

Macro-Economics of Mineral and Water Resources

Kaulir Kisor Chatterjee

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*Dedicated to my inner God
who inspires me to do all that I do*

Preface

This book had for long been in my mind. The issues like land acquisition, forest and biodiversity conservation, environment preservation, energy security and water security have been and are being talked about in many countries by the planners and industries alike. In some countries, the more visionaries amongst the planners are beginning to worry about even mineral raw material security for sustaining the industries without affecting agriculture and food security. By now, the industrial products have so much pervaded into the daily lives of one and all that today's humans cannot imagine a single day without them just like food and water.

After publishing my three books on the uses of energy minerals, metals and metallic minerals, and industrial minerals, rocks and freshwater during the last decade, I was somewhat disturbed by the absence of a single ready-reckoner from which one can know about the uses of hundreds of metals, minerals and rocks in countless industrial processes and products and also from which one can quickly know, given the name of a product or process, the metals, minerals and rocks that go into it. Another disappointing situation arises from the fact that I have not yet come across a policy research institution dedicated to and engaged in holistic research covering all intricately interrelated policies concerning land, water, mineral, energy, forest, biodiversity, environment and industry for which the first step is to recognize the complexities of the relationships and the limitations of the options.

However, launching of this book project had somehow been getting delayed. It was only when I was one day sharing my thoughts with Mrs. Varsha Avinash Gharote, my ex-colleague in the Indian Bureau of Mines, that my long-dormant plan got revived and I mustered my will and resolution to draw up a plan of the chapters and their outlines and jotted down the first line of the first chapter. That small step about a couple of years ago has now given birth to this book. I am indeed indebted to her.

Besides my personal field studies and interactions, this writing has required me to rummage through whatever relevant literature that I came across and to surf through the sites of the UN, USA, World Energy Agency, World Coal Institute and many more international government and non-government bodies including those

of India and USA. For keeping me up-to-date with news of current developments, the newsletters/journals published by the Federation of Indian Mineral Industry, the Mining Metallurgical Geological Institute of India, and the Mining Engineers' Association of India and various other journals and newspapers were also helpful.

It is hoped that the book will be useful to policy researchers across the world and also the teachers and students of mineral economics, mining engineering and geology. The latter section of readers may find Chaps. 9 and 10 especially useful.

Nagpur, India
October 7, 2014

Kaulir Kisor Chatterjee, Ph.D.

Introduction

Minerals have been both the means and the cause of countless battles and wars fought since time immemorial. But, today, wars are fought not merely with weapons but with economic and industrial strength, which in turn come from the minerals. Mineral resources being natural endowments most erratically distributed over the globe, there is not a single nation or state that is fully self-sufficient in all the minerals needed by its industries and people. In modern times, a country's military strength is ultimately determined by how many minerals and how much resources it possesses. From the first mineral flint used more than 100,000 years ago to fullerene and shirasu towards the fag end of the twentieth century, and still later, in the twenty-first century, longsdaleite, a mineral harder and tougher than diamond; from the first metals copper and gold around 6,500 years ago, to the host of nuclear metals discovered during the twentieth century; and from the energy harnessed from coal for running industries in the early seventeenth century to that harnessed from uranium in the twentieth century—the evolution of economic usage of minerals has kept pace with that of the human civilization. Goods and services are turned out by the industries every day and we see and use them. But the minerals, which are made use of by the industries for producing those goods and services, are not at all seen by us. Every moment of our lives, we are using one or the other mineral without being conscious of it.

Humans need three basic natural entities for not only progressing but also surviving—land, ecology and mineral resources. Humans are born on land, depend on ecology for breathing and living and they are differentiated from their animal predecessors by how they exploit and utilize the mineral resources. While both land and mineral resources are finite, the latter are invisible, underground and unpredictably erratic both in geographic and geologic distribution as well as in their nature. And today these entities are in fierce conflict with each other. This conflict has become fiercer and fiercer since the onset of the industrial revolution about 250 years ago, later on getting a boost in the twentieth century by the two world wars and the Great Depression in between them to manage which John Maynard Keynes promoted the Epicurean ideology. Moreover, for extraction of minerals both land and ecology have to be destroyed.

