for immediate conservational measures designed not for abstinence but to increase the levels of recovery from the known deposits

3.6. Empirical Analysis and Assessment of Conservation:

To keep pace with the ever expanding coal markets due to its location and to face the faster depletion rates, the SCCL undertook several exploration programs on a significantly large scale (See, Table-8). It is reported that a large part of the suspected coal-bearing areas in the state have already been explored fairly intensely. In a sense, the exploration is reaching its near asymptotic limits (See Table-8). Therefore, the potential additions of new found deposits may not be in consonance with the rising coal demands. Thus, the life span of the coal deposits in AP is stressed too far. Or, we can even say that the life span of deposits is endangered due to faster depletion. This could be our perceptual judgement. Whatever be the case, this calls for an immediate concern on conservation through various techno-economic methods. This issue needs to be placed on both the political and corporate agenda for an immediate policy formulation.

No Substitute to Conservation: Exploration, no doubt, enhances the life span of coal industry by bringing into new deposits and virgin areas which were hither to unknown, for exploitation. Its output is information/knowledge which is of extreme value in managerial decision making on matters relating to exploitation. **However, exploration can not be considered as the solution nor is it a substitute to conservation. Both**

denote different phenomenon. Whatever exploration can do, the mineral resources, in the ultimate analysis, are definitely finite/fixed and also exhaustible/non-replenishable, and hence, they need to be conserved in the interests of sustainability. Exploration can not go beyond certain physical limits and hence, it can not give us a license to take up and rationalise the slaughter mining practices to support the reckless and unaffordable consumption patterns/levels.

Similar is the case with the development of substitutes and recycling. Since their main objective is to overcome the problems of scarce resources, they can not be considered as a substitute to conservation. Here again, both represent different phenomena though they may converge in the parsimonious/wise use of resources. The development of substitutes and recycling together can not rule out the need for conservation in minerals exploitation. Because, the central concern of conservation in this context is to maximise the levels of recovery from the known deposits under working by attacking all kinds of wastages (or mining losses) in the extraction process. Since mineral resources are finite, exhaustible and non-replenishable, they should not be subjected to any kind of wastages/losses particularly arising out of skimming, unscientific mining, bad mine planning, profit motive and so on. So to say, conservation is unique to mining and there is no substitute to conservation.

Empirical Analysis and Assessment: It has been observed earlier that the one-year output, say in 1997-98, is more than the cumulated total sum of the first fifty-years output. This is to show that depletion is much faster in recent years. As observed earlier in Table-6 that the SCCL has extracted so far a cumulated total sum of 526.7 mil.tonnes since the start of its mining operations in the year 1889. In the process of extracting this cumulated sum of 526.7 mil.tonnes over the past 115 years, **it has consumed a total sum of 845 mil.tonnes of proved geological reserves (Table-7).** This is the most **startling observation** with a definite bearing on conservation. This means that:

- ⇒ **Only 62% of the proved reserves are extracted; or**
- ⇒ **38% of the proved reserves are lost in the mining process; or**
- ⇒ **the mining-losses are found to be to the tune of 38%; or**
- ⇒ **to extract one tonne of coal, 1.6 tonnes of proved reserves are used, or may be required.**
- ⇒ **In absolute terms, the mining losses = 845m.t – 526.7m.t. = 318.3m.t. or 38% of 845m.t.**

This confirms or even conforms the fact that all the proved reserves can not be extracted fully because of the reasons given earlier. In this case, it is only 62% and the remaining 38% are lost in the process. That 38% loss is almost a permanent loss/damage and this occurs due to various economic and geological factors like the bad seam behaviour, faults and other disturbances, unduly long hauls, bad mine planning, bad roof and floor etc They are designated as mining losses. This is the concern of conservation which avowedly aims to reduce these mining losses to the minimum possible extent; say to 15 to 20% by better mining methods, better mine planning etc.

The Policy Issues: The extent of high mining losses (38%) is noticed in spite of the fact that the industry (SCCL) is under public ownership since long. Had it been under private ownership, the mining losses would have been much higher because of its skimming, slaughter mining practices, profit-motive etc. Things must have been worse. History confirms this reality. In fact, one of the main reasons for nationalisation of the coal sector was to achieve conservation. The issue then boils down to one of ownership in conformity with conservation. Our analysis and the discussions we have had with the mining experts during field visits show that the public ownership of coal resource development may be preferred from conservation view point.

The second issue is one of economics in dealing with the permanent loss of 38% or say 40%. This 40% of left out deposits can be extracted technically but with higher costs than the prevailing market price and the all-industry average cost. This is the economic problem in achieving conservation. Thus conservation involves costs or the damage-avoidance cost. It can not be achieved free of costs. This is the problem and this can be tackled by following **a policy of cross-subsidization** under public ownership with multiple operating units. (This aspect will be discussed later in this paper). Thus, the cross-subsidization is one of the most effective policy instruments through which the industry can minimise the mining losses to the barest minimum. In other words, conservation can be achieved through cross-subsidization. The private enterprise may not like to follow this path. Instead, they may prefer to close down the loss-making units and thereby, cause irreparable damages to the resources. Further, the law of increasing costs to which the mining sector in general is subjected to, gives credence to the conclusion that the public ownership with cross-subsidization will achieve conservation in the exploitation of resources. In a sense, the public sector is thus considered to be both an instrument and an objective of public policy in the mining sector. This is an empirical reality.

Similar is the case with the multiple seams under a mine. Suppose there are four coal seams under a mine. Two or three top seams can be extracted within the cost-constraints but not the bottom most one. Thus the bottom seam becomes a total loss almost permanently. But this can be mitigated through cross-subsidization and thereby, conservation can be achieved. Given technology and mining methods, conservation thus turns out to be primarily an economic problem.

The third issue comes out from Table-7 in which it can be noticed that there is a sum of 243.5 mil.tonnes or about 30% of the consumed geological reserves. And these coals (243.5 mil.tonnes) are lock up under abandoned mines. They are difficult to extract for various techno-economic reasons. It may also be recalled that the mining losses are found to be:

⇒ Mining losses = 845 m.t. – 526.7 m.t. = 318.3 m.t. or 38% of the proved geological reserved consumed to produce 526.7 m.t.

In this loss of 318.3 m.t., the recoverable (or available) geological reserves under the abandoned mines are estimated to be 243.5 m.t. (See Table-7) which forms about 30% of the consumed reserves. This is the **concern of conservation as well as its**

quantitative dimension. In other words, a sum of 243.5 m.t. of recoverable reserves are being locked up under the closed mines. Though difficult, they can be recovered technically but at higher costs. This is the problem. To be more specific, the problem is one of additional (or extra) costs of getting a higher level of recovery from the deposits by mitigating the losses/wastages. This mitigation involves costs. How to deal with these mitigational or avoidance costs? **This is the crux of the conservation problem**. One way to handle this problem is through cross-subsidization as argued earlier. The other way is through socialising the conservation costs in the sense that a conservation-cess can be charged to the current outputs and the revenues thus collected can be spent on recovering the locked up coals and the difficult-to-get coals which otherwise would have been left unmined as almost a permanent loss. Or the other way would be through the conventional approach of subsidies/economic incentives. Whatever be the approach, the huge mining losses/wastages as estimated above, can not be left unmined. This the conservation principle attacks.

The above analysis gives the empirical/quantitative dimensions of the conservation problem. This problem is partly financial/economics and partly technical in nature. Both economics and technology need to be blended in policy-making regarding conservation in minerals extraction.

3.7. The Future Scenario of Coal Mining:

The important lessons that can be drawn from the above analysis of the alarming growth rates of coal outputs in recent years are as below:

a The first and the foremost important lesson is that the fast increasing depletion rates in recent years will bring the conservation issue to the forefront of the corporate strategy. In addition, this will also become an important public policy issue.

b. Due to fast expanding coal demands from the Southern (including AP) region coupled with its locational feature, the AP coal mining industry will come under **increasing pressures** from:

i. Rising mining costs arising out of increased mine-size and the consequent increased hauling distances within the underground mines along with increased capital outlays, combined with a resort to the inferior/lesser fertile coal deposits both in quality and mineability.

ii. Social factors such as the concern for the Quality of environment and alternative uses of land (reclamation). The shift to opencast mining will generate more acute problems in displacement of people and their rehabilitation. Land acquisitions are likely to become more critical resulting in unduly long delays in project implementation. In some cases, some new projects may not see the light of the day at all.

These two factors are likely to impose heavy constraints on the future expansion of the coal sector in AP. Even the all-India coal industry seems to be subjected to these severe constraints on its future expansion.

c. The niggardliness of nature will be felt more by the succeeding generations because of the exhaustion of the more fertile deposits.
d. Posterity will have to face the brunt of higher costs (real) of coal extraction. Mechanisation may not off set fully. They are likely to inherit the damaged resource base and damaged land resources. This is, indeed, an alarming signal to the future.
e. There will be mounting public opposition to the opencast mining system and other environmental damages. More stringent environmental legislation may come in future.
f. Conservational measures should be taken up seriously and explicitly to reduce the mining losses; to increase the levels of recovery; to increase better utilisation of all grades of coals and to increase the life span of coal deposits.
g. The future real costs of coal will be much higher than the present costs because of the inclusion of environmental protection costs, and conservation costs besides other contributory factors like the depletion of better deposits, long hauling distances and so on. No more cheap coal.

3.8. Some Favourable Trends Towards Conservation:

We have observed some important unintended and unplanned trends in AP coal industry that certainly go in favour of conservation. However, conservation did not enter explicitly either in production/mine planning or in corporate strategy. It happens to be incidental. It is taking place as a byproduct or unintended consequence of the company's decisions to expand capacities to extract larger quantities annually to meet the coal demands*. Thus conservation is market-driven. In other words, the expanding coal markets have fostered conservation. This is, indeed, surprisingly laudable. Among such unintended trends towards conservation, the following are importantly note-worthy.

i. Public Ownership: The first and the foremost significant step in the direction of conservation of coal resources in AP is the bringing of this industry under the fold of public ownership in early sixties. This is a wise step. However, the underlying intent was not conservation but something else. But it did contribute towards conservation in a significant measure. As stated earlier, the resources get damaged (loss/waste) under private ownership mainly because of the law of increasing costs and its associated effects. The opposite is true in the case of public ownership which generally adopts scientific mining systems with higher levels of recovery. Further, it is also possible to reach the "difficult" or even inaccessible seams lying below the first one which otherwise would not have been tapped under private ownership. As a matter of fact, this happened in AP coal fields. Thus, the public ownership made several favourable impacts of varied nature on achieving conservation in AP coal fields. The profit-motive of private enterprise and conservation of resources do not go together. In fact, they conflict with each other.

ii. Cross-Subsidization: This is generally associated with the public sector undertakings which operate more than one unit like railways, roadways, electricity boards etc. Under

---

*The industry shifted from the conventional bord & pillar method to the longwall and opencast mining methods in which the levels of recovery are much higher (See Chart-2 and Tables 9 and 10).

this scheme, the financial losses of one unit will be cross-subsidized by the financial gains accrued elsewhere in others. In mining sector, this assumes special dimensions in the sense that the geologically unfavourable (or less fertile) mines can be cross-subsidized by favourable (or more fertile) mines, which otherwise the less-fertile mines will have to leave the production/market and thus resulting in loss/waste of natural resources. The later is the situation under private ownership with competitive conditions. Under public ownership, the disadvantaged-mines which otherwise would have been closed resulting in loss/waste of resources, can be put into operation through cross-subsidization to result in the avoidance of "loss/waste". Thus, the level of recovery is, by logical necessity, higher under public ownership than its counterpart.

Empirical evidence on costs of extraction shows that the SCCL undertakes cross-subsidization, though not as an explicit policy measure (See, Naganna 1974) to conserve coal resources. The latest mine-by-mine cost data show that some of the loss-making mines due to their unfavourable geological conditions are getting cross-subsidized by other profit-making mines (See also, Table-11). As a matter of fact, the evidence in Table-11 reveals that the underground mines with a very low O.M.S. are getting cross-subsidized by the opencast mines with high O.M.S. Thus, the cross subsidization policy can be used to overcome the niggardliness of nature to achieve conservation.

The SCCL undertakes cross-subsidization primarily to maintain the high levels of output to satisfy the ever expanding coal markets. Whatever be its stated objective, the cross-subsidization leads to better resource management with less or no damages (or loss/waste). In other words, conservation is also the result of cross-subsidization. For instance, the SCCL is operating a mine with one of the thickest seams in the country as also highly disturbed. This could have been closed under private ownership. Thus, the AP coal industry operates some high-cost (less fertile) mines through cross-subsidization, which otherwise would have been closed resulting in heavy "loss/waste" of resources

Another aspect is that the Ricardian rental element (differential)can be appropriated for better resource management or conservation through cross-subsidization under public ownership. **Therefore, a better resource management model would be the one that considers together the Ricardian (differential) rent, cross-subsidization and conservation** because this would ensure a solution on the annual rate of production with higher levels of recovery while simultaneously considering the costs of extraction explicitly. This model may be complemented by the lifecycle costing model (See, Naganna, 1982, 1984). Both together would give a fairly comprehensive theoretical framework to the practice of conservation as also provide with an in-built mechanism to tackle the problem of niggardliness of nature and thereby, to achieve conservation.

iii. Mine-Size : Small Vs. Large. On general grounds and on the basis of our experience, it can be said that the small-sized mines are not generally conducive to conservation because they are **prone to lower levels of recovery** (See, Figure-2). This was, in fact, implicit in the Report of the Amalgamation committee (1956). (See also, Naganna, 1980) Experience shows that the small-sized mines, also called the rat-hole mining, normally resort to slaughter-mining practices, skimming of deposits, no mechanisation, unscientific mining etc., causing or resulting in heavy damages to the resource-base. Generally, they go against the principle of conservation. They are the impediments to as also impair conservation. Thus, mine-size is one of the major contributory factors to conservation. In fact, it is a major determinant of the extent of the recovery level from a given deposit (or conservation).

On the contrary, the large-mines are conducive to conservation because they offer wider scope for mechanisation, better mining systems etc., resulting in higher levels of recovery. Further, they could also be more favourable to exploit multiple-seams as also offer scope for cross-subsidization within the mine itself to extract the disadvantaged section. Thus **conservation entails large** mine size. With this background in view, the growth of average mine-size in the SCCL for the period from 1964-65 to 1998-99 is examined. The relevant data on this aspect are presented in tables 10,14 and 15.

It is evident from Tables 10, 10A, 14 and 15 that the average mine-size has increased substantially in the recent past.[14] At the outset, it may be noted that the **mining enterprise (the SCCL) is enticed by large mine size to satisfy the expanding coal markets while conservation entails large size. In effect, conservation is benefited.** The average mine-size (U-G) was small at about 1.2 lakh tonnes in 1950's and it is almost doubled in recent years. Comparatively, the average mine-size in the O-C system has increased much higher than the U-G system. For instance, the average mine-size in O-C was about 2 lakh tonnes when it was first introduced in 1979-80, which made a many fold, rise to about 13 lakh tonnes by the late nineties. This is a notable feature. The average mine-size for all the mines (i.e., U-G + O-C) has more than doubled during the period between 1979-80 and 1998-99. Thus there is a substantial growth in the average mine-size in the AP coal industry. Mines have become bigger. This could take place because of:

a. a shift in mining systems to opencast and longwall methods.
b. Mechanisation programmes
c. Expanding coal markets

In fact, the extent of expanding markets led to both a shift in mining methods and mechanisation; and thereby to enhanced mine-size. The mines should be large enough to absorb technology and mechanisation (See, Naganna, 1980). The increased mine size together with mechanisation would result in higher levels of recovery. This is the experience reported by all the mineral industries. Though the stated intention is not to achieve conservation, the ultimate result is on increased levels of conservation in the AP coal industry. In this context, it is to be noted that it is the expanding coal markets (See, Table-6) and the industry's plans to satisfy them that led to promote conservation incidentally. So to say, this is an unintended-benefit. The increasing trends in the growth of average mine size is a healthy phenomenon from conservation viewpoint.

---

[14] It has been observed (See Naganna, 1981 and 1984) that there is an inverted U-shape relation between mine-size and age of the mine. It helps understanding mine-size. This aspect is not discussed in this paper. However, it may be noted in Table-6 that each peak is followed by a decline in many instances.

Due to various technoeconomic improvements along with suitable organisational changes brought out by the industry from time to time, the labour productivity as measured in terms of output per manshift (O.M.S.) increased substantially in recent times (See Tables 11, 12 and 14). The issue of sharing productivity gains is a different matter. The increased mine-size is one of the major contributing factors to the increased labour productivity.

In conclusion, it can be stated that the increased mine-size for whatever reason it could be, has substantially benefited conservation resulting in higher levels of recovery from the existing mines.

iv. Trends in Output Composition by Technology and Mining Methods: Increased mine-size can be considered both as a cause and effect of increased levels of technology. The trends in output composition by technology and mining methods in the SCCL are presented in Tables 9 & 16. At the outset, it can be stated that these trends go in favour of promoting conservation. They are the healthy signs because the net effect of mechanisation will be to enhance the recovery levels from the working mines. From Table 16, the following can be observed with broad implications in conservation.

a. The output from manual sections (or non-mechanised workings/faces) declined as much as to 69% in 1987-88 from a high of 93% in 1973-74. And, thereafter it has still come down further to only 38.5% of total output by 1997-98 (See Table 9). The output from the machine mining sections has risen from 3.71 lakh tonnes in 1973-74 to a high of 13.96 lakh tonnes in 1997-98 (Table 9). The evidence shows that the extent of mechanisation is significantly high during the period under study. This is a favourable trend in the direction of conservation because non-mechanised workings generally result in "loss/waste" of resources. Here, the level of recovery, is low leading to resource-damages. Knowledge and experience in mining practices confirms this analysis.

b. It is known that the mechanisation leads to higher levels of recovery due to technical reasons and hence, promotes conservation as an unintended consequence or benefit; the intended or stated objective being to increase the output levels to meet the demands of the expanding markets. Though unintended, conservation gets fulfilled in the process. In the year 1973-74, only 3.7 lakh tonnes of the total output was registered from the mechanised sections, which gradually increased to a high of 12.52 lakh tonnes by 1987-88 (See, Table 16). Thereafter, it has continued to go up to 33.2 lakh tonnesby 1997-98. All the long wall faces are mechanised. This is a favourable trend that go definitely in line with achieving conservation.

The impact of the increased mine-size and the subsequent mechanisation programmes as outlined above is felt largely on the increased energy intensities. Table-8 gives the consumption pattern of electric power for the A.P. coal fields during the period 1973-74 to 1998-99. In Table 8, the energy-intensity is measured as the power consumption (mil.kwh.) divided by otuput (lakh tonnes). By this measure, the energy-intensity has increased to 2.38 (or 38% rise) in 1998-99 from a low of 1.72 in 1973-74.

