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# CONTRIBUTION OF SMALL-SCALE MINING TO EMPLOYMENT, DEVELOPMENT AND SUSTAINABILITY – AN INDIAN SCENARIO

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**Abstract.** Small-scale mining is more prevalent in India. The maximum production capacity of 50,000 tonnes/year has been accepted as a criterion to Indian small-scale mine. Such mines constitute about 90% of total number of mines, 42% of the total non-fuel minerals and metals, 5% of the fuel minerals. Some 3000 small scale mines account for a work force of about 0.5 million people. Yet this sector is a neglected sector in Indian economy and still considered as an unorganized sector. This paper examines the contribution of small-scale mines to employment and national mineral production, practices, and Indian policy on small-scale mining. It identifies the drawbacks in the existing Government policy and discusses the role of Government for up gradation in this sector. It focuses the need for technical up gradation and to ensure the economic and social infrastructure. It also discusses how the pursuit of sustainable livelihoods, poverty alleviation and indigenous peoples right in artisanal and small-scale mining be more effective when these communities are disadvantaged or neglected by Government policies. This paper concludes that this sector can make significant contribution to Indian economy and employment generation. It recommends that by establishing mining centre consist of shared mining and processing facilities, educating and training related initiatives it can be achieved.

**Keywords:** artisanal, mineral policy, mining centre**,** non-fuel minerals, rural, socio-economic.

## 1. Introduction

The criteria adopted for categorizing the mines units as small, medium and large scale, differ from country to country, and there exists no universal yardstick. India has the experience of mining for fairly long period. In the post-independence period the growth, barring some public sector units, has been in small and medium mining units (Rudra, 2002). Mining and quarrying of industrial minerals and construction material on a small-scale i.e. producing relatively smaller quantity of mineral and employing relatively less number of persons, may be termed as small mines. The maximum production capacity of 50,000 tonnes per annum has been accepted as the criteria to define Indian small-scale mines (Ghose, 2003a). As per Indian Mines Act 1952, it does not make much of a distinction between small mines or others (Anon,

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1991). However, some of the mines are exempted from provisions of most of the Mines Act in certain cases on the basis of type of minerals mined, purpose of mining like for prospecting and others, depth of workings and number of workers etc. (Ghose, 2003b).

Recognition of the fact that small-scale mining can make a significant contribution to developmental objectives, which has been one of the principal motives for this persistent interest (Noetstaller, 1994). The socioeconomic significance of operations is often overlooked As opposed to large-scale mining, requirements of small mines in terms of minimum reserves, implementation time, and initial investments are small, skills and infrastructural requirements are moderate and employment per unit out put is high (Argall, 1978). While small minimum reserve requirements together with short construction period are an advantage in any economic environment, it is the combination of moderate capital skills and infrastructural needs with the general use of labor that is particular relevance in less developed economics. The specific consumption pattern of the factors of production, these, is what makes attractive option for developing countries like India. The objective of this paper is to examine the main categories of small-scale mining practices, to identify further initiatives and opportunities for socioeconomic development and to focus the contribution of small-scale mining to employment and national mineral production in India.

## 2. Contribution of small-scale mining to national mineral production in India

Small-scale mines represent a growing and important component of the mineral sector in terms of value output, contribution to the economy and employment. It has been estimated that small-scale mines contribute about one sixth of the value of the world's non-fuel mineral cut. In many developing countries output is significantly higher than this figure. In India some 3000 small-scale mines account for about 5% of fuel mineral production (Ghose, 2003c). The most important aspect of small-scale mining in India is the absence of any nationally accepted criteria for identifying such mines. As a result, no statistical data are collected, maintained and published for proper appreciation of the role of small-scale mining in the country's economy. It has been reported (Chakraborty, 2002) that such mines constitute about 90% of the total number of mines (about 3700) and produce about 42% of the value of total output of non-fuel minerals and minor minerals taken together, and 6% of the fuel-mineral (Coal) (Anon, 2001). If the productions are added up from non-reporting informal mines (500) all of which work on small- scale (mostly minor minerals) the total contribution of small-scale mines (SSM) would be slightly more.