This conflict has resulted in a significant shrinkage on the mineral resources endowed by nature which can actually be extracted and supplied. On the other hand, increasing population and industrialization are exerting relentless pressure on the mineral supply triggering worldwide a sense of insecurity about how to keep the industries going 20 or 30 or 50 years down the line. This underscores the importance of an approach to management of the mineral resources from a macroeconomic perspective i.e. in a national or regional scale.

Another essential economic commodity is water. While groundwater is regarded as a mineral, surface water is not. But they are links in the same water cycle along with seawater, atmospheric water and wetland water. While the humans, the agriculture and the industries directly consume potable freshwater, all the water subsystems are equally important from the ecologic point of view. Sources of fresh water—both surface and underground—were the cornerstones of the civilizations. Yet hardly any attention is given to management of its resource by the governments across the world.

The book seeks to bring to focus the indispensability of minerals, the vulnerability of the humans and also the issues that the governments across the world have to face and their management. It has been organized into ten chapters.

The first chapter 'Mineral Resources and Land Cover' deals with the paradoxical relationship between the land and the mineral resources. In spite of the classical economists considering the latter as a part of the former, the two are different in the eyes of both nature and the laws of different countries. The evolution of the process of division of land into geographical and political units and that of the 'land ownership' concept have been traced back to the early civilization of the human race. And this happened without affecting the mineral resources which lay hidden underneath the land, in oceans and in space. Moreover, the geological history of minerals is older than that of the land. It has also been highlighted how mining can contribute to both destruction of and value-addition to land. In this chapter the attributes that first determined the value of a land and how this value shifted to the mineral resources lying underneath have been described and a brief history of conquering land solely for acquiring control over mineral resources has been presented, then the present day parameters of the value of land such as forests, industries, buildings, freshwater source, infrastructure, various utilities and archeological significance have been discussed; and finally the laws relating to land have been analyzed objectively.

In the second chapter 'Minerals and Other Economic Entities', the special and unique characteristics of mineral resources vis-a-vis various overground economic entities have been explained. The latter include agricultural produce, forest and wildlife, biodiversity, human settlement, industries, real estate and environment. The essentiality of minerals to the very survival and civilization of man; the finiteness, non-renewability, invisibility and perpetuity of mineral resources; the uncertainty of their quantity and quality; and their location-specificity and independence of any political boundary—all together set mineral resources apart from the other economic entities. Keeping these differences in view, the economic significance of each of these entities as well as their pros and cons has been critically discussed in

this chapter. The outlooks in India and other countries towards all these economic entities have also been reviewed. Finally, the land management policy in India along with the deficiency therein has been critically analyzed.

The third chapter 'Relationship between Minerals and Human' traces the history and significance of minerals. All productions are essentially the result of interaction between humans and one or the other mineral which comes through mining. Although a section of the humans take part in the production of minerals, all humans are actually consumers of minerals either directly or indirectly. Consumption of minerals is related to growth of population and industrialization both of which have registered stiff rise after the industrial revolution. The history of exploitation of various forms of energy culminating in coal, petroleum and uranium and now in the renewable energy has been tracked. The relationship between growth of population and that of consumption of the important metallic and non-metallic minerals has been analyzed with the help of statistical data. As regards production of minerals, the limitations and the technological opportunities of exploration in remote locations, ocean and space resulting in augmentation of the knowledge of the reserves and resources have been described and explained with the help of statistical data. The emerging technologies have created new demand for certain not-so-widely used metals like gallium, germanium, rare earth metals etc., and this trend has been demonstrated with the help of statistical data. The need for management of such challenges by policy measures has been stressed.

The fourth, fifth and sixth chapters deal with different issues relating to energy and include sources, security etc. In these three chapters, as many as 29 sources of energy have been grouped into nonrenewable conventional, nonrenewable unconventional, renewable conventional and renewable unconventional. Each of these has been described and analyzed in terms of their advantages and disadvantages, measures for mitigating the disadvantages, status of production and consumption in India and certain other economically important countries, governmental policies and future trends. Finally, the determinant factors for deciding on the optimum energy mix in any country have been critically analyzed—need for diversification of generating capacity, local availability, ease of transportation, infrastructure, human skill level, cost and price, requirement of investment, dynamics of fiscal and other policies of governments, political viability, risks of natural hazards and man-made disruptions, nature of resources, geological factors, substitution, accessibility to foreign source, environmental and ecological regulations, problems of land acquisition and those of mindset. Evolution of energy-mix models in the world, USA and India have been shown with the help of statistical data sourced to Indian and international agencies. Finally the energy security aspects and some significant innovations in the field of energy have been described. In these chapters, statistical data have been quoted profusely and there are as many as 26 tables.