Thus, the coal industry in A.P. is becoming more and more energy-intensive due mainly to technological change or mechanisation programmes.

The empirical evidence indicates that the output and the mine size are increasing at faster rates than the growth in employment, resulting in increased productivity levels. This is obvious due to mechansiation programmes. Whether or not these trends are in the right desirable direction is a matter of social policy.

c. *Shift in Mining Systems:* The age-old conventional "Bord and Pillar" method of working normally fail to cope with ever expanding coal markets due to the low mine capacities (See Naganna, 1980). See also, chart-2. Accordingly a significant shift took place to other mining systems viz., long wall and opencast mining. Again, it is to be remembered that this shift was planned not to achieve conservation but to increase mine capacities and thereby, the output levels. It is widely known that the level of recovery in both longwall and opencast mining is much higher in that order than in the "Bord and Pillar" method. From the conservation angle, the shift is extremely beneficial. Of the mining systems known to the industry, the level of recovery is the highest in opencast mining. It can go even to 80 to 90%, if planned well.

The opencast mining system went into stabilised state of production stream in 1979-80 with a meagre 2.04 lakh tonnes which made a tremendous jump to 38.36 lakh tonnes by 1987-88 and thereafter, it made a further jump to 153.2 lakh tonnes by the year 1997-98. This is, indeed, a significant shift with significant implications in conservation. (See Table 10).

The opencast mining contributed only 2.2% to total output in 1979-80 which mustered a remarkable rise to 23.4% by 1987-88. And, it continued to rise to reach a peak of 53% by 1997-98. The reasons are given in the chart. Of all the trends noticed so far, this is the most significant and favourable one in terms of conservation. Thus, the level of conservation increased substantially due to the introduction of opencast mining. There is one more dimension to this trend. Table-11 reveals that the labour productivity (OMS) is found to be much higher in the opencast mining than its counterpart. It is found to be a high of 3.92 tonnes in the opencast mining (4.2 times higher) while it is as low as 0.75 tonnes in the underground mining during 1998-99. The same is true all through the period under study. It is to be specially noted that the coal mining industry is notoriously labour-intensive in which wage-cost alone forms as high as 70% of the total costs. This being the case, if the the labour productivity (O.M.S.) is converted into monetary terms, then it becomes obvious that the outputs from underground mining are **cross-subsidized** by the outputs from opencast mining. In the absence of cross-subsidization, some of the udnerground mines will have to be closed down resulting in the severe losses/damages of resources. Thus, cross-subsidization saves resources from getting damaged and help achieve conservation.

The industry also introduced two longwall faces in 1983-84 on an experimental basis. It is proved to be effective to make a dent on the AP coal fields. However, this is a positive trend in favour of conservation. It is reported that the longwall method of mining has a fair chance of being successful both technically and economically in these coal fields. Table 9 reveals that the SCCL could get only 1.33 lakh tonnes from the long wall faces in 1983-84. This made a many fold rise to 19.2 lakh tonnes by the year 1997-98. When a large number of possible seams are gradually brought under longwall method, the positive impacts on conservation would be very substantial.

The trends in the composition of output by technology and mining methods clearly suggest that the level of conservation has increased in AP coal industry, though unplanned and unintended.

v. Stowing: It is an additional activity by which the voids created by extraction are filled with non-combustible matter like sand etc. Stowing is undertaken under special conditions. This has two main advantages.

a. it increases the level of recovery of the deposit in a mine; and

b. it increases safety and ventilation levels in a mine.

It helps achieve conservation. The SCCL undertakes stowing only in a couple of mines whose seams are highly disturbed with unpredictable behaviour. Since stowing increases the level of recovery, the industry can rise the extent of stowing gradually to other mines. This involves additional costs. The issue of financing stowing is a different one. Further, the availability of sand in required quantities within reasonable distances is a major limiting factor in this regard.

3.9. Some Suggestions to Improve Conservation:

The suggestions tendered here are based mostly on logic and our experience in mining sector, and partly on our perceptual judgments. In view of its all-pervading importance, the conservation of depletable resources should be taken up as a matter of public policy issue. Appropriate policy measures, both at the macro level and at micro (industry) level are to be immediately initiated to control, regulate, minimise or even to avoid the damages increasingly caused to the precious natural resources. As was stated by Hise (1910) that the issue of conservation is the most important of all before the public, is more applicable today, particularly for our country whose mining history stretches over several centuries. The following are the recommendations made on the basis of analysis carried out in this paper.

a. Awareness among the industry and the public towards conservation should be promoted through education and training programmes. This is the first and the foremost measure. (See, Hise, 1910).

b. The issue of conservation should enter explicitly into the production and corporate strategies/planning. It must be considered explicitly in all policy-making processes and at all levels. It should not, however, be considered as an unintended consequence/benefit of some policy decisions. Conservation needs to be considered as the core issue in policy making instead of periphery as is the case now.

c. Mine-size can be increased further to conduce conservation.

d. Mechanisation programmes can be encouraged to increase the levels of recovery from the deposits.

e. Stowing has to be increased gradually to cover increasingly more number of mines.

f. There must be an appropriate choice of mining methods on the basis of a detailed study with a view to increase the levels of recovery while at the same time protecting and preserving environment. The opencast mining can be pushed further with precautionary measures to protect decoaled lands by undertaking suitable reclamation programmes.

g. Cross-subsidization can be used as a deliberate policy instrument to promote conservation with a thrust on the enhancement of the levels of recovery from the deposits.

h. Conservation, in the ultimate analysis, involves costs. Therefore, financing conservation projects has to be investigated in detail. The society has to accept the fact that the "cost of development" will be higher if conservation and environment are taken care of fully in the planning process. In other words, the social costs of "development" like conservation, environment etc., which were hitherto ignored, are likely to add new dimensions to the development process.

Summing Up: In this case study, the concept of conservation is restricted mainly to the levels of recovery from the deposits under exploitation. Conservation of coal resources no doubt is taking place on a fairly significant measure but as an outcome of market-driven forces. In other words, **The expanding coal markets have fostered conservation.** This the case study confirms.

SECTION – IV

The primary concern of this section is to show the **conflicts between conservation and environment.** One choice will affect the other. If conservation is advocated for various reasons, then the environment get adversely affected. In this context, it appears that conservation can only be achieved at the cost of sacrifising environment. Thus, the problem becomes more complicated if both are considered together. The solution, however, involves expressing a value-judgment, or perhaps the collective value judgement or a social choice reflecting its priorities, preferences, values and needs. Therefore, the choice becomes one of prioritising among conservation, environment and depletion.[15] The focus in this section is on the conflicts arising out of the suggestions made earlier.

4.1. Conflicts Arising out of Mining Choices:

The extent of achieving conservation and the extent of environmental damages due to coal mining vary from one mining method to the other. Each method has different degrees of impacts. The extent of severity and diffusion also differ. Please refer to Naganna 1983 and 1984A for environmental impacts of coal mining. For a brief description of different mining systems, see Naganna 1980. (Also, see Naganna and Subba Rao, 1979). There are broadly three widely used mining methods available to the industry for coal extraction, viz.,

- Bord and Pillar method
- Longwall methods and
- Opencast mining

The properties of each of the mining system and their respective extent of impacts on land resources (forestry) are given in Chart-II. The Chart-I presents the environmental impacts of expanding use of coal. Chart-III delineates the conflicts arising out of choices on mining methods. These charts are prepared in the interests of brevity and not to suppress analysis. Each choice reflects not only the corporate values but of the social-values (or preferences) at large, since the coal industry is under public ownership. The issues that are either implicitly or explicitly involved in these choices contain public interest to a large measure. In what follows is a brief account of the identification and assessment of the conflicts arising out of the choices on extraction methods, environment, depletion and conservation.

a. **The Bord and Pillar Method:** This popular and widely used method is characterised by: low mine-capacities, long gestation periods; low subsidence rates; low level of recovery etc. Consequently, it fails to cope with the newly emerging coal markets and coal demands. This method with stowing has the least damages to

[15] In this context, environment is restricted mainly to land (including forestry), water and air with further restricting to land resources. This is for the sake of brevity. As a matter of fact, conservation is part of environment or environ mental planning. In this paper, they are considered as two different concepts referring to land and mineral resources separately. This is to facilitate the ease of analysis.

surface land resources, forestry, etc. Thus, we can have coal without disturbing environment, particularly land and forestry resources. But, conservation is the least in this method – since levels of recovery are the lowest. Therefore, the choice turns out to be : which resource, either land or coal, we intend to conserve. There is also the problem of stowing costs and coal prices.

b. **Longwall Methods:** The properties of this method are : higher mine-capacities, higher rates of subsidence, higher levels of recovery etc. In this case, one can have better conservation but land gets damaged due to subsidence to a significant measure. Of course, it depends on the local conditions. Therefore, the emerging choice is between : better conservation on the one hand, and more damages to land resources, on the other.

c. **Opencast Mining**: From the view point of conservation, the opencast mining has been advocated earlier. In fact, this is the best method for conservation because the level of recovery is the highest in this system. In addition, mine-capacities are also the largest and the costs of extraction the least. But, the major problem is that the land and other forest resources get almost totally damaged in this system; and the whole surface vicinity gets disturbed.[16] Therefore, the choice will be one of between the total conservation of coal resources and the total protection to land resources. Both cannot be achieved together. As a result, there is a mounting public opinion in the West against this mining method. Even in our country, it started building up. Therefore, in this system, one can save one resource only at the cost of the others. This is the problem in resource management.

After looking at the social problems of displacement and land damages, one can suspect on general grounds that the benefits accruing out of the opencast mining may not outweigh its severe social costs. But ensures conservation. The choice is between land and coal.

4.2. Other Conflicting Considerations:

To a large extent, environmental (land) problems can be mitigated through both stowing and land reclamation programmes in some combination depending upon the local conditions and situation. But, this leads to another problem that the costs of coal extraction go up considerably and tends to conflict with the well accepted policy on the interfuel substitution. This may even lead to an enhanced dependence on oil which is not a desirable thing. This is another conflict. Further, the objective of supplying low cost power for developmental purposes will also get into conflict. This laudable objective becomes at stake. Thus, the problem of conservation becomes much more complicated if viewed from different angles. In the same vein, the issue of mechanisation follows.

---

[16] More importantly, this method requires large tracts of land for its mining and other operations. Hence this obviously involves the involuntary displacement of a large number of families and their rehabilitation and resettlement. This is the most acute problem giving rise to the other problem of land acquisition. See Roli Asthana, "Involuntary Resettlement : Survey of International Experience", **Economic & Political Weekly**, June 15, 1996. See also, M Sen, "National Rehabilitation Policy : A Critique", EPW, Feb. 4, 1995. See also, Michael M Cernea," Risks, Safeguards and Reconstruction : A Model for Population Displacement and Resettlement", EPW, October 7, 2000.

Mechanisation: This has been advocated earlier since it will improve the levels of recovery. But, this conflicts with the employment generation — the social objective of the industry. The choice, then, becomes between conservation and employment generation.

The Cross-Subsidization Policy: To our understanding, this is the measure that does not conflict with any other. In this case, the social costs of conservation, environment and depletion get internalised through a delicate techno-economic mechanism. Therefore, the industry can bank more and more on this policy instrument to achieve both conservation and environmental protection simultaneously. In fact, this provides with a built-in mechanism by which the industry can internalise the social costs including conservation. It should be the core of resources management because the essence of cross-subsidization is, by mobilising rental elements, to protect the less fertile deposits from getting damaged by either skimming or closure; or by any other means. It gives an integrated framework in which extraction, conservation, depletion and environment find their due space.

Because of the interdependence of various techno-economic factors one finds that there are a large number of conflicting situations arising out of the search for a solution to the problem of conservation in isolation. It is difficult to find an analytical solution to overcome the conflicting situations as observed above. Each solution gives rise to a new problem, or even at times the solution itself becomes a problem. The choice is between/among : conservation (mineral resources), Environment (particularly land and forestry) and additional extra costs over and above the normal extraction costs; besides employment, capital costs etc.[17] Its scope indicates that it is in the nature of a social or public choice. Under these circumstances, the choice may therefore be guided by and adhere to the currently prevailing social priorities or preferences which are supposed to be reflected in the political will in a democratic set up.

4.3. Conservation & Markets:

Our lurking hunch/surmise based on our filed visits not only to several coal belts but also to other mineral belts in the country from time to time during the past couple of decades, is that the expanding markets for minerals promote and foster conservation of mineral resources through increased mine size, mechanisation programmes, better (scientific) mining methods and so on. Expanding extent of markets may even bring the lower grades into productive uses which otherwise would have been discarded (or wasted). Further, this situation also encourages the blending of different grades wherever possible, resulting in the parsimonious use of resources (conservation). In the same vein, it can also be inferred that the mineral market expansion creates the awareness for the need to conserve. So to say, market expansion and increasing levels of awareness for conservation go together. The oil crisis of 70's and its aftermath would substantiate the

---

[17] In fact, it is a complex exercise because each choice conflicts with others (such as : conservation with environment, mechanisation with employment, environment with costs etc). Since a policy reflects a choice, this shows that the chosen policy will conflict with other policies. **Therefore, the policy analysis will have to be viewed within a paradigm of conflict rather than of a rational choice.**

case in point. Thus, the market expansion would ensure wise-use of resources (or conservation).

History of coal mining industry (all-India and A.P.) gives ample evidence on this surmise (See Naganna, 1980). But the contraction of markets or lower levels of demand do the opposite and even promote slaughter mining, skimming etc. Thus, the extent of market has a definite bearing on conservation from the point of view of **"level of recovery"**. Experience shows that larger markets promote and foster conservation.*

A Conflict: A conflicting situation arises in the context of markets and conservation. Expanding markets may foster conservation through increasing the "levels of recovery" including the extraction of lower grades **but conflicts with the rates of recovery (or, the sustainability).** To be more specific, the expanding markets obviously imply the higher rates of annual recovery which is same as the higher rates of depletion. In other words, sustainability becomes critical. This conflicting situation among the expanding markets, conservation and sustainability needs to be resolved through compromises. There is no other way, other than working out some agreeable compromises/trade offs. Consequently, the issue gets drifted from mineral economics to the domain of public policy.

The following proposition follows from the above analysis.

⇒ **If the extent of market is low relative to the resource-base, then the extractive sector in general is prone to resort to the slaughter mining practices, skimming the deposits, rat hole mining and of sort; or in other words, the resource damages/wastages will be more and unheeded as well. And Vice Versa.**

This proposition, in fact, follows from a careful study of the history of national coal mining industry (See Naganna, 1980) as well as the A.P. coal industry, in particular. From this proposition, we can also derive that the principle of conservation becomes more relevant and necessary when mineral markets get expanded. In simple terms, it is to say that conservation does not catch the attention of the policy makers (See Naganna, 2000b) if the resources are found to be plentiful and abundant in relation to the needs/requirements. But the situation is totally different now.

There is the population explosion with increasing aspiration levels for higher consumption standards resulting in industrialisation on a larger scale, and there are also so many socioeconomic changes that have a direct bearing on the resource-base. Consequently, the extent of mineral markets are getting expanded; and the mining sector is growing at much faster rates than ever before, giving rise to the problem of sustainability (See Naganna, 2000a). It is in this context that the need for conservation becomes imperative because the expanding markets may lead to wasteful extraction

* However, this is not to be mistaken that we are advocating to leave the issue of conservation to market forces. Policy intervention is necessary to achieve conservation because market expansions may only help to some degree, say 10%.

processes. It has been observed that "It is easier to agree on policies that would contribute to sustainable development than to define the term itself. Examples of unsustainable development or at least inefficient or wasteful practices are numerous" (Charles S Pearson, 2000; p 479).

4.4. Socio-Economic Environmental Impacts of Coal Mining:

In what follows is a brief account of observations made through, what is known as, the Initial Environmental Examination on the A.P. coal fields This is based on four field visits of different durations each (1966-67; 1979; 1989 and 1999) made to the coal fields. Thus, the time span of our observations spreads over for about four decades. During this period, several structural changes of far-reaching consequences took place both at the industry level and its vicinity or the environment. The coal industry, as seen earlier, underwent a lot of structural changes in terms of growth, shifts in mining systems, mechanisation and so on. These changes have been necessitated and facilitated by the phenomenal expansion of coal markets. In other words, the whole empirical analysis and data as presented in this paper unfolds the story of how an industry responds to the fast expanding markets. All these changes have, in some way or the other, and in some measure, have contributed towards the environmental degradation in all the coal-bearing regions of Andhra Pradesh. In this context, one can identify three broad phases in the historical developments that took place in this coal region.

In the first phase, the region was richly endowed with a high quality of environmental and ecological resources before the start of mining operations. Historical records lend credence to this state of environment. It is true that people might have been poor economically or materially. In the second phase, coal mining industry started towards the end of the last century. This gave an element of hope; and consequently the regions could lift themselves above the ravages of poverty. This is because of obvious reasons. In this third phase, it is becoming clear that the economic success attained in the earlier phase may result in social, environmental and ecological collapse. Our considered hunch is that this process of collapse has already set in, as the continued economic success imposes an ever more serious burdens on the natural environment (See Naganna, 1984A).

One may question the serious concern as shown both by the economic and physical planners for the protection and preservation of environmental and ecological balance on the sole ground that the proportion of geographical area occupied by the mining industry is not significantly high. In fact, this is not a sound argument. The minerals are by their nature exhaustible and hence, the extraction activity becomes essentially a "Shifting" one comparable to that of shifting cultivation in Assam's mountainous regions. This shows that new virgin areas are sequentially brought under mining machinery immediately after the depletion of the old areas There is thus a new problem for this sector in dealing with the abandoned closed mines The development of new mines and closing of depleted ones is a distinctive feature of this industry The shifting nature of mining activity amply justifies our concern for the maintenance of a fairly reasonable quality of environment and ecology. This being the case, lower rates of growth both of coal and other sectors must be accepted, if the environment and ecological balance is to be maintained at fairly acceptable levels.

The data as presented in Tables 18, 19, 20 and 21 give enough clues, either explicitly or implicitly, with respect to the socio-economic environmental impacts of coal mining on the coal-bearing regions and their respective vicinities. Since the coals by their very nature of formation are found mostly in the thick dense forest zones, the extent of adverse impacts on forest lands by the magnitude of operations as shown in Tables 18 through 21 can easily be visualised. All the coal endowed regions are exposed to new stimuli in terms of mining, industrialisation and so on. Huge amounts of money (capital outlays) are continually injected into these regions over the last four or five decades. These geogrpahical regions responded in many and varied ways. Economic development/industrialisation did take place in significant measures. In the process, the precious environment and ecology got adversely affected. Several irreparable, or even irretrievable damages have been inflicted on many of the precious and sensitive environmental resources (See Naganna, 1983, 1984A).