Nevertheless, small-scale mining is more prevalent in India. The facts and figures indicate that small-scale mining (SSM) that exists to a great extent in India and would continue to be there for decades to come (Ghose, 1990a). For the growth of Indian mining industry, it is essential to improve the techno-economic efficacy of small-scale mining in all spheres of its activities form exploration to exploitation, including management and control (Chakraborty, 2002). It is estimated that the share of production by Indian small-scale mining to the global production is significantly high in case of certain minerals viz. antimony (45%), calcium (50%), chromites (75%), clays (75%), feldspar (80%), fluorspar (90%), gypsum (70%), tungsten (80%) vermiculite (90%) (Table I) (Anon, 2000).

While eighty odd minerals (including minor ores) are operated in India, around seventy of them are extracted by small-scale mining (Table II) (Anon, 2001). Number of small-scale mines of some selected important minerals in India during 1985–1990 is given in Table III (Anon, 2000). However, it is not easy to group these mines. In many mines, production is as low as tens of tonnes per day and even less, while some of them have daily production of 150 to 200 tonnes. Investment and productivity in these mines also vary widely. While some of the mines are operated manually, some are considerably mechanized. India can have a number of benefits from small-scale mining. Small-scale mining is the only alternative to exploit small deposits and can be worked with small capital and low gestation period. Each small-scale mining belt has its unique techno-economic and socio cultural characteristics. To have a clear concept of the common and major problems in this sector, one needs to know various geo-mining and socio-economic status in which it operates. Figure 1 provides an overview of important Indian mineral deposits suitable for small-scale mining (Anon, 2001).

## 3. Contribution to employment and social perspective

The increasing importance of small-scale mines, particularly in India, has led to increased employment and economic activity. Because little is known of the extent of their activities and their technical and environmental implications, there is a need to obtain better information so that the promotion of small-scale mines can proceed in an effective manner. Information on employment, output, capital employed, revenue generated, safety and health is either inadequate or non-existent. In conjunction with their assistance to the sector, a case can be made for implementation by the government of a straightforward reporting scheme, which would provide the data, necessary for policy development and subsequent control of the sector, so that small-scale mines can make their best contribution to the economy and welfare of the country.

The employment effects of such activity are considerable, especially in tribal and rural areas. It has high employment potential and around 0.5 million people are employed in Indian small-scale mines (Carmen and Berger, 1990; Ghose, 2004). Unfortunately, hardly these benefits are properly occurred in Indian small-scale mines (Cramer, 1990). Despite of some drawbacks, small-scale mining has several benefits. These include the ability to operate in remote areas with little infrastructure, enabling the exploration of otherwise uneconomic resources, and a high degree of flexibility because of low overheads. Small-scale mining may also fit in well with the existing social structure, particularly if seasonal operations are required because of agricultural production in the same area. The ability of small-scale mines to generate employment, income, and entrepreneurial skills in the rural areas can act as restraint

TABLE I. Contribution and position of India in world production of the principal minerals and metals during 1998–1999.

| Commodity | World | India | Contribution (%) | Rank |
|---|---|---|---|---|
| 1. *Mineral fuels* (million tonnes) | | | | |
| (i) Coal and lignite | 4598 | 315.6 | 6.8 | 3rd |
| (ii)Petroleum | 3355 | 32.7 | 1.0 | 26th |
| 2. *Metallic minerals* (thousand tonnes) | | | | |
| (i) Bauxite | 125500 | 6609.5 | 5.2 | 6th |
| (ii) Chromite | 13200 | 1418.8.1 | 10.7 | 3rd |
| (iii) Iron ore | 1111000 | 72230.0 | 6.5 | 6th |
| (iv) Manganese ore | 23300 | 1537.7 | 6.6 | 6th |
| 3. *Industrial materials* (thousand tonnes) | | | | |
| (i) Barytes | 62000 | 660.8 | 10.6 | 7th |
| (ii) Kyanite, Andhausite & Sillimanite | 360 | 18.2 | 5.1 | 3rd |
| (iii) Magnasite | 18500 | 349.8 | 1.9 | 13th |
| (iv) Apatite &Rock phosphate | 135000 | 127.6 | 0.9 | 13th |
| (v) Tac/ Steatite Pyrophyllite | 7600 | 573.4 | 7.5 | 4th |
| (vi) Mica (Tonnes) | 3000000 | 14840.0 | 0.5 | 1st[a] |
| 4. *Metals/Alloys* (thousand tonnes) | | | | |
| (i) Aluminum | 22700 | 543.4 | 2.4 | 11th |
| (ii) Copper (refined) | 14000 | 148.8[b] | 1.1 | 20th |
| (iii) Steel (crude) | 776000 | 23333.0[c] | 3.0 | 5th |
| (iv) Lead (primary & secondary) | 6000 | 47.9 | 0.8 | 21st |
| (v) Zinc (primary) | 8000 | 173 | 2.1 | 21st |