The seventh chapter is about groundwater and water management. Mode of occurrence of ground water has some similarities with that of the minerals, particularly petroleum, and it is legally recognized as a mineral whereas surface and atmospheric waters are not. However, groundwater, surface freshwater, ocean water, atmospheric water and wetland water behave as parts of the whole water resource

system and there are constant and smooth interactions amongst all these forms of water. In this chapter the desirability of approaching them as one system has been emphasized. Quality parameters of water have been described as also the economic significance of virtual water, blue water and grey water. Uses and consumption of water for agriculture, industries, drinking, household activities and mineral water production have been described with the help of statistical data as also the economic significance of all the forms of water and the role of environment. Critical appraisal of the management challenges like resource nationalism; quality; distribution amongst the different end-users; various socio-political and economic issues; and ensuring sustainability through science, technology and innovation has been presented. The reasons why many countries have not been able to formulate water policies have been identified, and finally a comparative evaluation of the current status of progress towards water policies in India, USA, European Union, Russia, South Africa and Australia has been made with reference to 12 parameters.

The eighth chapter is titled 'Sustainability and Sustainable Development of Mineral Resources'. Sustainability of mineral resources is security-centric whereas sustainable development of mineral resources is welfare-centric. The backdrop of growing insecurity about mineral raw material availability to feed the industries has been described in terms of firstly, the conflict between epicurean and environmentalist approaches; secondly, the importance of minerals to human life; thirdly, human resource development; fourthly, growing political unviability of mining projects; and lastly, policy measures. The evolution and diversification of use of the minerals and the role of particularly two minerals, namely aggregates and gold, have been explained with the help of statistical data. This has been followed up by an analysis of the various available options such as military control, recycling, substitution and foreign sourcing. Under sustainable development of mineral resources, issues relating to human health, corporate social responsibility and industrial ethics, business opportunities from closed mines and the sustainable development framework parameters have been described.

The text is followed by Chaps. 9 and 10 and then a glossary. Chapter 9 is a unique one in which over 925 consumer products and processes are listed and against each of them can be found a list of the minerals, metals and rocks as well as the intermediate chemicals and alloys which go into the making of that product or that process. Chapter 10 is a list of about 835 minerals, metals, rocks and intermediate chemicals and alloys and against each of them are listed the names of the end-products and processes for which they are used. Thus, Chaps. 9 and 10 are complementary to each other. If a reader has a consumer product or is concerned with some industrial process, he can immediately find out from Chap. 9 the names of the minerals that are necessary as raw materials for it. On the other hand, if he is concerned with mining or, in any other way, with some mineral or metal or rock, he can see from Chap. 10 the names of the consumer products or industrial processes in which it can be used. These two chapters and the glossary together are expected to serve as a ready-reference material for those concerned with industrial usage of the economic minerals, metals and rocks, and also with the manufactured products and the manufacturing

processes. When we talk about the industrial uses of minerals etc., there are three questions to find answers to:

1. What is the use?
2. Why is the use?
3. How is the use?

These chapters readily answer the first question. For the other two, the reader will have to refer to some other books dealing with industrial uses of minerals, metals and rocks.

Now-a-days, the roles of the professionals and the governments concerned with mineral development have gone beyond exploration for and production of minerals and metals. Whenever and wherever an exploration or mining or industrial project is started, it seldom happens that there is no opposition from the local people or environmentalists. In this book no solution is provided because there is no quick-fix solution. The first step towards that is identification of the root of the problems responsible for the perceived threats to shortage of mineral raw materials and to growing insecurity resulting in social tensions world over. The solution will come only through holistic research covering all the natural resources—particularly the competing ones—required by humankind. No such initiative is visible anywhere. This book seeks to concentrate on the first part which is a sine qua non for the second one.

It is primarily targeted to the students, teachers, professionals and researchers in the fields of geoscience, mining engineering and metallurgy as well as those associated and concerned with the industrial use of minerals, metals and rocks.

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