It is widely recognised that environment is a tightly connected system with four interdependent and interconnected subsystems, viz., (a) physical resources (land, water, air); (b) Ecological resources; (c) Human use values; and (d) Quality of life values. (See any popular text book on Environmental Management). There is a delicate balance between/among these four subsystems; and this balance is being disturbed due to indiscriminate mining and other induced and related socio-economic activities. The result is the Nature's Fury. Hence, the concern. (See, M.J. Chadwick, et.al. 1987).

4.5. Socio-Economic Environmental Impacts:

The following is a brief list of socio-economic environmental impacts of coal mining on the basis of our Initial Environmental Examination. However, the list is by no means exhaustive.

i. **Land and forest Resources:** These two are the first and the foremost environmental resources that are damaged very badly by the mining activity. Both have several alternative uses, perhaps better ones, than just putting under mining machinery for coal extraction as a one-time benefit to society. On the other hand, land and forestry yield infinite streams of benefits to society in various forms and ways. Such perennial sources of income are almost permanently damaged and made defunct of their functions. Their uses are many and varied. They even cannot be priced through conventional market mechanism. For instance, the top soil forest cover of one foot thickness (resembling a sponge-like material) takes about a 1000 years to get formed which absorbs rain waters and keeps moisture levels in balance. Then, can we price it or impute its cost? It is futile and needless here to highlight their (land & forests) functions, uses and utility to society.

   Land and forest resources get damaged, denuded and impaired mainly in two ways (See Chart-1). Firstly, there are direct impacts. Large tracts of lands are directly put under mining operations including office buildings, access roads, workshops, bunkers, stockyards and so on. Dumping of mineral wastes like shale etc., itself occupy large tracts of forest lands. Subsidence is another major hazard to land. Both get totally damaged particularly under strip-mining (rightly called). This is the reason why mining is defined, sometimes, as the **"destructive use of land".**

Since mining is a shifting activity from one geographical area to the other, the adverse impacts on land and forest resources are almost continuously and constantly inflicted. It is not a one-time affair. It was there ever since the start of mining operations more than a century back and it will be there till the coal deposits are totally depleted. The cumulated sum of all these "damages and impairments" is indeed alarming, or even frightening to assess objectively. Ultimately, our posterity will inherit the damaged lands and denuded forests. It is equally frightening to visualise the shape of environment and the landscape after the closure of mining when once the deposits are fully exhausted.

Secondly, there are indirect environmental impacts which are larger and more hazardous. The very availabilities of coals in plentiful quantities attracts a large number of coal consuming industries because of obvious advantages. In this case, several coal consuming industries like paper, metallurgical, thermal power stations etc., have cropped up in the coal bearing regions. They also generate indirect employment and create auxiliary industries. As a result of this industrialisation, large tracts of forest lands are occupied by their direct and indirect operations. Consequences of such land-use patterns are widely (like soil erosion, desertification, impaired capacity to absorb rain waters, loss of moisture etc.) known. The secondary impacts (environmental) arising out of the induced growth are much larger in number and at times, more damaging to environment than the direct impacts.

ii. **Growth of Townships:** Due to coal mining industry and other related industrial projects, a large number of towns are growing fast in these areas due to direct and indirect employment generation. The local labour markets cannot cope with the manpower requirements of the industry. Hence, in-migration is taking place on a large scale. Several new villages have cropped up while the old ones got expanded as a result of migration to these forest zones. The net result is the growth of townships which again consume large tracts of forest lands. In the process of urbanisation, some towns have been made as growth centres and education centres to arrest their decline (See, Naganna, 1989). The Kothagudem town in Kammam district of A.P. is a case in point. The urbanisation is causing deforestation through large scale illegal felling of trees. Once the thick and dense forests are totally denuded.

iii. **Detribalisation**: Coal mining industry made a large adverse dent on the tribal communities. More importantly, the deforestation or denudation of forestry affected the tribal communities very harshly because they lost the very source of their livelihood (i.e., forest). They lost their hereditary occupations and their mainstream activities in which they have hereditary skills. Their skills have become defunct. They are deprived of their habitats and economic base. There is thus the detribalisation process going on in these coal belts. Social and political processes have further accentuated the detribalisation. Besides, some tribal people are getting unskilled jobs in the coal industry on reservation-basis. They are acting as agents of social change in their respective communities. Detribalisation has again harmful effects on forest lands.

iv. **Problem of Catchment Areas:** The catchment areas of the rivers that flow in these coal belts have all been deforested. They have become bald. The obvious result will be floods and other natural calamities in the downstream areas. Because, deforestation reduces the rain water absorption-capacity of the forest cover which cause the release of more rain water to the streams and rivers—more than their carrying capacity; and in effect, causing floods in the downstream areas.

Future appears to be more hazardous with frequent natural calamities if one takes into account the total damages.

v. **Wild Life:** The habitat zones of wild life are totally disturbed. There is a near extinction of wildlife in these regions due to ecological disasters. Once, these regions were considered as "hunters' paradise".

vi. **Water and Air Resources:** Both are getting contaminated and polluted due to coal mining and other coal burning related activities. The use of explosives, dust, coal burning emissions etc., are some of the major sources of pollution.

vii. **Problems of Residuals Management**: Of late, this problem has become more severe and relevant than ever before. This refers to the "wastes" of all types generated both in the production and consumption process in any region (For more details, see Alan V Kneese, 1977). In principle, all the products become discarded (or waste) after their useful life and thereby, become "residuals". The extent of residuals generation increases with the rate of development. Their composition also get changed. Since both production and consumption levels in these coal-belts are increasing at much faster rates than before due to expanding mining activity, growth of townships and other industrial projects, the menace of rising levels of residuals/wastes is posing a severe threat to environment. Its capacity to absorb and assimilate these residuals is continuously impaired due to deforestation and other disturbances. No one considers this problem explicitly. The problem of residuals management coupled with deforestation will become very severe and complex in the coming years. Remedial measures should be devised immediately, otherwise there will be a total environmental and ecological collapse in these coal belts. And, these effects will be spread to the downstream areas.

viii. **Intersectoral Problems:** One can also observe some intersectoral imbalances cropping up in these regions. Before the start of mining, agriculture was not a significant sector. With the advent of mining, agriculture gradually emerged as a sizable sector. This was made possible through deforestation. The present trends seem to be different. Though, trade and commerce are flourishing well, the agriculture is getting negatively affected due to the shift of labour force from agriculture to mining and other non-agricultural activities. This is due to higher wage rates in non-agricultural sectors. Besides, deforestation is also causing disturbances to agriculture. The household sector is facing the shortages of fuelwood, rising prices etc. Social frictions are likely to come to the fore in the coming years due to the conflicts between migrants and the locals. Local societies and communities are undergoing significant structural changes.

ix. **Magnitude of Operations:** The magnitude of operations as undertaken by the coal industry (The S.C.C.L) is enormous and very divergent. At the outset, the mere size of operations itself enables one to get the feel of the possible and likely impacts on the ecology and environment in the coal-belts even without attempting to identify, assess and evaluate the impacts. The exercise on environmental impact assessment may give numbers and quantitative dimensions to give direct perceptibility to the phenomena. But, the very size itself speaks volumes negating the need for such a detailed analysis. The fact that coals are found in the thickly dense forest zones would substantiate the case in point.

The data as presented in Table 18 through 21 give the extent of the magnitude of coal mining operations undertaken by the S.C.C.L. The intention is to give the feel of the extent of social overheads that the industry is maintaining, besides its production operations and their overheads. All these operations will have their own impacts on environment in their own way. To this, if one adds similar data from other industries operating in these regions, one can get the total impacts on environment. Of course, indirect employment etc., are also to be considered. Our analysis is restricted only to coal mining industry. It is suggestive or indicative in nature. Each item in the above mentioned tables indicates roughly the extent of its impacts on environment in some way or the other. In other words, different environmental resources are affected by different degrees in different ways by different items of activities as outlined in the above said tables

To keep pace with the expanding coal markets, the coal industry as a whole appears to be better or more professionally managed than before to undertake such a large scale operations of raising annually about 30 million tonnes of coal by employing more than a lakh workforce. To this magnitude of coal mining operations and overheads maintenance, the indirect employment, the induced growth etc., are to be added. All this implies a lot of construction activity which inflicts physical disruption on the environment The notable point is that the labour force is no more considered as a mere factor of production. It is much more. This is reflected in the welfare expenditures incurred by the industry (See Table – 20).

Even today, coal mining is difficult and hazardous work. Since the workforce is subjected to severe occupational hazards like blacklung etc., the company provides adequate medical facilities (See Tables 18 and 19). Educational facilities and other social amenities are also provided. All these infrastructural facilities and social amenities contribute sigfnificantly to the growth of townships. In addition, they also encourage in-migration from nearby villages as also attract new industrial projects. The ultimate impact will be on the land and forest resources.

The above is a brief presentation on the environmental impacts of coal mining that need corrective measures to keep the environmental and ecological balance at reasonable levels

4.6. Environmental Legislation:

The ineffectiveness and the failure of the underground mining systems to meet and cope with the ever increasing levels of coal demands and the endowment of substantial amounts of demonstrated coal reserves at shallow depths constitutes the two principal reasons for the inevitable shift to strip mining system which is inherently damaging to the forestry and other land resources. There is a similar shift from the conventional "bord and pillar" method to the longwall systems which are again comparatively more damaging to the land due to higher rates of subsidence after mining. All these shifts in methods of extraction are resulting in continuous damages to land resources on a massive scale and thus, degrading environment in general. Therefore, there arises an imperative need to protect and conserve the increasingly scarce and valuable land resources. This can be achieved through appropriate legislative measures on the control and regulation of strip mining as also on the reclamation of strip mined land or the decoaled areas. But the solution should not become a problem. The legislation should not become a major barrier for coal expansion in our energy future and on the other hand, it should conduce reclamation programmes in such a way that the land productivity shows an increase after extraction is completed. Then only, the reclamation benefits outweigh their costs; otherwise, the opposite will result. Further, this would ensure an optimum trade-off between land and coal without much impairment on environmental resources. In the same vein, it follows that the energy strategy cannot be formulated in isolation or independent of environmental considerations. The later enters as a constraint.

At present, there is a general consensus that sustainable development implies an active role for government in efficient and equitable management of natural and environmental resources. A.C. Pigou observes way back in 1932 as: "It is the clear duty of government, which is the trustee for unborn generations as well as for its present citizens, to watch over, and if need be, by legislative enactment, to defend the exhaustible natural resources of this country from rash and reckless spoilation" (Requoted from Charles S Pearson, 2000; p 463).

4.7. Environmental Management Planning:

If one takes into account all the social costs, the gains from coal extraction may not outweigh the total costs. Hence, there is a growing concern for the restoration of environmental balance after extraction, or at times concurrently. At present, there are no reclamation programmes being undertaken either to restore the damaged lands or to bring back the decoaled areas to their "original or premined state". No doubt, one can see some aforestation programmes being undertaken here and there in these regions. But, they are not in consonance with the rates of deforestation. They do not appear to cope with the requirements of replenishment. The aforestation programs as implemented at present cannot make a natural forestry. They cannot retrieve wildlife habitats.

Keeping in view of the whole environmental impact analysis, it can be suggested that a detailed Comprehensive Environmental Management plan for the entire coal belts may be prepared with the help of an expert interdisciplinary team. Such a regional plan can take into account all the cumulated impacts of all the working and closed mines both overtime and space. Such a plan may also include, among other things, the legislative controls and regulations. This should also include a separate plan for the restoration of environment under the abandoned/closed mines because of some unique features. The coal industry must create an Environmental management cell to implement and monitor the environmental management plan both in letter and spirit. The guiding principle will be the extraction of coal without environmental damages. Then, the gains from coal mining may outweigh the social costs.

Conclusion:

In view of the above analysis, it can be said that the problem of conservation has to be considered through a wholesome approach and a total systems view. Partial analysis is likely to generate conflicts. So to say, such solutions will not have wider acceptability both in theory and practice of conservation. The law of increasing costs is the underlying cause for the whole problem of conservation. The later, in fact, is the effect.

The paper brings out some broad implications in theory and practice of conservation and its bearing on environment. In the process, it identifies some inevitable conflicts that arise between environmental protection and conservation. Both are interwoven. Some compromises are needed in resolving the conflicts. But the implementation of conservation and environmental protection involve additional costs, resulting in higher prices of coal. This has several other implications

The choices before the policy makers should reflect the social values and social-priorities/preferences at that point in time Today's choice may not sound meaningful for tomorrow. Since there are a number of conflicts arising out of choices on conservation and environment, some meaningful and agreed-upon compromises or trade-offs are to be worked out through a detailed study and analysis. Consequently, **the conservation analysis will be more effective, more meaningful and more solution-oriented if it is primarily viewed within a paradigm of conflict and compromise rather than of rational choice.**

Most of the analytical part as presented in this paper is equally applicable to the rest of the mineral resources. Among other things, the paper highlights the role of cross-subsidization in resource management

The SCCL is doing a commendable job in coal resources management and exploitation With its managerial and technical skills, it is able to cope with the ever expanding coal markets. In this case study, conservation is restricted mainly to the levels of recovery from the deposits under working. Conservation of coal resources is no doubt taking place in a fairly significant measure but as an outcome of market-driven forces. So to say, **the expanding coal markets have fostered conservation.**

A POLICY INITIATIVE/PRESCRIPTION.........

In the context of "**Conservation & Markets**" (see p.47 of this paper), it has been observed that there is a major conflict between the level of recovery and the rate of recovery. There is yet the problem of the law of increasing costs. From these two fundamental observations and from the feel of the detailed analysis on conservation and environment as presented in this paper, it follows that the mining activity in general need to be geographically planned, controlled and regulated through state intervention. In the ultimate analysis, this implies concentration of workings/higher mining intensities in smaller geographical areas. Wide scatteration of mines over large areas with lower mining-intensities seems to be a major deterrent to conservation. Instead of opening a large number of small scattered mines over large tracts of mineral-bearing areas, it is better to open a few large mines in smaller areas. Thus the deterrent is overcome. The evaluation and monitoring parameter will be the **"mineral output per hectare of mineral-bearing area".** This is the remedial policy measure to achieve conservation/sustainability which, together with cross-subsidization, would ensure not only conservation but also more rational management of natural resources.

Operationalisation & Strategy: The implementation package for such a policy will comprise the following: i) a detailed mapping of the whole mineral-bearing area; ii) stratify/segment this area by blocks; iii) grade these blocks by their quality, quantity, mineability/recoverability and other geological factors; iv) then take up block-after-block extraction; (i.e., a new block will be permitted only when the old one is totally depleted or the last ton removed); v) regulation & control through legislation and licensing; vi) sequencing of blocks for extraction overtime, involves social choice on the basis of quality/grades, recoverability etc.

This system of block-after-block extraction would ensure better laying and utilisation of infrastructural facilities, ease of management and supervision, better public vigilance and transparency, better environmental protection planning and so on. The proposed policy initiative with an alternative arrangement of mining facilities is, perhaps, ingrained in the very nature of the resource base. It is only brought to the fore.

REFERENCES

1. Charles R Van Hise (1910), "The Conservation of Natural Resources in the United States" (The MacMillan Company, New York).

2. Hotelling Herald (1931), "The Economics of exhaustible Resources", **Journal of Political Economy**, 39 (April 1931), pp. 137-75.

3. Anthony D Scott (1959), Natural Resources : The Economics of Conservation", Toronto, University of toronto Press, 1955.

4. Donald Carlisle (1954), "The Economics of a Fund Resource with particular Reference to Mining", **American Review**, 44, 1954, pp. 595-616.

5. Oriss C Herfindahl (1959), "Some Fundamentals of Mineral Economics", **Land Economics**, 31, 1955, pp. 31-38.

6. Meadows D et.al. (1972), "The Limits to Growth", (New York, Universal Books, 1972).

7. N Naganna (1983), "Coal and the Environment : Issues in policy and Planning" (Technical Report No. 13; 1983, CEM, IIM-B, Mimeographed).

8. N Naganna (1974), "Economic Analysis of the Coal Mining Industry: With Some Empirical Explorations in the Behaviour of Costs and Input-Output Relations" (Unpublished Ph.D. Thesis, University of Poona, Poona, 1974).

9. N Naganna (1980), "Technical Change in India's Coal Mining Industry : Structure, Tend, Impact and Exgtent". (Published in V Vyasulu (Ed.) Book "Technological Choice in Indian Environment", Sterling Publishers, New Delhi, 1980, pp.175-279).

10. N Naganna (1982), "Two Studies in Mineral Economics : The Case of Coal Mining" (Technical Report No.10; CEM, IIMB, Mimeographed, 1982).

11. N Naganna (1984A), "Environmental Impact of Coal Mining: A Case Study" **U R J A**, Dec. 1984.

12. N Naganna (1989), "A Structural Analysis of India's Mining Sector in the context of Development planning", **The Indian Journal of economics**, January 1989, No.274.

13. Carroll L Wilson (1980), "Coal : Bridge to the Future", Report of the World Coal Study. MIT, 1980.

14. N Naganna and S Subba Rao (1979), "Perspectives for Coal Demand in the Southern Region : 1990", **U R J A**, July 1979, pp.31-50.

15. James F McDivitt and WG Jeffery 91976), "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, Metallurgical and Petroleum Engineers, Inc., New York, 1976.

16. Kauffman, R.J. (1969), "Life Cycle Costing : Decision Making Tool for Capital Equipment Acquisition", **Journal of Purchasing,** Vol.5, No.3, August 1969, pp.16-31. Also see, Harvey Graham, "Life Cycle Costing – A Review of the technique", **Management Accounting**, Vol.54, No.9, October 1976, pp.343-347.

17. FE Schumacher, "Small is Beautiful", ABACUS edition, 1984.

18. N Naganna 91981), "A Methodology of Materials Planning at the Corporate Level : Case of Coal Mining Industry"" **Productivity**, July-September 1981; Vol.XXII; No.2, pp.19-40.

19. "Concentration of Colliery Workings in Selected European Countries" **United Nations,** Geneva, 1964, p.3.

20. AB Ghosh, 1977, "Coal Industry in India", **Sultan Chand and Sons**, Delhi, 1977.

21. N Naganna, 1984, "Structural Composition of Costs in Coal Mining Industry : New Perspectives", **The Indian Economic Journal**, Vol.32, No.2, December 1984, pp.104-132.

22. Harold J Barnett and Chandler Morse, 1963, "Scarcity and Growth", R.F.F. Inc, The John Hopkins University Press, Baltimore; 1963.