[a]World data relating to mica blocks and splitting is not available for 1998. As such India's ranking in the mica blocks and splitting production is not known. However, it would descend to the 9th rank, if all forms are considered. Indian production in the table relates to crude mica only.
[b]Relates to copper production of primary.
[c]Relates to steel ingots only.

on urban migration. In addition, because they are generally locally owned, small-scale mines can provide a larger net gain to the community and to the national economy than do larger foreign owned mine. At the same time small-scale mining can be inefficient, poor working conditions, problems of safety and health and environmental degradation abound (Hickie and Wade, 1998). Much small-scale mining activity is carried out illegally and is thus difficult to monitor and control. Because of widespread smuggling, there can be considerable losses to the miners themselves and to the government. In India, more than 50% of the total mining labor force can be engaged in small-scale mining. Thus, these operations, which make an essential contribution to economic growth, need to be integrated fully into their respective economics.

### 3.1. Socioeconomic Status of Artisanal Mining Areas

Small-scale mining does contribute towards the improvement in the social environment of around its locality, provided this sector is given some attention in the interest of the State and the workforce engaged in operations. In regard to industrial status, small-scale mining is still considered as an unorganized industrial sector, which, from both local and central governments, alike receive a step-motherly

TABLE II. Mineral reserves in India (Thousand tonne of recoverable reserves as on 1.4.1995).

| Mineral | Proved | Probable | Possible | Total |
|---|---|---|---|---|
| 1. Andaluside[a] | – | – | 18450 | 18450 |
| 2. Antimony | | | | |
| (i) Ore (t) | – | – | 10588 | 10588 |
| (ii) Metal(t) | – | – | 174 | 174 |
| 3. Apatite | 655 | 10268 | 2721 | 13644 |
| 4. Asbestos(t) | 2659874 | 2620188 | 4102776 | 9382838 |
| 5. Ballclay | 7329 | 7960 | 22238 | 37527 |
| 6. Barytes. | 52705 | 27780 | 6577 | 87062 |
| 7. Bauxite | 768216 | 586427 | 1107788 | 2462431 |
| 8. Bentonite | 37200 | 108766 | 219523 | 365489 |
| 9. Borax[a] (t) | – | – | 74204 | 74204 |
| 10. China clay | 45833 | 301615 | 695020 | 1042468 |
| 11. Chromite | 25734 | 30775 | 29720 | 86229 |
| 12. Cobalt ore[a] (Mt) | 30.63 | 2.00 | 7.28 | 39.91 |
| 13. Copper | | | | |
| (i) Ore | 165648 | 151712 | 99450 | 416810 |
| (ii) Metal | 1722 | 1611 | 1041 | 4374 |
| 14. Corundurn (t) | 793 | 673 | 26871 | 28337 |
| 15. Diamond (carats) | 851156 | – | 130359 | 981515 |
| 16. Dispore (t) | 497101 | 482635 | 453531 | 1433267 |
| 17. Diatomite | – | – | 2008 | 2008 |
| 18. Dolomite | 515979 | 705356 | 3085520 | 4386855 |
| 19. Feldspar (t) | 4468664 | 6298998 | 20518327 | 31285989 |
| 20. Fire clay | 64296 | 46017 | 407820 | 518133 |
| 21. Fluorite | 1503 | 1000 | 448 | 2951 |
| 22. Fuller's earth | – | 763 | 227567 | 228330 |
| 23. Garnet | 104 | 9734 | 41878 | 51716 |
| 24. Gold | | | | |
| (i) Ore (t) | 4178910 | 10003179 | 3605886 | 17747975 |
| (ii) Metal (t) | 21.1 | 36.0 | 10.8 | 67.9 |
| 25. Granite ('000 $m^3$ ) | 11114 | 332457 | 683850 | 1027421 |
| 26. Graphite (t) | 792637 | 1236719 | 2550120 | 4579476 |
| 27. Gypsum | 26247 | 31380 | 179974 | 297601 |
| 28. Iron ore | | | | |
| (i) Hematite (Mt) | 5106 | 2367 | 2577 | 10052 |
| (ii) Magnetite (Mt) | 1530 | 781 | 1097 | 3408 |
| 29. Kyanite | 322 | 1570 | 925 | 2817 |
| 30. Lead & Zinc | | | | |
| (i) Ore | 71287 | 47801 | 60044 | 179132 |
| (ii) Lead metal | 879 | 642 | 801 | 2322 |
| (iii) Zinc metal | 4660 | 2554 | 2864 | 10078 |
| 31. Limestone | 12061132 | 16705201 | 46912557 | 75678890 |
| 32. Magnesite | 48775 | 145829 | 50537 | 245141 |
| 33. Marble | 3294 | 120292 | 701038 | 824624 |
| 34. Mica (t) | – | – | 59980 | 59980 |
| 33. Manganese ore | 40075 | 49401 | 77833 | 16730 |
| 34. Molybdenum | | | | |
| (i) Ore (t) | – | 36000 | 800090 | 8036900 |
| (ii) Contained Mo $S_2$ (t) | – | 62 | 2764 | 2826 |
| 35. Nickel ore[a] (Mt) | 51.54 | 73.68 | 58.26 | 183.48 |
| 36. Ochre | 3431 | 8009 | 15924 | 27364 |
| 37. Phosphorite | 88646 | 16843 | 39885 | 145374 |
| 38. Quartz/ Silica sand | 323381 | 602994 | 1475806 | 2402181 |

