Manganese nodules also popularly known as polymetallic nodules and are the major mineral deposits on the seabed beyond continental shelf and slope. These deposits have attracted the attention of the world community way back in 1965 and a regulatory body has been established through negotiation in the United Nations Law of the Sea Conference (UNCLOS III). The International Seabed Authority (ISBA) at Jamaica has been the body that controls the licensing for exploitation of these deposits in seas beyond Exclusive Economic Zone. Since 1981 India initiated systematic surveys for mapping and exploration of polymetallic nodules in Indian Ocean for resource potential. The efforts of the country culminated in India getting an area of 150,000 sq. km. beyond EEZ in Indian Ocean by UNCLOS along with other nations like USSR, France, and Japan. Subsequently Inter Ocean Metal (Consortia of Poland, USSR, Bulgaria, Czechoslovakia etc.), China, South Korea were recognized as the pioneer investors.

The polymetallic nodules in Indian Ocean have been extensively studied on various aspects and studies include mineralogy, morphology, chemistry and other related aspects such as the environment, topography of the region, sediment characteristics, sea bed conditions nodule potential and distribution. For nearly two and half decades the nodule deposits in Indian Ocean have attracted the attention of scientists from this country both for resource potential and basic science of formation of these deposits. However, there is no systematic documentation on the economic, environmental and feasibility of mining aspects and their viability in Indian Ocean that are future resources of the country for alternate exploitation to terrestrial deposits.

The Assembly of ISBA adopted regulation on exploration of polymetallic nodules to facilitate the exploitation activities in the area. In order to obtain production authorization, it is obligatory on the part of India to the ISBA to provide data sets on environmental aspects by conducting prototype mining experiments in the
area. Currently India conducted experiment in the Pioneer Area and continuous monitoring is in progress, to understand the likely affects of mining on the environment prevailing in the area. The results are being documented as the work is in progress.

The results of the studies carried out on “A Comprehensive Study And Analysis Of Polymetallic Nodule Deposits In Indian Ocean With An Emphasis On Economic, Environmental And Mining Aspects” the basis of available data in the Indian ocean site, models were used for selection of promising site, demand perspectives have been brought out and cost model has been arrived at for the Indian Ocean Site. The thesis is presented in eight chapters.

Chapter 1: gives a general introduction, global scenario, metal resources of polymetallic nodules, nodule recovery in world Oceans, international efforts on deep sea mining, Indian activities etc. Also includes Objectives of the study, and reviews of previous work.

Chapter 2: Detailed reviews have been carried out on manganese nodule resources, and their global distribution. This chapter also provides analyses of the Indian interests vis-à-vis global interest followed by the Indian activities for polymetallic nodules.

Chapter 3: Presents systematic surveys at regular grid interval over the entire area in the Central Indian Basin at various grid intervals as the prospecting was in progress. Thus resulted in a large database of polymetallic nodules deposits in the Indian Ocean. These data formed a basis for a comprehensive geostatistical evaluation of the resources of manganese nodules and their spatial distribution in the area of study.

Chapter 4: gives the grade-tonnage relationship as a function of Cut-off grades has been evaluated. First, a general statistical approach of computing such curves for a three parameters log normal distribution model has been suggested and graphic solutions are presented. This is followed by computing the grade-
tonnage curves based on two different dimensions. There are two relative objectives of the investigations for the nodule study area. First it is intended to demonstrate the dependence of the curve on the block size and second, to develop a practical decision tool to select areas having greater potential in terms of abundance and grade. The results of the study area are presented in terms of evaluation of impact of cut-off values on resultant values. These studies have been made with reference to station wise mean values as well as block wise estimated values. The two results produced, represent the limiting values of selection if it was based on nodule abundance and metal values only. Based on the above studies, the overall estimates and the estimates of resources for the study area are presented.

Chapter 5: Comprises the status of development of various mining technologies globally. A comprehensive review of past & present mining technology perceptions for exploitation of polymetallic nodules has been carried out. The comparison has been made considering the various technologies and their impact on environment and economic aspects. The strength and weakness of various systems have been analyzed in order to optimize a design and propose an environmentally safe commercial mining system. The requirement of various parameters for environmentally safe mining system has been drawn up. The modes of transportation of nodules from the mine site to the land based processing plant have also been dealt in this chapter. An environmentally friendly mining system has been proposed on the basis of analyses of various available technologies and forecasting the future seabed mining developments.

Chapter 6: In this chapter, a review has been carried out on global and Indian studies on environmental impact likely to be caused due to mining. In addition specific investigation have been carried out on granulometric analysis and heavy metals in water column based on prototype studies carried out and the data generated specific to Central Indian Basin.

Chapter 7: Presents the detailed review of demand supply position of four metals of interest from polymetallic nodules. They are Copper(Cu), Nickel(Ni),
Cobalt (Co) and Manganese (Mn). The compounded growth rate in demand from 1950 to 2003 for various metals has been analyzed. While reviewing and analyzing the demand-supply growth both globally and in Indian context, an analysis has also been made for the trend in prices of these metals (Cu, Ni & Co) for the last century.

Finally considering the growth in demand supply and the trends in price variations, the expected level of demand-supply of Cu, Ni, Co & Mn for the year 2020 has been projected. Although, the metal prices are very volatile and governed by the market forces though the demand and supply plays an important role, an expected long-term metal prices increase has been projected on the basis of average price growth rate of these metals over the coming years.

Chapter 8: Presents the review of studies made by various state parties in this regime. A cost model has been prepared on the basis of promising exploitation technology, extractive metallurgy considering a promising process package already developed by India. Based on this a cost model has been prepared in respect of mining system, transportation, processing. The net present value at different discounted rates for base case of the model has been worked out. A number of critical parameters (Capital cost revenue, metal prices and grade of nodules) have been considered for analyzing the sensitivity of the project and impacts on profitability of the project. The cost model finally concluded that the polymetallic nodule mining would be economical by 2015 considering the present price trends of Cu, Ni, Co, & Mn with the proposed mining technology application in the selected first generation mining site.

Based on the above chapters suitable conclusions are drawn with an emphasis on economic, environmental and mining aspects related to polymetallic nodule deposits in Indian Ocean.