23. Myron W Watkins (1944), Scarce Raw Materials : An analysis and a Proposal", **American Economic Review,** 1944.

24. TJC Robinson, 1989, "Economic Theories of Exhaustible Resources", Routledge, London, 1989.

25. David Pearce, et.al., 1989, "Blue Print for a Green Economy", Routledge, London, 1989.

26. Allen V Kneese, 1977, "Economics and Environment", Harmonds Worth, Penguin dated 1977.

27. N Naganna, 1994, "Some investigations on the Determinants of Cost Behaviour in Coal Mining Industry", **The Indian Journal of Economics**, Vol.LXXV, Part I, No 296, July 1994, pp.1-39.

28. N Naganna; 2000, "Economic Reforms and sustainability : A Conceptual Analysis and Framework", **The Indian Journal of Economics**, Vol. LXXX, No.318, January 2000, pp.355-394.

29. Chandler Morse, 1976, "Depletion, Exhaustibility and Conservation", in '**Economics of the Mineral Industries'**, William A Vogely & Hubert E Risses (Ed.), American Institute of Mining, Metallurgical & Petroleum Engineers, Inc. New York, 1976. pp.224-270.

30. N Naganna, 2000a, "**Management Responses to Growth : A Case Study"**, Working Paper No.151, April 2000, IIM-B.

31. N Naganna, 2000b, **"Public Expenditure Programmes, Natural Resoruces and Public Policy"**, Working Paper No.161, November 2000, IIM-B.

32. MJ Chadwick, NH Highton & N Lindman (Ed.) 1987, "**Environmental Impacts of Coal Mining and Utilisation"**, Pergamon Press, 1987.

33. Charles S Pearson, 2000, **"Economics and the Global Environment"**, Cambridge University Press, 2000.

34. David Novick, 1976, **"A World of Scarcities – Critical Issues in Public Policy"**, Associated Business Programmes, London.

35. Frederick M Peterson & Anthony C Fisher, 1977, "The Exploitation of Extractive Resources : A Survey", **The Economic Journal,** December 1977, Vol.87, pp 681-721.

36. Anthony C Fisher and Frederick M Peterson, 1976, "The Environment in Economics – A Survey", **Journal of Economic Literature**, vol.14, March 1976, pp 1-33.

APPENDIX – 1

Environmental Impacts of Mining Sector with Special Reference to Coal Mining

Part-I : Non-Coal Mining:

1. Importance of mining needs no mention. Environment gets affected in many and varied ways. The nature and extent of environmental impacts **vary by**:

    a. The type of mineral deposit (vein or stratified; metallic or non-metallic, etc.) together with,
    b. Mining system applied
    c. Location (Eco-system) & Vicinity
    d. Technology used

2. Mining sector has three-level impacts by varying degrees and types, viz.,

Mining Sector →
- → Extraction
- → Transport/handling of minerals
- → Benefication/processing/smelting etc. (Location; more damaging than extraction)

3. Important parameters to be considered in environmental impact assessment.

    a. % ore content in the mineral; and quality
    b. % of ore body to mineral wastes or ratio of overburden to the ore body
    c. Depth of the mineral deposit
    d. Ratio of mineral output to waste rock
    e. Mineralogical properties including geological
    f. Benefication (or Removal of impurities)
    g. Mineral processing (Smelters etc.)
    h. Nature of location (or the eco-system); vicinity

⇒ Mining as a sector vs. a single mineral.
Mine vs. a mineral-belt or mineral bearing area.
(Requires Area Plans).

4. Mining did not receive public attention though it is environmentally devastating. Because, it is remote from urban centres. No concern is shown.

Environmental Impacts:

a. Downstream water pollution both in terms of silt and of toxic chemicals or metallic substances. Affect downstream fisheries and aquatic biology. Minerals by definition are chemical compounds and hence, their impacts are hazardous.

⇒ Toxic heavy metals (e.g., from copper mining) and acids (from coal mining) are examples of chemicals which can exert toxic effects on downstream ecology.
⇒ Can be disseminated throughout the entire stream flow. (eg., Thungabhadra dam).
⇒ Demineraled areas left barren and stripped; and without vegetative cover. Hence, surface run off waters creates problems like soil erosion, siltation etc.

b. **Other Adverse Impacts:**

⇒ Impairments on wild life; wild life habitats destroyed. Deforestation and its aftermath; infrastructure and its impacts. Minerals transport is a major polluter.
⇒ On land for agricultural uses; land productivity goes down due to dust emissions etc.
⇒ Pollution (water and air); dust emissions; community water supplies get contaminated. Air pollution.

* Explosives create problems. Risk and hazards.

⇒ Depreciation of recreational values; landscapes.
⇒ Noise and vibration. Quality of life goes down.
⇒ Health hazards on workers; and in the vicinity.
⇒ Migration & townships. Local & migrant conflicts.

c. **Protective Measures**: are available to treat toxic substances, removal of silt etc. Erosion and sediment control for surface mining operations is a highly specialised technology in itself. It includes the physical systems to control run off and use of vegetative covers.

* Reclamation measures required.

⇒ Mining a **shifting activity** and hence, the impacts continuously spread to large tracts of forest lands.

d. Mineral processing (smelting etc.) and the Benefication process or the removal of impurities (like dressing, sizing etc.) create more damages to environment than extraction, as such. Residues are thrown into open lands. Untreated used water released to the down stream areas.

* Low grades/lower quality minerals for which, market is not there, are thrown open into the environment. This causes a lot of damages to land, air and water.

e. **Effects of Environment on Mining Projects/Operations:**

The local surface and underground hydrology; climate and geology (minerological conditions) are major CONSTRAINTS that affect mining operations. Dedicated land uses may also affect.

Conclusion: The environmental impacts of mining as broadly listed above are mostly quantifiable and measurable.

So far, the environmental impacts of mining sector were not noticed either by the public or by the governments. Now, the things are changing. Public is becoming more aware of the severe problems posed by the mining sector. The public participation and pressures are mounting in recent years. They are demanding environmental protection and preservation. Therefore, the mining sector needs to take up environmental protection measures including the land reclamation programs. All these remedial measures cost money to the sector. If these additional costs are included, the costs and prices of mineral supplies will go up substantially. Further, the environmental dimensions will affect the free flow of material supplies to the using sectors. The future material availabilities will get affected . **Therefore, no more cheap raw materials or no more cheaply and abundantly available raw materials.** The using sectors need to take note of this newly emerging situation.

Part-II : Coal Mining & the Environmental Impacts:

All human actions are directed towards altering and using the natural (or environmental) resources to satisfy the human wants and needs whether legitimate or otherwise. In a sense, development means satisfying human wants and needs.

⇒ **Therefore, environmental problems are to be considered as INTEGRAL part of the overall processes of development including** the coal and non-coal mineral resources development and exploitation. In effect, development means exploitation of minerals.

1. **Coal Mining and Environment:**

Mining may be defined as the REMOVAL of minerals from the earth's crust for use in the service of man. Therefore, all mining activities affect environment in several ways.

⇒ **Mineral exploitation is defined as the DESTRUCTIVE USE of land. It is a TRANSITORY USE of land. This is perhaps the best definition in the context of environmental impact analysis.**

⇒ As land is a non-renewable resource-base; and supports all primary productive systems as well as PROVIDES the essential social-environment, it must be put to productive use after mining is completed. Therefore, the Reclamation or back filling necessary.

2. **Fnvironmental Impacts of Underground Coal Mining:**

⇒ Subsidence of land and land damages due to huge cracks, pot holes, depressions etc.
⇒ Mine fires and risks. Gas emissions.
⇒ Formation of underground lakes and disturbing the underground water systems.
⇒ Flood disasters in mines and mining areas. Water logging through seepage and cracks.
⇒ Damages to surface property due to subsidence. Risks.
⇒ Damages to surface agricultural land and forest resources.
⇒ Dewatering of mines disrupts water regimes and lowering of water table and drying of ponds/lakes.
⇒ Water pollution due to dewatering of contaminated waters from the mines using explosives.
⇒ Disposal of shale and other wastes at the mine sites causing damages to vegitative cover etc.
⇒ Deforestation due to mining operations and timber consumption for roofing supports.
⇒ Deforestation due office buildings, townships, workshops, coal handling and transport etc., their effluents/wastes.
⇒ Secondary impacts on forestry and land resources due to the location of coal-based industries and detribalisation processes.
⇒ Mining is a shifting activity and hence, the impacts spread both over time and space. This needs to be specially noted.

3. **Environmental & Ecological Impacts Due to Opencast Mining:**

⇒ Land damages/degradation in its entirety.
Over-burden or mine dumps; disposal of shale and other wastes.
⇒ Total deforestation; agricultural lands become defunct.
⇒ Surface hydrology; Hydrological regimes get affected.
⇒ Top soil, soil erosion, vegitative cover etc., destroyed.
⇒ Ecological disturbances. Wild life; birds life affected.
⇒ Floods and natural hazards.
⇒ Meteorological disturbances.
⇒ Immediate vicinity and land scapes destroyed.
⇒ Rivers; sedimentaiton; siltation etc.
⇒ Non-mining operations, overheads and infrastructure; townships and in-migration.
⇒ Sedimentation in water bodies; dry up; excessive soil erosion from mine dumps. Instability of slopes/land slides. Interference with natural drainage (nalas); gully erosion; depressions and cavities.
⇒ Vibration and noise pollution due to blasting/explosives. Damages to surface property. Water and air pollution.

- ⇒ Coal and earth dust emissions and settling on land, vegitation, forests, crops, buildings etc., cause damages. Health problems. Photosynthesis process damaged.
- ⇒ Coal transport and handling: dust, sound, injuries etc.
- ⇒ Problems of land acquisition; compensation; rehabilitation and resettlement; displacement of tribals and villages. Psychological problems.
- ⇒ Mounting public participation, opposition; agitations etc.
- ⇒ Illegal mining from abandoned closed mines and safety issues.

4. **State and Environment:** For the first time, the Seventh Five Year Plan proposes:

a. To take into account explicitly the environmental dimensions while preparing the coal mining projects;
b. Proposes to set up an environmental protection agency and
c. EIS is made mandatory for all the new mining projects and to be included in the project reports for approval;
d. A plan to reclaim the abandoned mines.

Since opencast mining has become more important than the underground mining, it is necessary to have:

i. Legislation on strip mining and reclamation of decoaled areas, water and clean air; afforestation etc.
ii. Resettlement and Rehabilitation of displaced families.
iii. Restoration of strip mined land to their pre-mined state or 'original state'.

But, legislation should not impede the exploitation of coal resources and thereby, increase the nation's dependence on foreign oil.

SOME PREVENTIVE MEASURES

Generally, the mineral lands pass through a CYCLE of land uses such as:

a. Exploitation of VIRGIN land for mineral removal;
b. Abandonment of the land and subsequent dereliction; and
c. After an interval of a few years, the treatment of that derelicted land to make it suitable for some productive use.

The Choices are:

i. RESTORATION: generally means creating conditions for the PREVIOUS USE of the area

ii. REHABILITATION: generally means creating conditons for a NEW AND SUBSTANTIALLY DIFFERENT USE of the mine-site after extraction completed.

iii. RECLAMATION: Returning a derelicted land/site to **some USE,** such as farming, forestry, grazing or even recreation.

If not reclaimed, adverse environmental impacts will follow.

⇒ The process of Reclamation depends on the depth, volume and structure of overburden dumps and mechanisation levels. It is done in two stages:

a. **Technical Reclamation:** includes BACKFILLING with the overburden of the excavated areas; and
b. **Biological Reclamation:** is devoted to the development of the structure of soil and its enrichment. Vegetation.

Conflicts Between Energy & Environmental Policies:

Costs vs. Benefits:

↓

Cost of coal goes up → Inflation → High cost economy

↓ (High cost economy) Competitive Strength goes down

↓

Conflicts with inter-fuel substitution

↓

Dependence on oil goes up

↓

Energy security becomes critical (Policy formulation becomes complex)

⇒ **Preventive and Corrective measures are to be taken up to**:

- Bring back the areas under vegetative cover
- Maintain water bodies in good condition
- Protect animal and bird life
- Re-use of mined out lands
- To create employment for the workers from abandoned mines
- Land use planning
- Afforestation and revegitaion; and to stabilize mine dumps
- Reclamation of spoil dumps
- Reduce run off and peak rate of water flows
- Utilisation of barren rocks as cheap building material
- Safety and health
- Improve civic amenities in the settlements

The above are some of the purposes for taking the corrective measures.

Conflicting Situations: Reclamation programmes though ensure environmental protection, give rise to a number of conflicting situations.

i. They increase the cost of coals; then energy prices go up and then inflation follows. High cost economy reduce competitive position.

ii. Another way to look at is this. Cost of coal goes and then inter-fuel substitution becomes critical; oil may even become cheaper and our dependence on oil goes up and energy-security of the nation becomes critical.

These issues need to be considered in policy formulation. Whatever it is, the future real costs of coal will be higher. No more cheap coal. When conservation and environment are considered together in coal extraction, the whole issue becomes highly complex involving several conflicting situations. The very concept of conservation which is the core of mineral economics and which is so vital in achieving sustainable development comes in to conflict with environment. The solution, however, lies in compromises and not in rational choice. The whole process of the combined analysis of conservation and environment together – the vital elements in sustainable development; seems to be not only tough but painful.

Conclusion: After carefully considering the environmental dimensions in their varied forms and ramifications, one is likely to get a feeling that the one-time gains from coal extraction **may not outweigh** the permanent losses to environment, particularly the forestry and land resources; - the perennial sources of income streams over infinite periods.

⇒ No more cheap coals; no more cheap energy and no more low-cost development.

Tables & Charts

TABLE 1

TRENDS IN PRODUCTION OF COAL BY STATES DURING 1983-84 TO 1997-98

(Mil.Tonnes)

Year	STATES									India	% of A.P.
	A.P.	Assam	Bihar	Jammu & Kashmir	M.P.	Maha rashtra	Orissa	U.P.	West Bengal		
1983-84	12.686	0.800	53.405	0.018	37.856	8.822	4.171	3.054	19.430	140.242	9.05
1984-85	12.328	0.81	54.879	0.022	41.03	10.298	5.442	3.426	19.203	147.438	8.36
1985-86	15.702	0.847	54.323	0.029	42.564	11.569	6.041	3.861	19.36	154.296	10.18
1986-87	16.58	0.908	59.064	0.022	44.799	12.303	7.072	4.916	20.022	165.686	10.01
1987-88	16.381	1.009	64.469	0.020	48.756	14.215	8.959	5.718	20.322	179.849	9.11
1988-89	18.605	0.899	66.953	0.017	53.874	15.111	10.926	6.192	21.798	194.375	9.57
1989-90	17.804	0.836	66.579	0.023	62.299	16.34	13.253	6.174	17.606	200.914	8.86
1990-91	17.709	0.678	67.279	0.016	65.221	16.848	16.212	10.46	17.175	211.616	8.37
1991-92	20.584	0.951	69.162	0.021	69.404	18.879	20.707	11.492	18.154	229.354	8.97
1992-93	22.511	1.101	71.137	0.012	70.648	19.679	23.144	12.165	18.111	238.508	9.44
1993-94	25.279	1.201	73.286	0.022	72.857	20.450	24.301	12.139	16.609	246.144	10.27
1994-95	25.648	1.191	73.334	0.021	74.864	21.066	27.325	13.817	17.238	254.504	10.08
1995-96	26.77	0.822	74.565	0.018	79.761	22.815	32.7	14.801	17.915	270.167	9.91
1996-97	28.734	0.752	77.678	0.021	83.283	24.857	37.365	15.397	17.993	286.08	10.04
1997-98	28.941	0.687	81.274	0.005	84.753	26.171	42.162	15.78	17.395	297.169	9.74
% Change over 83-84	128.1	-14.0	52.2	-72.0	124.0	196.6	910.8	416.7	-10.5	112.0	-
Average annual growth rate (%)	9.15	-1.0	3.73	-5.14	8.86	14.04	65.06	29.76	-0.75	8	-

Source : Annual Review of Coal Statistics, 1997-98, GOI.

TABLE – 1A

COAL PRODUCTION
(AFTER NATIONALISATION OF COAL SECTOR)

(in million Tonnes)

Year	SCCL	All India	% of SCCL in All-India
1973-74	5.311	78.17	6.79
1974-75	6.179	88.49	6.98
1975-76	7.358	99.68	7.38
1976-77	8.300	101.03	8.22
1977-78	8.912	100.02	8.91
1978-79	9.010	102.01	8.83
1979-80	9.400	103.80	9.06
1980-81	10.100	114.01	8.90
1981-82	12.100	124.93	9.68
1982.83	12.340	130.60	9.45
%change over 1973-74	132.3	67.1	-
Average annual growth rate (%)	14.7	7.4	-

TABLE – 1B
COMPARATIVE COAL OUTPUT TRENDS : SCCL AND COAL INDIA LTD.

(in Million Tonnes)

Year	SCCL	CIL
1973-75	5.31	69.80
1974-75	6.18	78.99
1975-76	7.36	88.98
1976-77	8.30	89.49
1977-78	8.91	88.96
1978-79	9.01	90.06
1979-80	9.40	91.44
1980-81	10.10	100.86
1981-82	12.10	109.53
1982.83	12.34	114.68
1983-84	12.69	121.41
1984-85	12.88	130.81
1985-86	15.66	134.13
1986-87	16.58	142.60
% rise over 1973-74	212.20	104.30
Average annual growth rate (%)	16.3	8.00
1987-88	16.38	159.21
1988-89	18.61	171.52
1989-90	17.80	178.62
1990-91	17.71	189.64
1991-92	20.58	204.15
1992-93	22.51	211.46
1993-94	25.28	216.10
1994-95	25.65	223.35
1995-96	26.77	237.27
1996-97	28.73	250.62
1997-98	28.94	261.01
% rise over 87-88 (%)	76.8	63.9
Average annual growth rate (%)	7.0	5.81

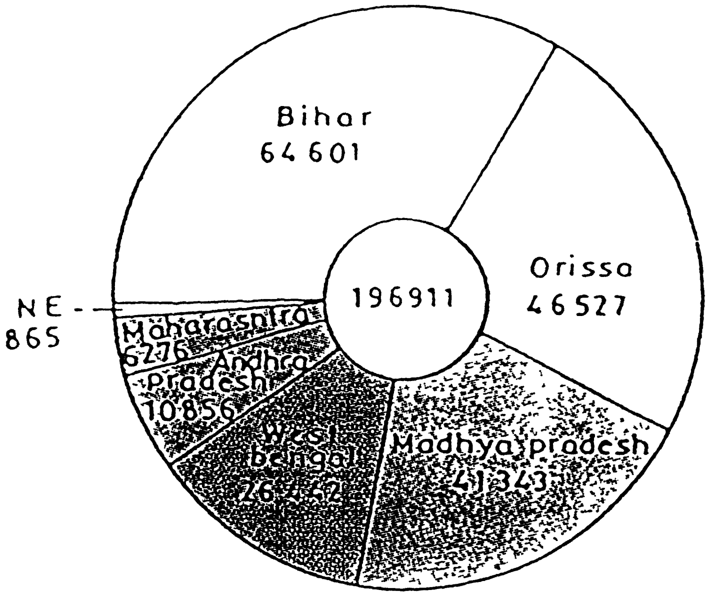
Source : Annual Review of Coal Statistics, 1997-98. Ministry of Coal, GOI
Coal Controller's Organisation, Calcutta – 1.