TABLE II. Mineral reserves in India (Thousand tonne of recoverable reserves as on 1.4.1995).

| Mineral | Proved | Probable | Possible | Total |
|---|---|---|---|---|
| 39. Quatrzite | 9516 | 49877 | 245684 | 305077 |
| 40. Rock salt | 2010 | 1540 | – | 3550 |
| 41. Ruby (kg) | 79.45 | 220.00 | 170.00 | 469.45 |
| 42. Sillimanite | 69 | 38683 | 12868 | 51620 |
| 43. Silver | | | | |
| (i) Ore (t) | 80240326 | 41132313 | 37423435 | 158796074 |
| (ii) Metal(t) | 2117.57 | 1575.51 | 1181.71 | 4874.79 |
| 44. Sulphur[a] | – | – | 210 | 210 |
| 45. Talc/Stearite/Soapstone | 7123 | 41862 | 100559 | 213704 |
| 46. Tin | | | | |
| (i) Ore(t) | 561325 | – | 28346000 | 28904325 |
| (ii) Metal (t) | 226 | – | 3046 | 3272 |
| 47. Titanium minerals | | | | |
| (i) Ilmenite | 15734 | 55094 | 19349 | 90146 |
| (ii) Rulite | 1657 | 3901 | 910 | 6468 |
| (iii) Leucoxene | 74 | – | – | 74 |
| (iv) Titaneferrous magnetite | 2170 | 1392 | 8737 | 12299 |
| 48. Tungsten | | | | |
| (i) Ore | 4250000 | 11153489 | 22707471 | 38110960 |
| (ii) $WO_3$ (t) | 4549 | 12564 | 69419 | 86532 |
| 49.Vanadium | | | | |
| (i) Ore (t) | 3033875 | 4032000 | 4460920 | 11526795 |
| (ii) Metal (t) | 6530 | 5670 | 51403 | 63603 |
| 50.Vermiculite | 56732 | 28949 | 136901 | 222582 |
| 51. Wollastonite | 1519 | 2769 | 2007 | 6295 |
| 52. Zircon | 1506 | 193 | – | 1699 |

[a]Conditional resources.

treatment. Located in far-flung areas, isolated, disadvantaged by lack of power and infrastructure, small-scale mines have always been considered as small-time investment and never have been considered as a continuous stream of income generation, both during and after mining. Unfortunately, viewed as quick money making proposition before leap forging into a new locale small-scale mining and ill-supervised, neglected and to sum it all.

It contributes to some extend towards development of rural areas. Small mining operations help to create improved infrastructural facilities, like approach roads energy and water supply in a low scale. Small mining activities, being situated in economically backward areas, stimulate greater variety in income distribution and create new job positions. Consequently, the social and economic standard of living of the people in place starts rising further. Apparent contribution to government is the taxes and royalties from operators. But a significant contribution is fulfilling the social planning, the objectives of rural income generation, infrastructural development and stoppage of migration of rural labor.