Note : CIL does not represent the All-India total coal output due to the exclusion of private sector mines, IISCO etc.

Table -2

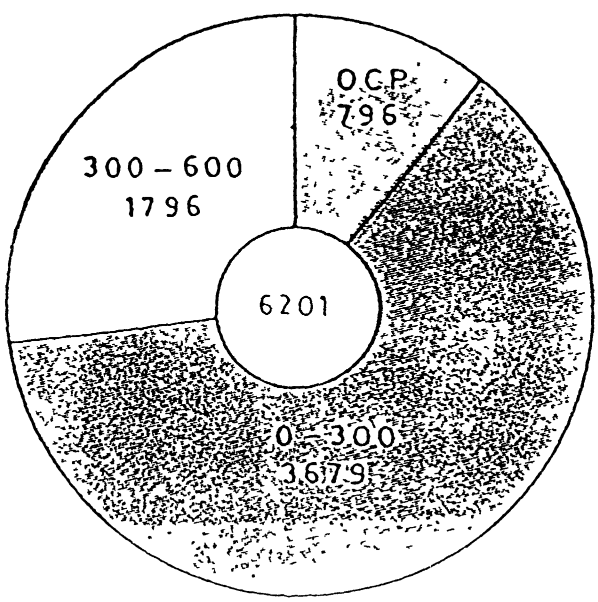
Pi DIAGRAMS OF RESERVES

STATEWISE COAL RESERVES



(mill. tonnes)

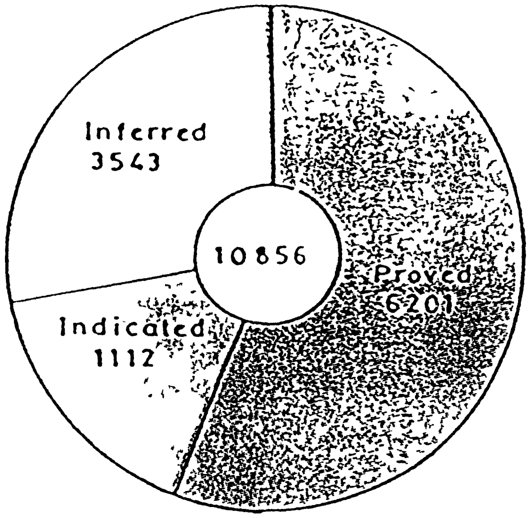
DEPTHWISE PROVED COAL RESERVES
OF GODAVARI VALLEY COALFIELD -AP.



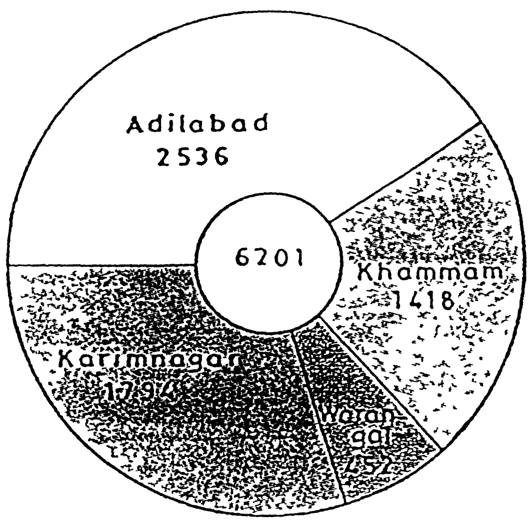
=> Depth in mts.
=> OCP= open cast proj
(less then 300mts)

Table-3

COAL RESERVES OF
GODAVARI VALLEY COALFIELD —-AP (mil -tonnes)



DISTRICTWISE PROVED COAL RESERVES OF
GODAVARI VALLEY COALFIELD -AP



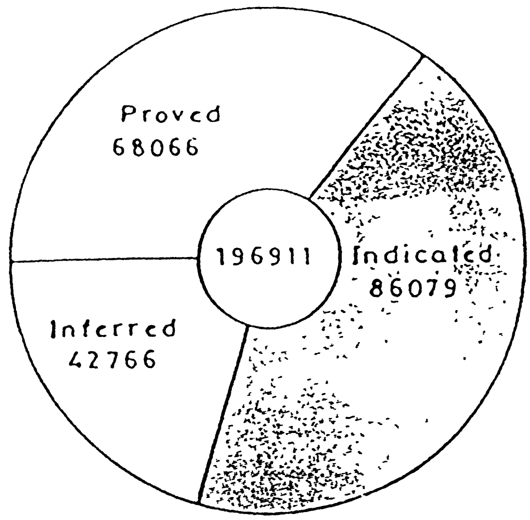
* COALBELTS

1	RAMAGUNDAM	1794
2	SOMAGUDEM - INDARAM	1388
3	MANUGURU	685
4	KOTHAGUDEM	612
5	DORLI - BELAMPALLI	468
6	MULUG	433
7	CHINNUR	33[illegible]
8	LINGALA KOYAGUDEM	219
9	YELLANDU	205
10	MERIPALLI - KAGHAZNAGAR	59
	TOTAL	6201

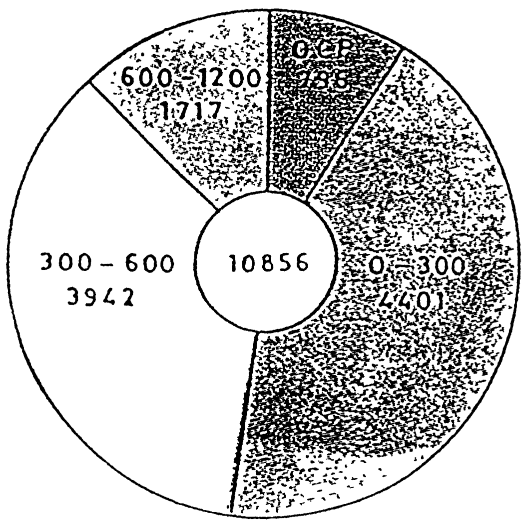
RESERVES IN MILLION TONNES

Table -4

COAL RESERVES OF INDIA



DEPTHWISE COAL RESERVES OF GODAVARI VALLEY COALFIELD – AP



BREAK UP OF PROVED RESERVES OF GODAVARI VALLEY COALFIELD -AP

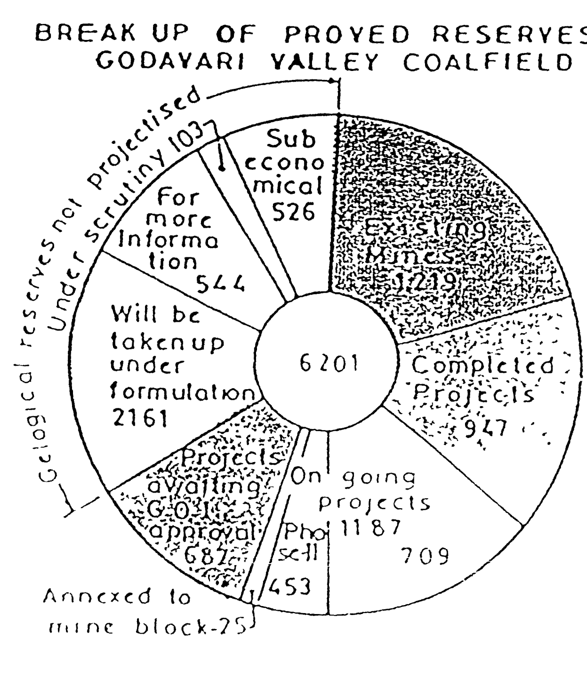


TABLE – 5

COAL RESERVE-OUTPUT RATIOS IN DIFFERENT STATES (1997-98)
(Or Measurement of Sustainability)

Sl.No.	States 1	Output (mil.tonnes) 2	Total Reserves (mil.tonnes) 3	Ratio (4)=(3)÷(2)
1	Andhrapradesh	28.94 (9.74)	10,856 (5.5)	**375.1**
2	Assam	0.68 (0.23)	865 (0.4)	1253.6
3	Jammu & Kashmir	0.1	-	-
4	Bihar	81.27 (27.35)	64,601 (32.8)	665.6
5	Madhyapradesh	84.75 (28.52)	41,343 (21.0)	487.8
6	Maharashtra	26 17 (8.80)	6,276 (3.2)	**240.0**
7	Orissa	42 16 (14.18)	46,527 (23.6)	1103.6
8	Uttarapradesh*	15.78 (5.32)	-	-
9	West Bengal	17.40 (5.86)	26,442 (13.4)	1519.7
10	All-India	297.16 (100.0)	1,96,911 (100.0)	662.6

***Output of UP is added to Bihar**
(Figures in brackets show percentages)
Total Reserves = Indicated + Inferred + Proved

Note: The above table gives an indirect way of measuring sustainability though it may only be suggestive/indicative. It is rightly said that sustainable development defies measurement by a single index.

TABLE – 6
COALFIELD-WISE PRODUCTION SINCE INCEPTION OF SCCL

(In Tonnes)

Year	Kothagudem	Yellandu	M.guru	B.palli	M.mari	RKP & SRP	R.gundam	BHPL	Total	% Gr. Rate
1889		59.671							59.671	
1890		125.471							125.471	110.27
1891		138.772							138.772	10.60
1892		125.656							125.656	-9.45
1893		157.915							157.915	25.67
1894		240.524							240.524	52.31
1895		292.913							292.913	21.78
1896		262.880							262.880	-10.25
1897		365.550							365.550	39.06
1898		394.621							394.621	7.95
1899		401.216							401.216	1.67
1900		469.291							469.291	16.97
1901		421.218							421.218	-10.24
1902		455.424							455.424	8.12
1903		362.733							362.733	-20.35
1904		419.545							419.545	15.66
1905		454.293							454.293	8.28
1906		467.924							467.924	3.00
1907		414.221							414.221	-11.48
1908		444.212							444.212	7.24
1909		442.893							442.893	-0.30
1910		506.173							506.173	14.29
1911		505.380							505.380	-0.16
1912		481.652							481.652	-4.70
1913		552.132							552.132	14.63
1914		555.991							555.991	0.70
1915		586.824							586.824	5.55
1916		614.520							614.520	4.72
1917		674.557							674.557	9.77
1918		647.487							647.487	-4.01
1919		641.474							641.474	-0.93
1920		666.334							666.334	3.88
1921		646.048							646.048	-3.04
1922		604.358							604.358	-6.45
1923		629.225							629.225	4.11
1924		619.725							619.725	-1.51

Table-6 (contd).

1925		629.725							629.725	1.61
1926		609.745							609.745	-3.17
1927		681.736							681.736	11.81
1928		689.020		10.130					699.150	2.55
1929		742.213		26.206					768.419	9.91
1930		713.056		52.434					765.490	-0.38
1931		657.628		46.530					704.158	-8.01
1932		593.466		126.471					719.937	2.24
1933		519.442		184.166					703.608	-2.27
1934		527.989		199.768					727.757	3.43
1935		513.259		165.610					678.869	-6.72
1936		606.107		193.043					769.150	17.72
1937	1.176	740.77		265.624					1007.570	26.08
1938	95.248	690.85		334.283					1120.381	11.20
1939	149.905	676.513		313.155					1139.573	1.71
1940	317.703	539.943		321.299					1178.945	3.45
1941	711.219	154.164		347.201					1212.584	2.85
1942	844.596			369.421					1214.019	0.12
1943	633.273			366.933					1000.206	-17.61
1944	567.763			311.204					878.967	-12.12
1945	648.087			309.819					957.906	8.98
1946	657.359			313.724					971.083	1.38
1947	786.663	413.000		314.72					1101.396	13.42
1948	705.084	14.234		296.737					1016.055	-7.75
1949	725.699	58.589		261.094					1045.382	2.89
1950	778.717	77.135		306.654					1162.506	11.20
1951	791.461	99.030		316.741					1207.232	3.85
1952	876.5	129.815		368.736					1375.051	13.90
1953	759.97	141.688		370.203					1271.861	-7.50
1954	839.764	145.440		472.982					1458.186	14.65
1955	919.863	133.494		473.213					1526.570	4.69
1956	939.414	185.073		557.09					1681.577	10.15
1957	1099.63	210.861		609.002					1919.494	14.15
1958	1146.89	224.283		745.389					2116.566	10.27
1959	1124.42	266.151		839.483					2230.049	5.36
1960	1151.55	301.692		1037.85					2491.089	11.71
1961	1278.33	350.480		808.288	342.433		15.866		2795.401	12.22
1962-63	1573.89	514.681		1024.52	632.308		193.931		3939.333	40.92
15 months										
1963-64	1181.61	437.551		816.811	636.166	26.688	371.264		3470.090	-11.91

Table-6 (concld.)

1964-65	1102.16	458.552		832.233	632.675	101.026	524.598		3651.247	5.22
1965-66	1002.39	544.839		872.297	604.964	190.890	835.470		4050.846	10.94
1966-67	988.368	554.709		863.541	616.586	189.094			4177.619	3.13
1967-68	963.252	552.910		846.806	624.794	211.411	895.871		4095.044	-1.98
1969-70	696.989	547.550		710.026	639.508	218.121	887.868		3700.062	-9.65
1970-71	784.25	596.144		739.552	636.678	221.661	1070.019		4048.304	9.41
1971-72	868.029	710.218		853.753	654.654	371.777	1248.980		4707.411	16.28
1972-73	919.524	783.173		867.804	678.501	483.063	1308.380		5038.445	7.03
1973-74	896.129	765.450		924.811	683.326	594.176	1447.613		5311.505	5.42
1974-75	986.981	767.502		1126.29	861.900	686.849	1749.404		6178.922	16.33
1975-76	1040.54	858.506	13.685	1347.23	995.059	760.068	2342.898		7357.985	19.08
1976-77	1143.94	1042.340	97.378	1296.87	1008.745	843.993	2864.387		8297.658	12.77
1977-78	1109.86	997.730	173.800	1466.47	1052.363	1018.589	3092.743		8911.551	7.40
1978-79	936.903	870.663	201.938	1498.96	1105.886	1268.234	3124.991		9007.574	1.08
1979-80	852.765	915.315	252.682	1439.53	1056.790	1290.831	3594.674		9402.582	4.39
1980-81	812.809	953.929	428.745	1522.63	1022.236	1406.238	3950.475		10097.064	7.39
1981-82	1009.14	1220.631	1074.627	1735.04	1023.174	1526.224	4514.022		12102.854	19.87
1982-83	1142.16	1324.917	1370.243	1687.01	1031.933	1351.018	4438.060		12345.343	2.00
1983-84	1067.12	1202.380	1323.898	1640.5	1086.741	1618.926	4747.984		12687.544	2.77
1984-85	980.381	1042.387	1204.191	1632.89	1023.130	1694.843	4750.493		12328.310	-2.83
1985-86	1326.35	1350.444	1399.699	1153.04	1890.296	2462.026	6073.098		15654.945	26.98
1986-87	1371.18	1887.402	1551.679	1264.69	1986.870	2787.539	5730.470		16579.826	5.91
1987-88	1348.65	1984.001	1774.703	1184.31	1766.196	2646.387	5697.205		16401.453	-1.08
1988-89	1349.16	2332.127	2101.439	1214.81	1955.759	3281.291	6370.410		18604.995	13.44
1990-91	1032.44	2421.057	3592.323	605.543	1682.096	2668.533	5706.918		17708.912	-4.82
1991-92	1009.28	2552.128	4192.626	783.81	1635.443	2770.817	7635.560	4.725	20583.392	16.23
1992-93	1264.2	2422.818	4567.082	860.759	1673.274	3330.773	8321.762	71.735	22512.397	9.37
1993-94	1691.49	2290.190	5053.028	1099.65	1692.857	3866.100	9388.611	127.139	25209.064	11.98
1994-95	1554.76	2228.194	5376.157	1219.58	1380.641	3574.677	10185.701	130.209	25649.916	1.75
1995-96	2309.55	2510.629	5216.515	871.381	1149.951	3160.824	11362.992	187.858	26769.699	4.37
1996-97	2619.84	2649.670	5492.152	870.243	1177.473	3117.666	12517.532	289.512	28734.091	7.34
1997-98	2223.42	2837.078	5410.502	823.68	1341.600	3419.059	12607.612	278.216	28941.167	0.72
1998-99	2436.23	2786.755	4889.495	773.019	1566.668	3534.911	10964.419	374.156	27325.649	-5.58

Source : Field Investigations

Notes: Growth took place mainly through geographical diversification.

Table - 7

THE PRESENT STATUS OF COAL RESERVES IN A.P. COAL FIELDS AS ON 31.03.1999

(Million Tonnes)

Area	Working Mines					Virgin Areas				
	Proved Geologi-cal Reser-ves	Consumed Geological Reserves	Available Geological Reserves	Available Mineable Reserves	Available Extractable Reserves	Projectised			Un-projec tised	
						Geological Reserves	Mineable Reserves	Extractable Reserves	Extrac table Reser ves	Total Available Extractable Reserves (6+9+10)
1	2	3	4	5	6	7	8	9	10	11
KGM	844	88.143	284.575	194.234	150.154			0.000	191	341
YLD	429	47.217	121.881	75.492	51.770	50.978	25.970	25.970	101	179
MNG	777	59.094	146.866	118.644	104.636	313.578	179.753	106.830	175	386
RG-1	384	102.350	285.738	178.206	120.707			0.000		121
RG-II	1162	49.706	246.978	158.725	104.221	128.350	68.990	50.000	265	419
RG-III	129	12.458	117.022	84.982	84.982			0.000		85
RG-IV	119	38.917	79.892	47.035	47.035			0.000		47
BHPL	645		33.875	26.170	12.972				150	163
BPA	707	84.193	216.725	145.946	84.29	106.313	54.720	33.869	170	288
MM	242	67.198	116.744	90.579	55.827					56
RKP	418	45.774	82.806	65.685	41.123				95	136
SRP	1239	5.458	104.188	296.927	162.692	37.230	30.560	14.700	301	478
Aban-doned Mines		243.500	243.500							
Total	7095	844.728	2380.790	1482.625	1020.409	636.449	359.993	231.369	1448	2700

Source : Field Investigations

Table – 8

EXPLORATION OPERATIONS FOR THE PERIOD 1973-74 TO 1998-99

Year	Meterage Drilled (Mtrs.)			Reserves Proved (M.Ts.)	M
	By SCCL	By MECL	Total		
1973-74	15693.00	12211.00	27904.00	262.50	106.3
1974-75	29118.71	6165.47	35284.18	157.00	224.7
1975-76	37565.78		37565.78	243.00	154.6
1976-77	38766.64		38766.64	289.00	134.1
1977-78	30470.88		30470.88	75.00	406.3
1978-79	31848.25		31848.25	126.00	252.7
1979-80	29940.10		29940.10	68.40	437.7
1980-81	29819.59		29819.59	115.59	257.9
1981-82	37477.48		37477.48	283.86	132
1982-83	47751.75		47751.75	779.35	61.3
1983-84	37973.69	1255.00	39228.69	408.00	96.1
1984-85	39343.36	8743.90	48087.26	151.00	318.5
1985-86	52292.64	18880.90	71173.54	204.00	348.9
1986-87	54059.97	21424.80	75484.77	219.00	344.7
1987-88	55175.13	24287.55	79462.68	518.00	153.4
1988-89	66688.32	26602.70	93291.02	416.00	224.3
1989-90	69767.22	17533.05	87300.27	520.00	167.9
1990-91	75336.94	25558.40	100895.34	432.00	233.6
1991-92	71664.62	19679.35	91343.97	337.00	271.1
1992-93	68190.69	37693.25	105883.94	144.00	735.3
1993-94	73219.05	34593.20	107812.25	129.61	831.8
1994-95	67544.22	31184.90	98729.12	162.22	608.6
1995-96	71784.30	21584.45	93368.75	209.72	445.2
1996-97	56148.90	20164.80	76313.7	297.07	256.9
1997-98	61155.80	25667.00	86822.8	200.00	434.1
1998-99	54410.80	32164.05	86574.85	251.00	344.9

Source : Field Investigations

MECL = Mineral Exploration Corporation Ltd.

M = Meters of drilling required to prove one million tonnes of new Reserves

Table - 9

TRENDS IN TECHNOLOGY-WISE PRODUCTION

(in Lakh Tonnes)

Year	Underground				Open-Cast	Total (UG+OC)	T
	Hand Section	Machine Mining	Long-wall	Total (U.G.)			
1973-74	49.41	3.71		53.12		53.12	7.0
1974-75	58.06	3.73		61.79		61.79	6
1975-76	68.73	4.85		73.58		73.58	6.6
1976-77	78.45	4.53		82.98		82.98	5.5
1977-78	84.31	4.81		89.12		89.12	5.4
1978-79	85.93	4.15		90.08		90.08	4 6
1979-80	87.54	4.45		91.99	2.04	94.03	4.8
1980-81	91.76	4.32		96.08	4.89	100.97	4.5
1981-82	102.70	6.59		109.29	11.74	121.03	6
1982-83	99.82	5.65		105.47	17.98	123.45	5.4
1983-84	100.89	7.01	1.33	109.23	17.64	126.87	7.6
1984-85	95.07	7.96	2.47	105.50	17.78	123.28	9.9
1985-86	118.76	7.85	5.75	132.36	24.19	156.55	10.3
1986-87	121.29	4.58	6.18	132.05	33.75	165.80	8.2
1987-88	113.12	6.41	6.12	125.65	38.36	164.01	10.0
1988-89	127.28	7.24	4.62	139.14	46.91	186.05	8.5
1989-90	107.61	8.07	4.64	120.32	57.73	178.05	10.6
1990-91	97.48	7.40	6.33	111.21	65.88	177.09	12.3
1991-92	103.19	8.10	12.2	123.49	82.34	205.83	16.4
1992-93	110.73	11.12	13.23	135.08	90.04	225.12	18.0
1993-94	123.19	12.26	16.11	151.56	100.53	252.09	18.7
1994-95	112.73	14.40	10.44	137.57	118.93	256.50	18.1
1995-96	97.36	14.09	20.19	131.64	136.06	267.70	26.0
1996-97	99.89	14.51	22.93	137.33	150.01	287.34	27.3
1997-98	103.05	13.96	19.2	136.21	153.20	289.41	24.3
1998-99	104.95	8.17	16.42	129.54	143.72	273.26	19.0

Source : Field Investigations

Notes: T = % of Machine-mining and Longwall outputs to total underground output.

TABLE 9A

POWER CONSUMPTION IN SCCL & ENERGY-INTENSITIES

(In Million KWH)

Total				
Year	Own Gen.	APSEB	Total	Energy Intensities
73-74	58.21	36.35	94.56	1.72
74-75	69.11	36.7	105.81	1.71
75-76	81.42	41.93	123.35	1.68
76-77	83.36	50.08	133.44	1.61
77-78	93.69	64.2	157.89	1.77
78-79	93.70	80.69	174.39	1.94
79-80	102.99	84.88	187.87	2.00
80-81	114.42	94.37	208.79	2.07
81-82	108.55	133.92	242.47	2.00
82-83	105.18	154.56	259.74	2.10
83-84	116.75	164.02	280.77	2.21
84-85	106.74	187.03	293.77	2.38
85-86	93.69	224.68	318.37	2.03
86-87	112.85	229.41	342.26	2.06
87-88	107.27	258.24	365.51	2.23
88-89	110.44	295.21	405.65	2.18
89-90	104.56	337.97	442.53	2.48
90-91	83.72	383.48	467.20	2.64
91-92	85.64	422.94	508.58	2.47
92-93	71.49	460.94	532.43	2.37
93-94	69.44	502.17	571.61	2.27
94-95	69.82	531.72	601.54	2.35
95-96	73.51	578.64	652.15	2.44
96-97	63.42	630.07	693.49	2.41
97-98	48.12	629.41	677.53	2.34
98-99	47.70	602.94	650.64	2.38

Source : Field Investigations.

APSEB = Andhra Pradesh State Electricity Board

Energy Intensity = $\frac{\text{Power Consumption (m.kwh)}}{\text{Output (lakh tonnes)}}$ = 38% rise in 98-99 over 1973-74

Table – 10

PRODUCTION PERFORMANCE AND OUTPUT COMPOSITION BY MINING METHODS

Year	No. of Mines			Production (Lakh Tonnes)						% of O.C. to total output (actual)
	Under-ground	Open cast	Total	Underground		Opencast		Total		
				Target	Actual	Target	Actual	Target	Actual	
1973-74	26		26	57.00	53.12			57.00	53.12	-
1974-75	26		26	60.00	61.79			60.00	61.79	-
1975-76	32		32	69.00	73.58			69.00	73.58	-
1976-77	44		44	82.00	82.98			82.00	82.98	-
1977-78	47		47	92.00	89.12			92.00	89.12	-
1978-79	49		49	100.00	90.08			100.00	90.08	-
1979-80	48	2	50	108.00	91.99	4.00	2.04	112.00	94.03	2.17
1980-81	49	2	51	106.00	96.08	9.00	4.89	115.00	100.97	4.84
1981-82	49	2	51	103.00	109.3	12.00	11.74	115.00	121.03	9.7
1982-83	51	2	53	118.00	105.5	17.00	17.98	135.00	123.45	14.6
1983-84	55	2	57	128.40	109.2	21.60	17.64	150.00	126.87	13.9
1984-85	56	2	58	138.50	105.5	31.50	17.78	170.00	123.28	14.4
1985-86	58	4	62	133.25	132.4	26.75	24.19	160.00	156.55	15.5
1986-87	57	5	62	144.40	132.1	35.60	33.75	180.00	165.80	20.4
1987-88	61	5	66	145.55	125.7	44.45	38.36	190.00	164.01	23.4
1988-89	61	5	66	154.00	139.1	51.00	46.91	205.00	186.05	25.2
1989-90	61	7	68	155.84	120.3	59.16	57.73	215.00	178.05	32.4
1990-91	61	7	68	158.20	111.2	66.80	65.88	225.00	177.09	37.2
1991-92	61	8	69	131.75	123.5	73.25	82.34	205.00	205.83	40.0
1992-93	59	8	67	150.05	135.1	83.95	90.04	234.00	225.12	40.0
1993-94	59	9	68	150.05	151.6	90.80	100.53	240.85	252.09	40.0
1994-95	60	10	70	148.70	137.6	107.30	118.92	256.00	256.50	46.4
1995-96	59	11	70	154.15	131.6	125.85	136.06	280.00	267.70	50.8
1996-97	60	11	71	161.00	137.3	141.00	150.01	302.00	287.34	52.2
1997-98	60	11	71	161.50	136.2	148.50	153.20	310.00	289.41	52.9
1998-99	58	11	69	155.35	129.5	154.65	143.72	310.00	273.26	52.6

Source : Field Investigations

TABLE – 10A

MINE-SIZE BY TYPE OF MINES

Year	Mine Size (lakh tonnes)			Variation Over Previous Year			% of O-C Output to Total Output
	Underground	Opencast	Total (all-mines)	Underground	Opencast	Total (all-mines)	
1979-80	1.916	1.020	1.881	-	-	-	2.2
1980-81	1.961	2.445	1.980	2.34	139.7	5.3	4.8
1981-82	2.230	5.870	2.373	13.72	140.1	19.8	9.7
1982-83	2.068	8.990	2.330	-7.27	53.2	-1.8	14.6
1983-84	1.986	8.820	2.226	-4.00	-2.0	-4.5	13.9
1984-85	1.884	8.890	2.126	-5.14	0.8	-4.5	14.4
1985-86	2.282	6.048	2.525	21.13	-32.0	18.7	15.5
1986-87	2.317	6.750	2.674	1.53	11.6	5.9	20.4
1987-88	2.060	7.672	2.485	-11.09	13.6	-7.1	23.4
1988-89	2.281	9.382	2.820	10.73	22.3	13.5	25.2
1989-90	1.972	8.247	2.618	-13.55	-12.1	-7.2	32.4
1990-91	1.823	9.411	2.604	-7.56	14.1	-0.5	37.2
1991-92	2.024	10.293	2.983	11.03	9.4	14.5	40.0
1992-93	2.289	11.255	3.360	13.09	9.3	12.6	40.0
1993-94	2.569	11.170	3.707	12.23	-0.8	10.3	40.0
1994-95	2.293	11.892	3.664	-10.75	6.5	-1.2	46.4
1995-96	2.231	12.369	3.824	-2.70	4.0	4.4	50.8
1996-97	2.289	13.637	4.047	2.60	11	5.8	52.2
1997-98	2.27	13.927	4.076	-0.83	2.1	0.7	52.9
1998-99	2.233	13.065	3.960	-1.63	-6.6	-2.9	52.6
% change in 97-98 over 1979-80	18.5	1265.4	116.7	-	-	-	-

Note : Computed on the basis of Table - 10.

Table - 11

PRODUCTIVITY (O.M.S.) BY DIFFERENT MINING SYSTEMS

(In Tonnes)

Year	Underground			Open-cast	Overall	
	UG-HS	UG-MM	Total		Mines	Mines & Depts.
1973-74	0.79		0.79		0.79	0.62
1974-75	0.81		0.81		0.81	0.64
1975-76	0.91		0.91		0.91	0.69
1976-77	0.91		0.91		0.91	0.72
1977-78	0.91		0.91		0.91	0.72
1978-79	0.88		0.88		0.88	0.70
1979-80	0.84		0.84	5.63	0.85	0.67
1980-81	0.79	1.39	0.83	2.95	0.87	0.69
1981-82	0.81	1.73	0.85	3.43	0.92	0.74
1982-83	0.77	1.37	0.78	4.10	0.88	0.72
1983-84	0.74	1.43	0.77	3.47	0.86	0.70
1984-85	0.74	1.48	0.77	3.50	0.88	0.70
1985-86	0.81	2.30	0.87	3.54	1.00	0.81
1986-87	0.77	2.44	0.82	3.08	0.97	0.80
1987-88	0.73	2.20	0.78	3.94	0.94	0.78
1988-89	0.72	1.91	0.76	3.70	0.95	0.80
1989-90	0.67	1.51	0.71	3.81	0.96	0.80
1990-91	0.60	1.59	0.65	4.74	0.96	0.77
1991-92	0.58	2.21	0.67	4.48	0.98	0.79
1992-93	0.61	2.40	0.70	4.42	1.04	0.84
1993-94	0.61	2.39	0.71	4.38	1.05	0.86
1994-95	0.60	1.97	0.69	3.63	1.08	0.89
1995-96	0.59	2.72	0.74	3.65	1.23	1.00
1996-97	0.57	2.25	0.72	2.97	1.19	0.98
1997-98	0.63	2.14	0.76	3.50	1.31	1.07
1998-99	0.66	1.97	0.75	3.92	1.31	1.07
% change over '73	-16.5	41.7	-5.1	32.9*	65.8	72.6

Source : Field Investigations

OMS = Output per Man Shift (Tonnes),
UG-HS = Underground Hand Section
UG-MM = Underground Machine Mining,
***Over 1980-81**

Notes: This shows indirectly that the U-G output is cross-subsidised by O-C output without the reclamation/social costs. In other words, we are consuming the capital stock of our posterity.

Table – 12

PERFORMANCE DURING PLAN PERIODS

Years	Plan	Output during plan periods	Average Output/Year	Growth Rate over previous plan period	O.M.S.	Men on Roll in the last year of the plan	Index of Employment
		(Lakh tonnes)	(Lakh Tonnes)	(in %)	(Tonnes)	(' 000)	
1951-55	I Plan	68.39	13.68		0.28	18.801	100
1956-60	II Plan	104.39	20.88	52.6	0.36	24.101	128.7
1961-66	III Plan	179.07	35.81	71.5	0.47	34.47	183.3
1966-69	Plan Holiday	121.27		12.9	0.50	31.422	167 1
1969-74	IV Plan	228.06	45.61	12.8	0.59	37.767	200.9 =100*
1974-79	V Plan	397.54	79.51	74.3	0.70	62.16	330.6 (164.6)
1979-80	Rolling Plan	94.03	94.03	18.3	0.67	64.87	345.0 (171.0)
1980-85	VI Plan	595.61	119.12	49.8	0.71	87.021	462.9 (230.4)
1985-90	VII Plan	850.46	170.09	42.79	0.80	109.724	583.6 (290.5)
1990-92	Plan Holiday	382.92	191.46	12.56	0.78	116.745	631.0 (309.1)
1992-97	VIII Plan	1288.75	257.75	34.62	0.92	114.486	609.0 (303.1)

Source : Field Investigations

* Figures in brackets show the Index with base 1969-74

TABLE – 13

GROWTH OF COAL MINING INDUSTRY IN A.P. (SCCL) FOR THE PERIOD 1965-66 TO 1978-79

Year	Output (Lakh Tonnes)	Man Power ('000)	Overall O.M.S. (Tonnes)
1965-66	40.51	34.47	0.48
1966-67	41.78	34.73	0.49
1967-68	40.95	34.59	0.50
1968-69	38.54	31.52	0.51
1969-70	37.00	29.47	0.52
1970-71	40.48	31.42	0.53
1971-72	47.07	32.72	0.62
1972-73	50.38	35.31	0.62
1973-74	53.12	37.77	0.62
1974-75	61.79	41.81	0.65
1975-76	73.58	48.44	0.69
1976-77	82.98	53.74	0.72
1977-78	89.12	57.25	0.72
1978-79	90.10	60.00	0.72
% change over 1965-1966	122.4	74.1	50.0

Source : Field Survey

OMS = Output per Man shift, a measure of labour productivity

TABLE – 14

AVERAGE DAILY LABOUR ATTENDANCE AND OUTPUT PER YEAR (SCCL) : 1947 TO 1967.

(Also Number of Mines, Mine-Size and Labour Productivity)

Year	Attendance (Nos.)	Output (Tonnes)	No. of Mines (Nos.)	Mine-Size (Lakh tonnes)	Labour Productivity* (Tonnes)
1947	17,316	11,00,983	-	-	0.216
1948	15,447	10,16,054	-	-	0.223
1949	15,946	10,45,283	-	-	0.222
1950	16,178	11,62,506	-	-	0.244
1951	15,907	12,07,233	10	1.2072	0.257
1952	15,449	13,75,051	10	1.3751	0.302
1953	15,148	12,71,861	10	1.2718	0.285
1954	15,658	14,58,186	11	1.3256	0.316
1955	15,387	15,26,570	11	1.3878	0.336
1956	16,146	16,81,577	12	1.4013	0.353
1957	17,425	19,19,494	12	1.5995	0.373
1958	18,307	21,16,566	13	1.6281	0.392
1959	19,170	22,30,070	14	1.5929	0.395
1960	20,917	25,05,199	15	1.6701	0.406
1961	21,612	27,95,402	15	1.8636	0.439
1962	22,171	31,20,531	16	1.9503	0.477
1963	23,433	33,46,985	18	1.8594	0.484
1964	25,967	34,75,300	21	1.6549	0.454
1965	27,027	40,83,049	22	1.8559	0.512
1966	27,668	41,44,185	23	1.8018	0.508
1967	27,874	41,96,095	24	1.7483	0.510
% change over 1947**	61.0	281.1	140.0	44.8	136.1

Data Source : Field Survey

*** Labour Productivity = (Annual Output) ÷(Daily Attendance) x 295 Working days per year.**
Attendance is net of absenteeism.
Both together give total labour force.

**** This gives the broad pattern of growth of mining.**

TABLE – 15

NUMBER OF MINES AND GROWTH OF MINE-SIZE (SCCL) (1965-66 TO 1987-88)

Year	No. of Mines	Mine-size (Lakh Tonnes)	Mine-size (Excluding O/C Mines Lakh Tonnes)
1964-65	22	1.6591	-
1965-66	23	1.7613	-
1966-67	24	1.7408	-
1967-68	23	1.7804	-
1968-69	22	1.7518	-
1969-70	21	1.7619	-
1970-71	22	1.8400	-
1971-72	23	2.0465	-
1972-73	25	2.0152	-
1973-74	26	2.0431	-
1974-75	28	2.2068	-
1975-76	33	2.2297	-
1976-77	44	1.8859	-
1977-78	46	1.9374	-
1978-79	50	1.8020	-
1979-80	50	1.8806	1.9167
1980-81	51	1.9798	1.9610
1981-82	51	2.3732	2.2304
1982-83	53	2.3300	2.0680
1983-84	57	2.2154	1.9862
1984-85	58	2.1255	1.8840
1985-86	60	2.6092	2.3636
1986-87	61	2.7179	2.3579
1987-88	66	2.4850	2.0598

Source : For the period 1965-66, See Naganna and Subba Rao, 1979. The rest is from field investigations. This includes two opencast mines for the period 1979-80 to 1984-85; and five thereafter. See Report of the Amalgamation committee (1956).

O/C = Opencast Mines

TABLE – 16

TRENDS IN OUTPUT COMPOSITION BY TECHNOLOGY AND MINING METHODS

(Lakh Tonnes)

Year	Hand-Sections	Machine mining	Opencast	Total
1973-74	49.41 (93.0)	3.71 (7.0)	-	53.12
1974-75	58.06 (94.0)	3.73 (6.0)	-	61.79
1975-76	68.73 (93.4)	4 85 (6.6)	-	73.58
1976-77	78.45 (94.5)	4.53 (5.5)	-	82.98
1977-78	84.32 (94.6)	4.80 (5.4)	-	89.12
1978-79	85.93 (95.4)	4.15 (4.6)	-	90.08
1979-80	87.54 (93.1)	4.46 (4.7)	2.06 (2.2)	94.06
1980-81	91.77 (90.9)	4.32 (4.3)	4.88 (4.8)	100.97
1981-82	102.55 (84.7)	6.74 (5.6)	11.74 (9.7)	121.03
1982-83	99.81 (80.8)	5.66 (4.6)	17.98 (14.6)	123.45
1983-84	102.17 (80.5)	7.07 (5.6)	17.64 (13.9)	126.88
1984-85	97.57 (79.1)	7.93 (6.4)	17.78 (14.4)	123.28
1985-86	119.02 (76.0)	13.34* (8.5)	24.19 (15.5)	156.55
1986-87	120.47 (72.7)	11.57 (7.0)	33.75 (20.4)	165.79
1987-88	113.13 (69.0)	12.52 (7.6)	38.36 (23.4)	164.01

Notes : * Longwall faces introduced (two numbers)

Source : Field Investigations. Figures in brackets show %'s.

TABLE – 17

GROWTH RATES IN COAL OUTPUT SINCE 1889 TO 1988

Periods	(a) (%)	(b) (%)
1889 to 1899	20.89	56.60
1900 to 1913	1.24	1.35
1914 to 1929	2.18	2.56
1930 to 1947	2.15	2.56
1920 to 1935	00	00
1935 to 1942	8.45	10.93
1943 to 1951	2.37	2.58
1900to 1935	1.05	1.29
1900 to 1947	1.84	2.88
1947 to 1988	6.64	37.90
1948 to 1973	6.61	16.30
1973 to 1988	7.66	14.90
1900 to 1951	1.88	3.10
1951 to 1988	7.31	34.02
1900 to 1953	1.90	7.00
1953 to 1988	7.58	34.00
1900 to 1980	3.30	25.70

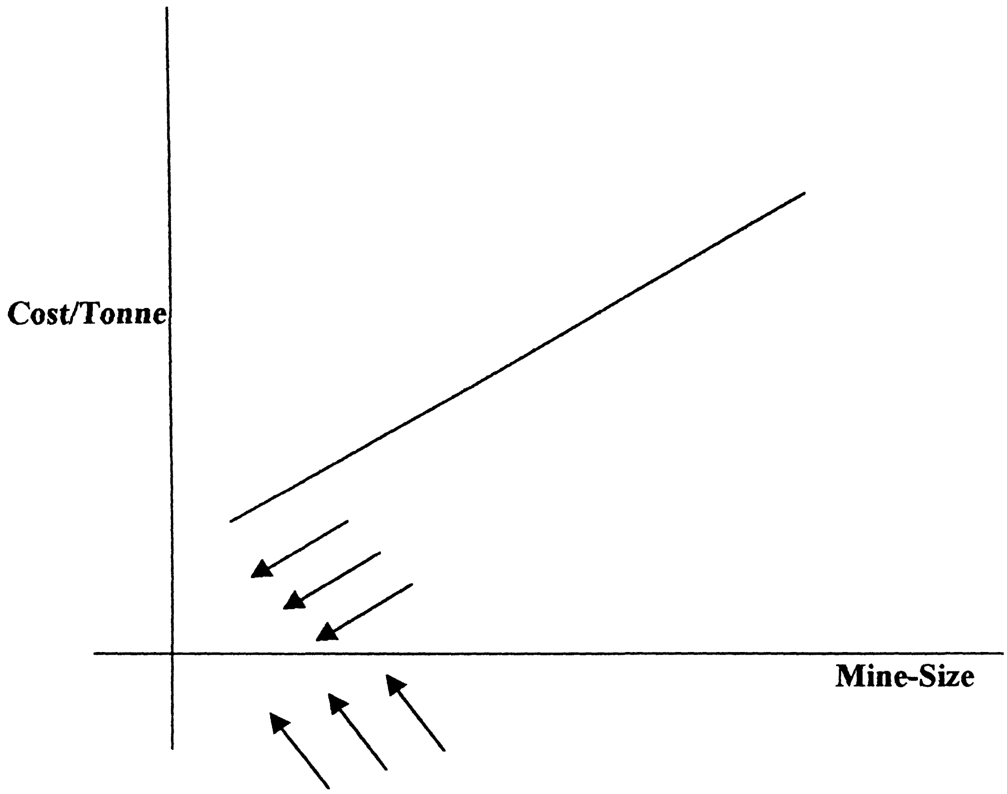
Notes: A simple equation,

$$Y = a + b_t$$

is fitted to the output data.

FIGURE – 1

SIZE-COST RELATION IN COAL MINING INDUSTRY



Notes : For a solution to the problem of optimum size of a colliery, see Naganna, 1974, 1982. The above relation is drawn from this.

TABLE – 18

FIELD-WISE WELFARE AMENITIES AS ON 31.03.99 AT THE SCCL

Area	No. of Houses Provided	MEDICAL				EDUCATION		Training Centres	RECREATION			Cante ens	Sales Depots of Super Bazaar
		No. of Hospitals	Beds	Dispen saries	Ambule nces	Colleges	Schools		Clubs	Play-grounds	Stadium		
Kothagudem	6,996	1	230	6	7	2	3	2	5		1	6	8
Yellandu	1,634	1	50	3	4		2	1	2		1	4	4
Manuguru	2,860	1	50	2	5		2	2	4	1	1	5	4
Belampalli	6,093	1	210	6	5		3	2	8	2	1	10	4
Mandamari	4,214			4	6		1	1	2	1		6	1
Rama krishnapur	4,611	1	180	4	8		1	1	2	2		8	4
Srirampur	5,512			5	6		2	1	5	2		9	2
Ramagundam	13,570	2	300	12	18		3	2	7	3	1	24	14
Bhoopalpalli	253			1	4			1	2			1	1
TOTAL	**45,743**	**7**	**1,020**	**43**	**63**	**2**	**17**	**13**	**37**	**11**	**5**	**73**	**42**

TABLE – 19

PROVISION OF HOUSING FACILITIES

Year	Total Manpower	Manpower Eligible for Housing	No. of Houses Provided	Housing Satisfaction (%)
1973-74	37,767	34,328	14,829	43.20
1974-75	41,811	35,580	16,200	45.53
1975-76	48,439	37,263	16,600	44.55
1976-77	53,741	51,689	16,809	32.52
1977-78	58,503	48,861	17,586	35.99
1978-79	62,160	53,984	18,546	34.35
1979-80	64,870	60,203	19,653	32.64
1980-81	68,031	63,299	23,085	36.47
1981-82	76,287	64,044	23,329	36.43
1982-83	83,109	72,893	25,127	34.47
1983-84	87,570	76,440	25,136	32.88
1984-85	87,021	77,086	25,912	33.61
1985-86	89,361	78,783	26,441	33.56
1986-87	92,450	81,757	27,122	33.17
1987-88	98,276	87,433	29,684	33.95
1988-89	100,565	88,471	31,156	35.22
1989-90	109,724	94,994	32,873	34.61
1990-91	116,918	100,139	35,535	35.49
1991-92	116,745	99,032	36,320	36.68
1992-93	115,040	96,719	37,489	38.76
1993-94	114,991	97,743	37,982	38.86
1994-95	114,496	97,278	40,111	41.23
1995-96	113,823	109,942	43,873	39.91
1996-97	114,486	108,493	45,594	42.02
1997-98	112,149	105,753	46,101	43.59
1998-99	109,419	103,103	*45,743	44.37

*** Reduction in number of houses from 46,101 during 97-99 to 45,743 during 98-99 is due to dismantling of 567 quarters at Gouthampur Colony, Kothagudem.**

Notes: Since a large number of eligible employees (more than 50%) are not provided with housing facilities, the townships and indirect employment grow in the vicinity of the coal mines. This has significant impacts on environment and forestry.

TABLE – 20

EXPENDITURE ON WELFARE AMENITIES AT THE SCCL

Year	Expenditure (Rs. Lakhs)	Expenditure/ Tonne of Coal Raised (Rs.)	Expenditure/ Employee (Rs.)
1973-74	96.72	1.82	256
1974-75	159.72	2.58	382
1975-76	316.45	4.30	653
1976-77	324.63	3.91	604
1977-78	386.14	4.33	660
1978-79	474.05	5.26	763
1979-80	604.64	6.43	932
1980-81	785.91	7.78	1,155
1981-82	1,006.34	8.31	1,319
1982-83	1,332.23	10.79	1,603
1983-84	1,611.65	12.70	1,840
1984-85	1,850.45	15.01	2,126
1985-86	2,175.27	13.90	2,434
1986-87	2,407.54	14.52	2,604
1987-88	2,923.68	17.83	2,975
1988-89	3,460.58	18.60	3,441
1989-90	4,337.00	24.35	3,901
1990-91	5,283.00	29.83	4,551
1991-92	6,555.12	31.85	5,615
1992-93	8,203.09	36.44	7,131
1993-94	10,417.33	41.32	9,059
1994-95	11,062.18	44.21	9,659
1995-96	13,813.64	51.81	12,135
1996-97	16,491.02	57.69	14,402
1997-98	19,159.65	66.74	17,081
1998-99 (Provnl.)	19,274.34	70.74	17,614

Notes: Besides coal mining operations, the above evidence indicates the broad extent of the magnitude of socioeconomic environmental impacts.

TABLE – 21

ROADS MAINTAINED BY SCCL

(In Kms.)

Year	ASPHALT	WBM/MURRAM	Total
1973-74	88.23	191.29	279.52
1974-75	96.20	197.43	293.63
1975-76	98.45	223.63	322.08
1976-77	102.11	235.72	337.83
1977-78	102.11	245.72	347.83
1978-79	119.75	238.53	358.28
1979-80	130.27	254.33	384.60
1980-81	140.32	274.65	414.97
1981-82	162.12	282.64	444.76
1982-83	178.25	294.41	472.66
1983-84	195.95	321.59	517.54
1984-85	205.76	340.77	546.53
1985-86	238.85	338.84	577.69
1986-87	271.82	369.05	640.87
1987-88	296.78	387.50	684.28
1988-89	327.46	419.93	747.39
1989-90	353.55	455.27	808.82
1990-91	384.57	482.03	866.60
1991-92	417.41	475.21	892.62
1992-93	424.89	499.40	924.29
1993-94	433.63	470.99	904.62
1994-95	455.61	507.91	963.52
1995-96	514.62	479.65	994.27
1996-97	546.14	489.71	1,035.85
1997-98	566.31	491.24	1,057.55
1998-99			

CHART – 1

ENVIRONMENTAL IMPACTS OF INCREASING USE OF COAL

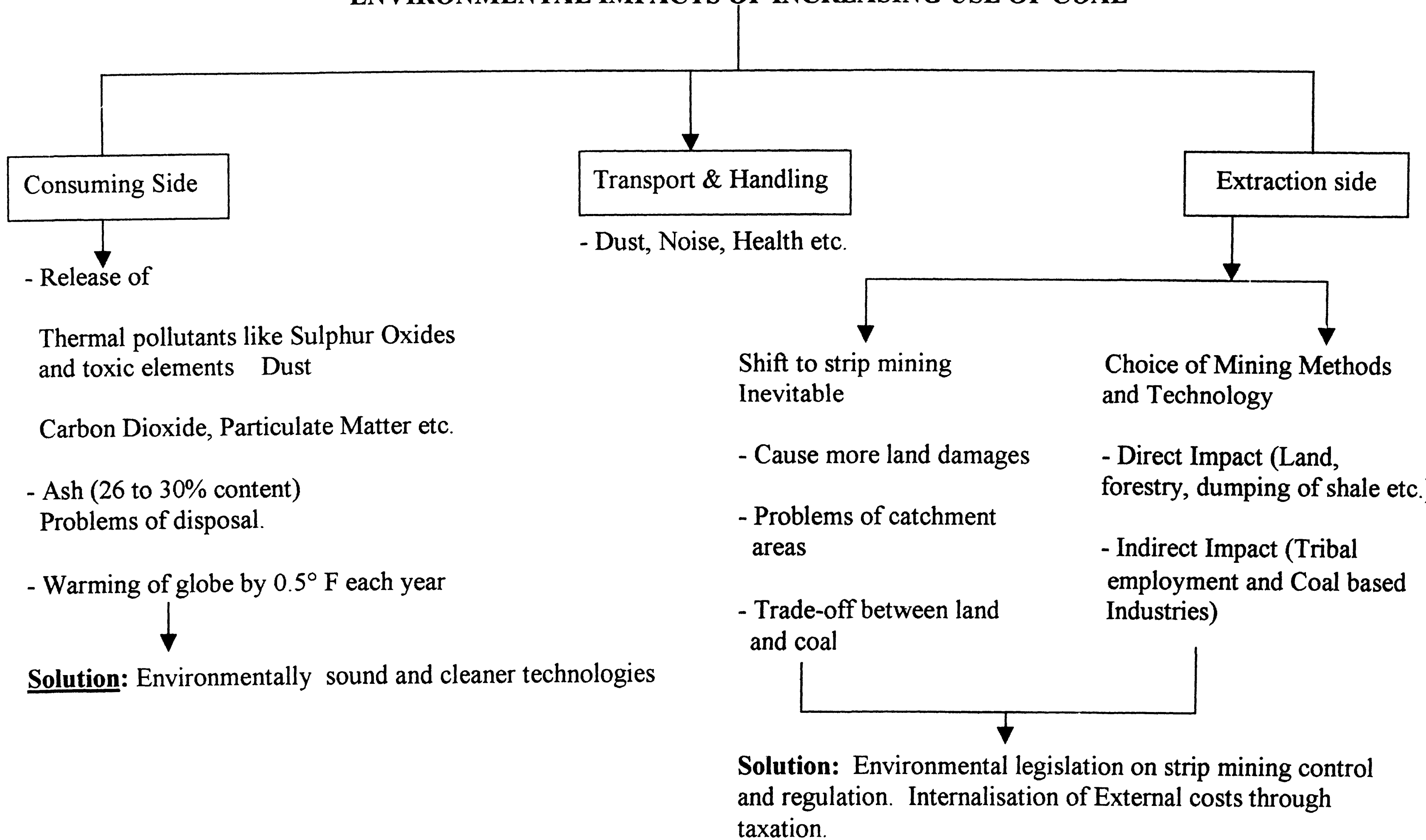


CHART – 2

MINING METHODS AND LAND RESOURCES : COAL EXTRACTION CHOICES

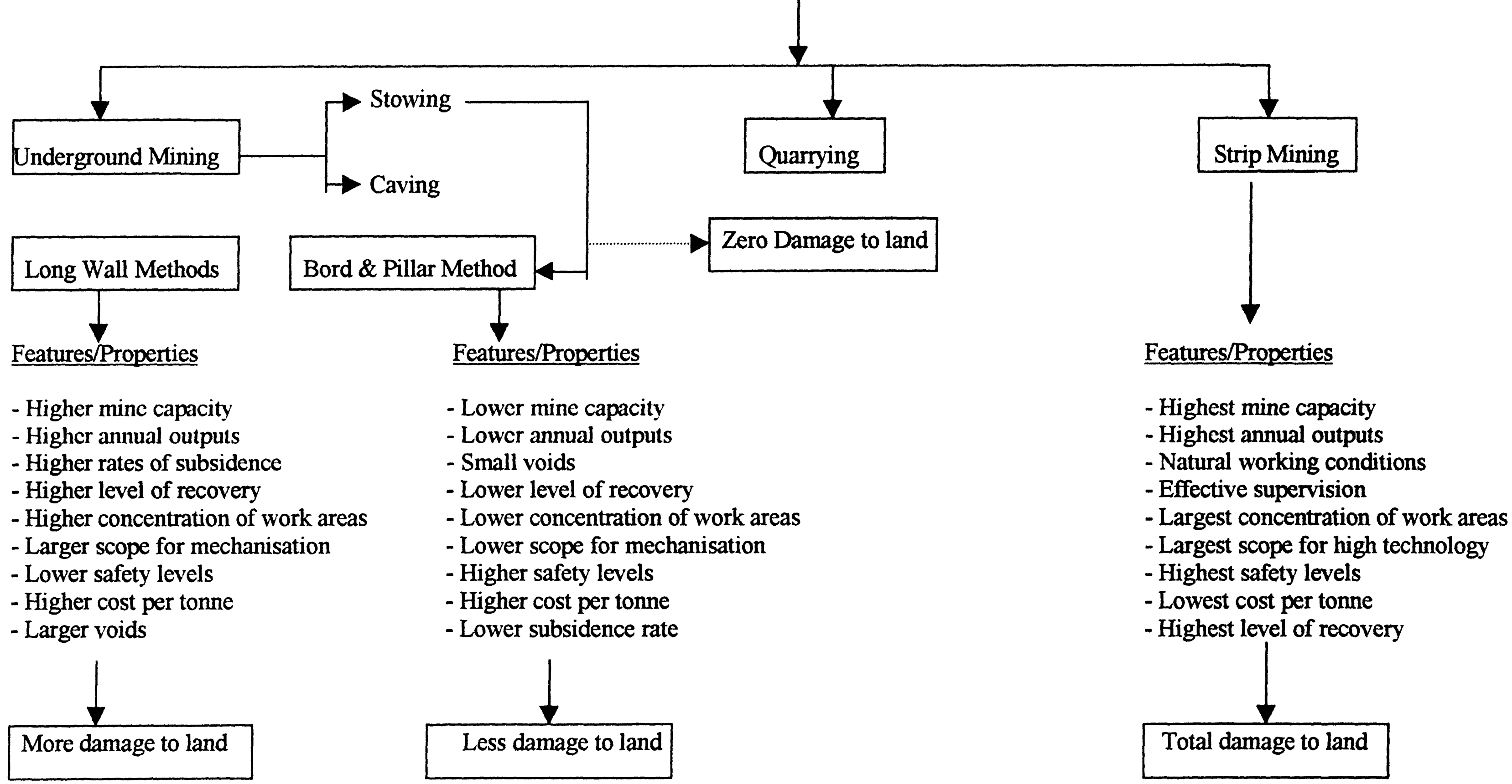
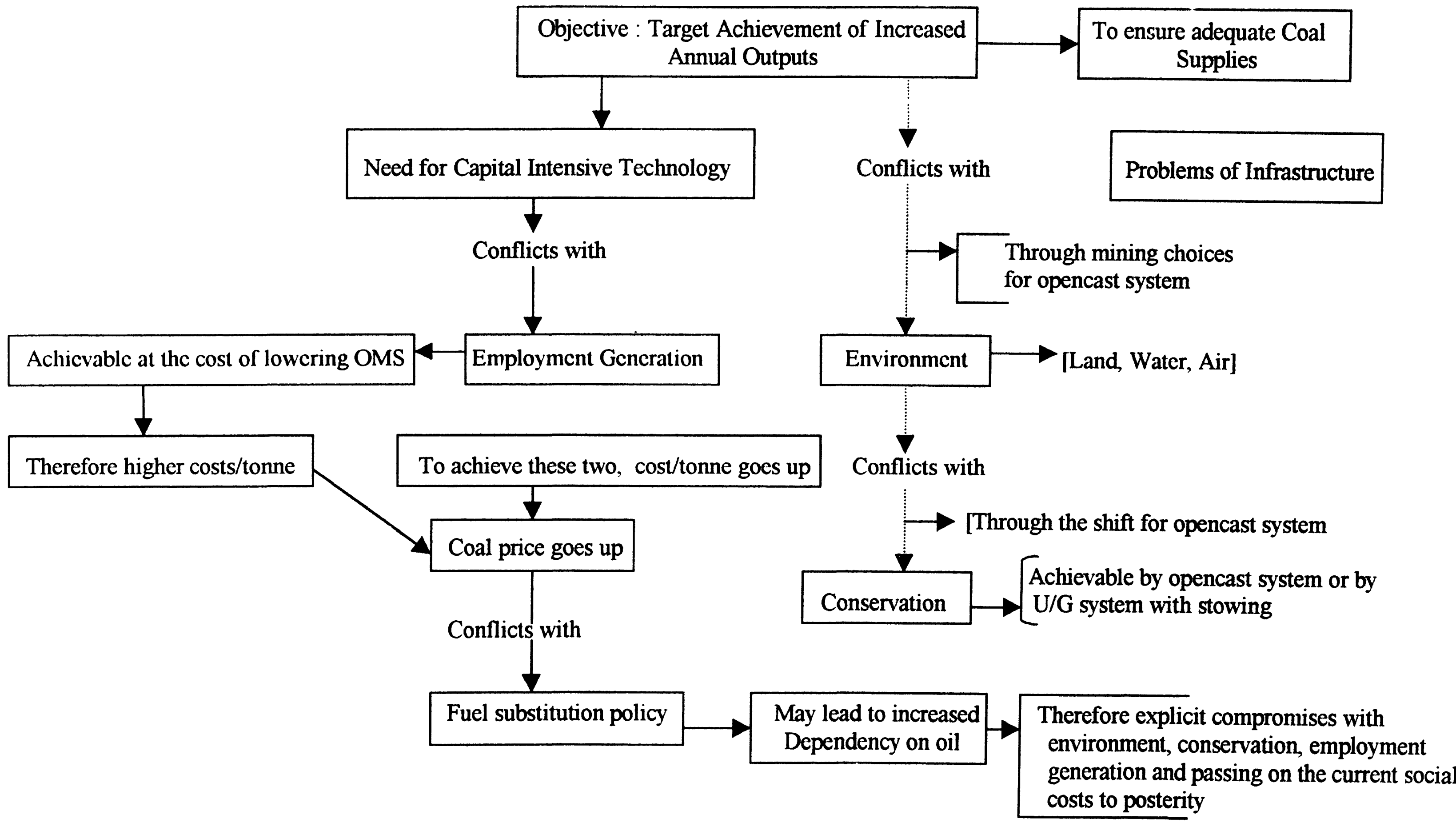
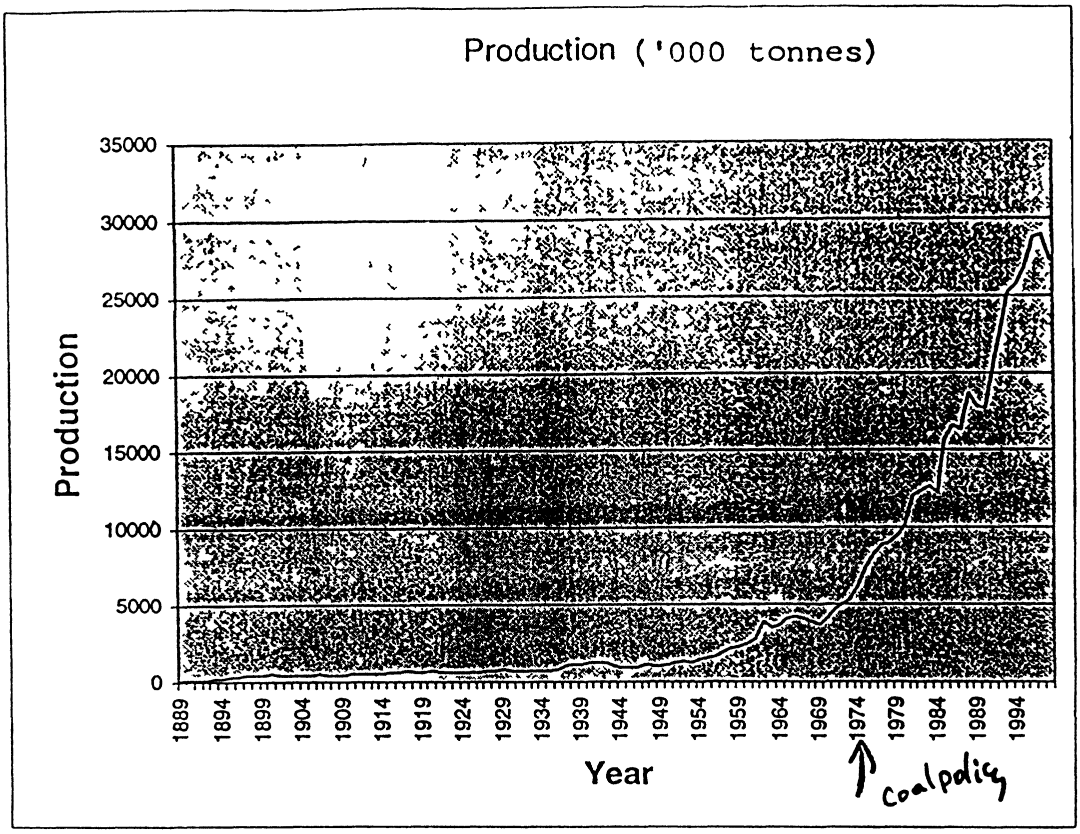


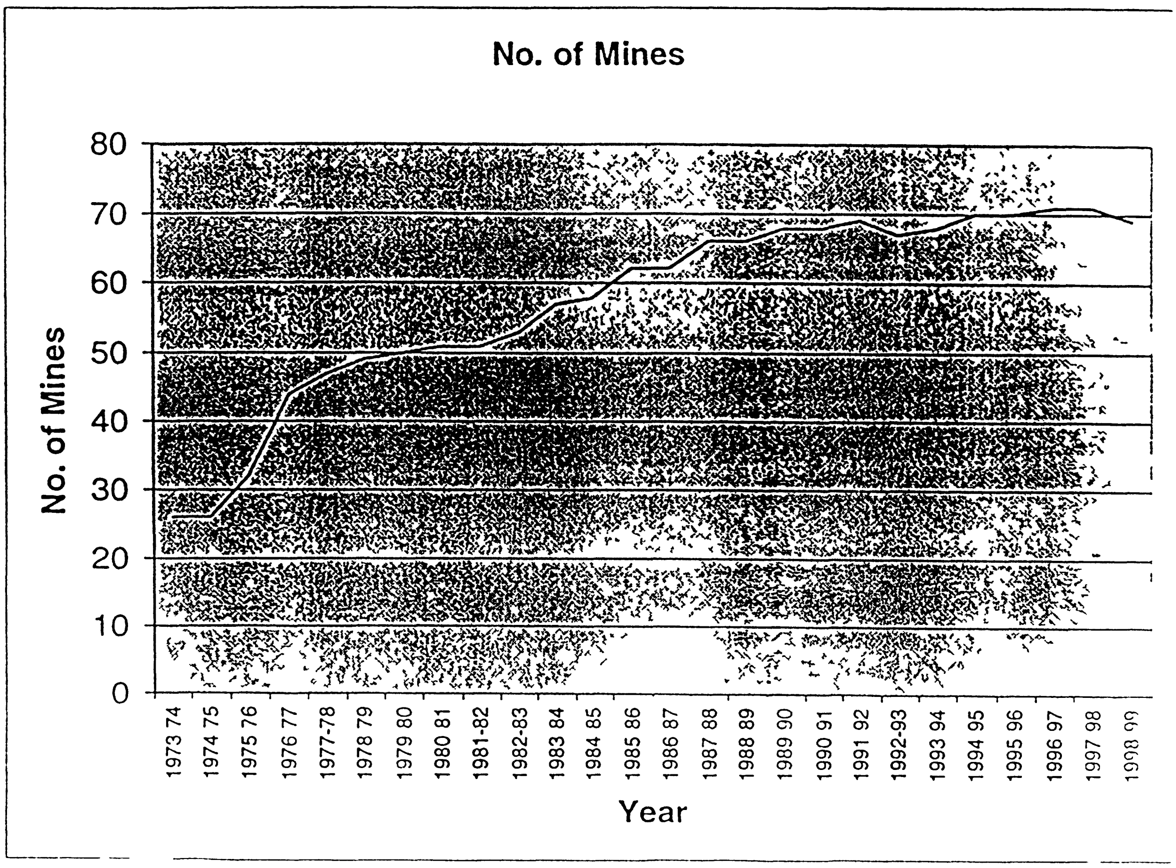
CHART – 3

CONFLICTS IN OBJECTIVES/GOALS OF THE COAL INDUSTRY



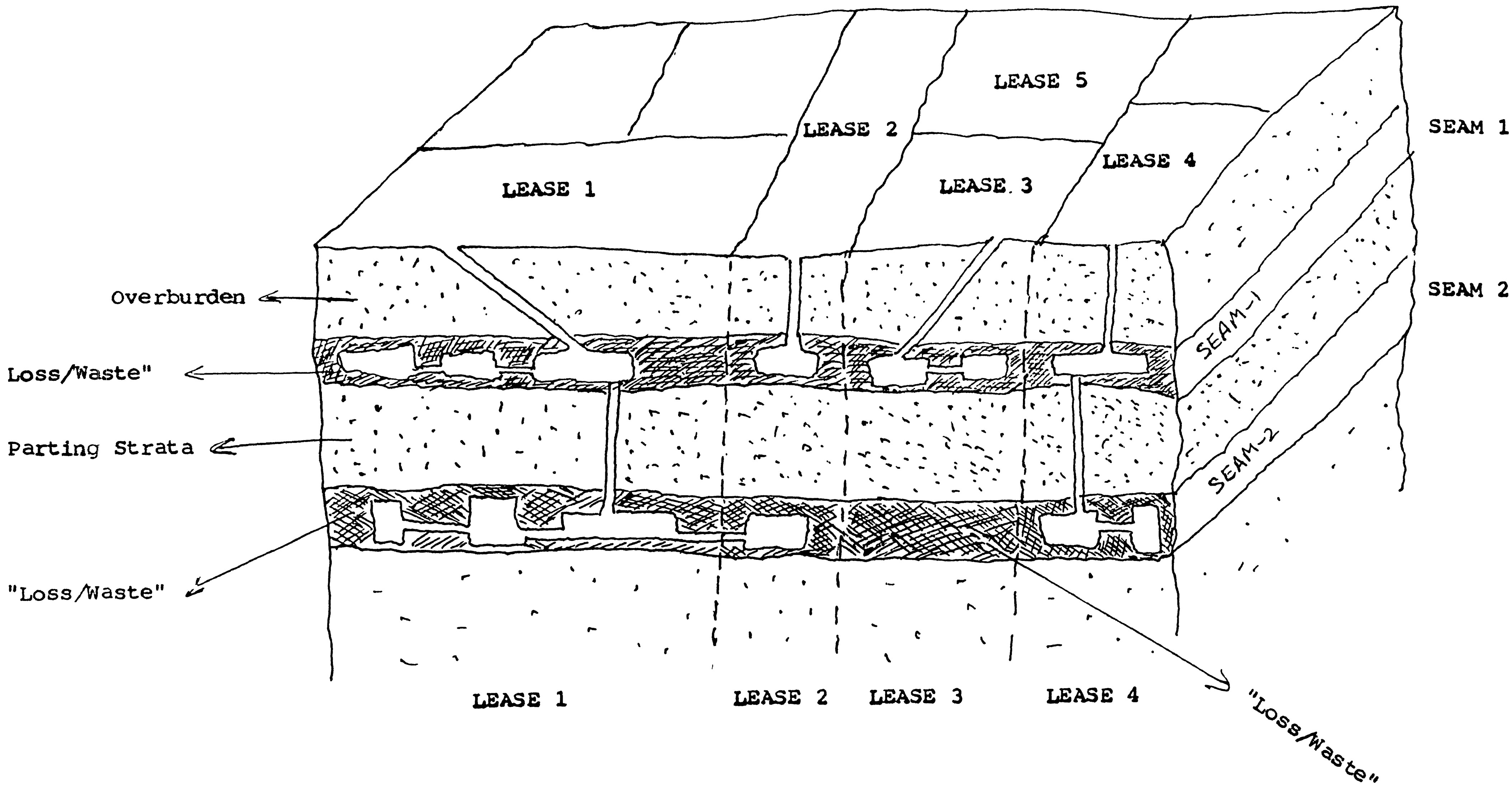
Solution: A programming approach to coal expansion and environmental resources to get rational compromises and trade-offs.

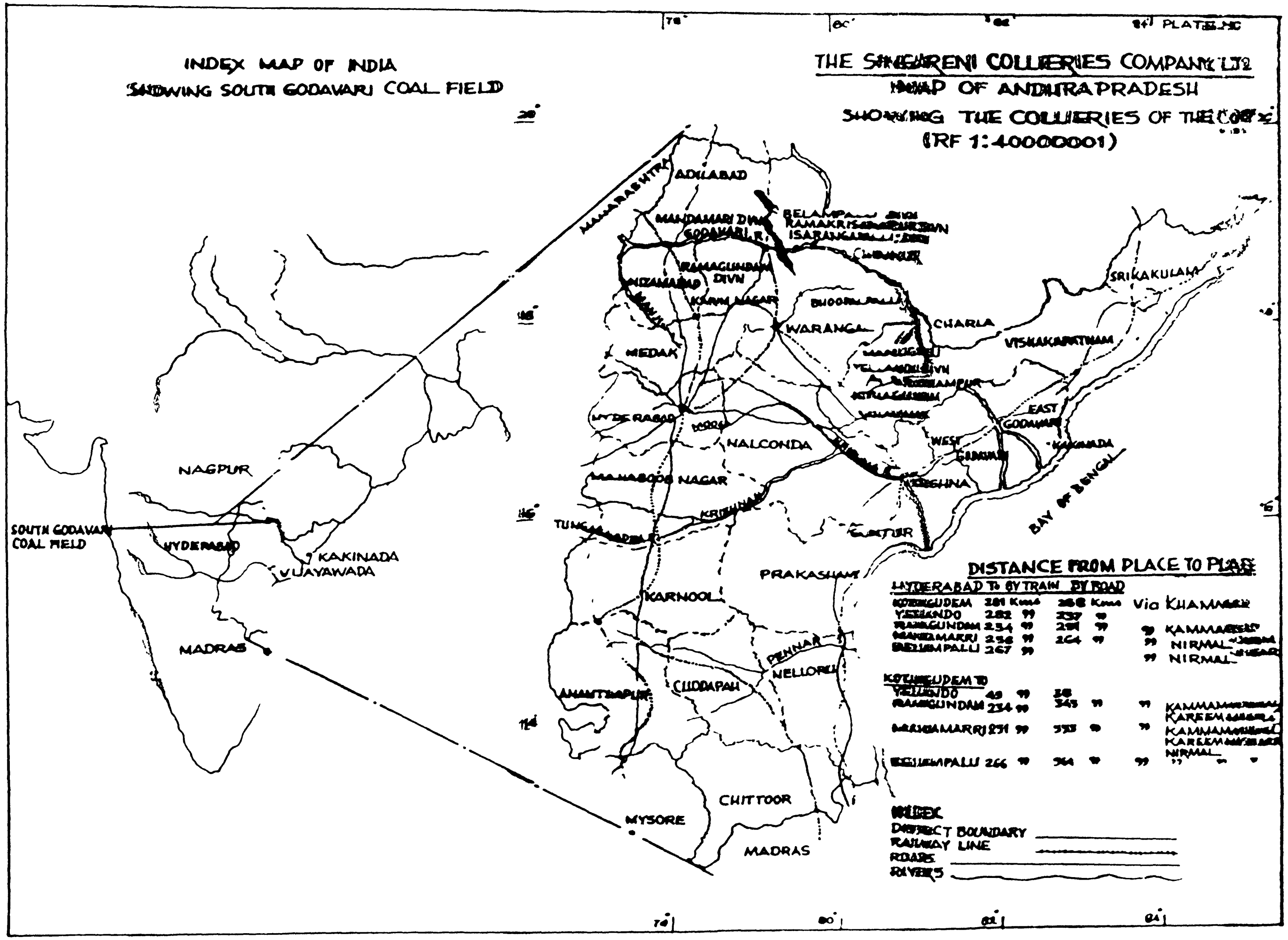




More or less, the same pattern is observed at All-India mining Sector . See IJE. 1987.

FIGURE - 2 : SHOWING THE DAMAGES (LOSS/WASTE) TO RESOURCES WHEN MINES ARE SMALL IN SIZE.





INDEX MAP OF INDIA
SHOWING SOUTH GODAVARI COAL FIELD
THE SINGARENI COLLIERIES COMPANY LTD
MAP OF ANDHRAPRADESH
SHOWING THE COLLIERIES OF THE CO.
(RF 1:4000000)
NAGPUR
SOUTH GODAVARI COAL FIELD
HYDERABAD
KAKINADA
VIJAYAWADA
MADRAS
ADILABAD
MAHARASHTRA
MANDAMARI DIVN
GODAVARI R.
RAMAGUNDAM DIVN
NIZAMABAD
KARIMNAGAR
WARANGAL
CHARLA
SRIKAKULAM
MEDAK
NALCONDA
EAST GODAVARI
WEST GODAVARI
KAKINADA
KRISHNA
GUNTUR
BAY OF BENGAL
MAHABOOB NAGAR
TUNGABHADRA
KARNOOL
PRAKASHAM
PENNAR
NELLORE
CUDDAPAH
ANANTHAPUR
CHITTOOR
MYSORE
MADRAS
DISTANCE FROM PLACE TO PLACE
HYDERABAD TO BY TRAIN BY ROAD
INDEX
DISTRICT BOUNDARY
RAILWAY LINE
ROADS
RIVERS