## 4. Practices in small-scale mining

As compared to underground mining, mechanization in Indian opencast workings, primarily because of more congenial environment, has less complexity in design,

TABLE III. Number of Small-scale mines of some selected important minerals in India (1985–1990).

| Minerals | No. of Small Mines (upto 50,000 tonnes/ annum) | | | | | Percentage of Total No. of Mines | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1986 | 1987 | 1988 | 1989 | 1990 | 1986 | 1987 | 1988 | 1989 | 1990 |
| Asbestos | 82 | 82 | 87 | 74 | 76 | 100 | 100 | 100 | 100 | 100 |
| Bauxite | 154 | 195 | 182 | 186 | 183 | 93 | 94 | 94 | 94 | 93 |
| Baryte | 52 | 46 | 51 | 51 | 45 | 100 | 100 | 100 | 100 | 100 |
| Chromite | 22 | 23 | 22 | 22 | 23 | 100 | 100 | 100 | 100 | 100 |
| Coal | 48 | 49 | 56 | 41 | 54 | 9 | 9 | 10 | 8 | 11 |
| Dolomite | 137 | 133 | 132 | 134 | 120 | 95 | 95 | 95 | 95 | 94 |
| Feldspar | 138 | 138 | 116 | 117 | 120 | 100 | 100 | 100 | 100 | 100 |
| Fire clay | 247 | 263 | 239 | 232 | 212 | 100 | 100 | 100 | 100 | 100 |
| Graphite | 31 | 40 | 51 | 51 | 50 | 100 | 100 | 100 | 100 | 100 |
| Iron Ore | 243 | 259 | 237 | 238 | 206 | 71 | 72 | 73 | 73 | 68 |
| Kaolin | 180 | 198 | 182 | 183 | 170 | 100 | 100 | 100 | 100 | 100 |
| Kyanite | 13 | 15 | 15 | 10 | 9 | 100 | 100 | 100 | 100 | 100 |
| Lime stone | 486 | 563 | 569 | 525 | 546 | 77 | 79 | 79 | 76 | 77 |
| Manganese Ore | 199 | 207 | 199 | 199 | 185 | 97 | 97 | 97 | 97 | 96 |
| Mica | 165 | 181 | 150 | 045 | 148 | 100 | 100 | 100 | 100 | 100 |
| Ochre | 93 | 113 | 91 | 87 | 91 | 100 | 100 | 100 | 100 | 100 |
| Pyrophilite | 40 | 45 | 43 | 44 | 44 | 100 | 100 | 100 | 100 | 100 |
| Quartz | 206 | 229 | 198 | 198 | 205 | 100 | 100 | 100 | 100 | 100 |
| Silica sand | 257 | 275 | 272 | 3012 | 274 | 100 | 100 | 100 | 100 | 100 |
| Steatite | 278 | 258 | 252 | 252 | 239 | 100 | 100 | 100 | 100 | 100 |

configuration and operation and ready availability of indigenous equipment in case of the latter. In small mines, particularly those producing minerals of less value are not mechanized. Most of the operations are carried out manually by opencast method. Generally, manual means are employed for both breaking and loading of the minerals. In case of very hard rocks, heating the rock and cooling with water subsequently forms cracks, and sometimes explosives are used. Shot holes are drilled either manually using crow boards or mechanically using compressed air operated jack hammers to form a block and chisels are used or to extract the block. The workings are extended downwards, generally without formation of any bench, and when the depth increases, many a times ropes are used to go down to the floor of the quarry or to work on the sides on very small ledges.

Small-scale mining practices are as diverse as the minerals produced. At the low end of the industry, informal micro-scale mining is the extraction of typically high value usually from alluvial liberalizations or outcrops conducted by individuals or families, using purely manual techniques. By contrast, traditional and advanced small-scale mining comprises formal, organized mining activities carried out by small enterprises with limited capacity. Micro mining is essentially confined to surface occurrences of minerals. Frequently, the pick, the shovel, and the pan are the only physical assets employed. Production and income are usually erratic and often marginal due to the resulting technical limitations. Unlicensed and unrecorded conduct of business is the rule rather than exception.

Micro mining has also record of inadequate safety, poor social facilities, and environmental neglect. In some areas the activity can be traced by the incidence of

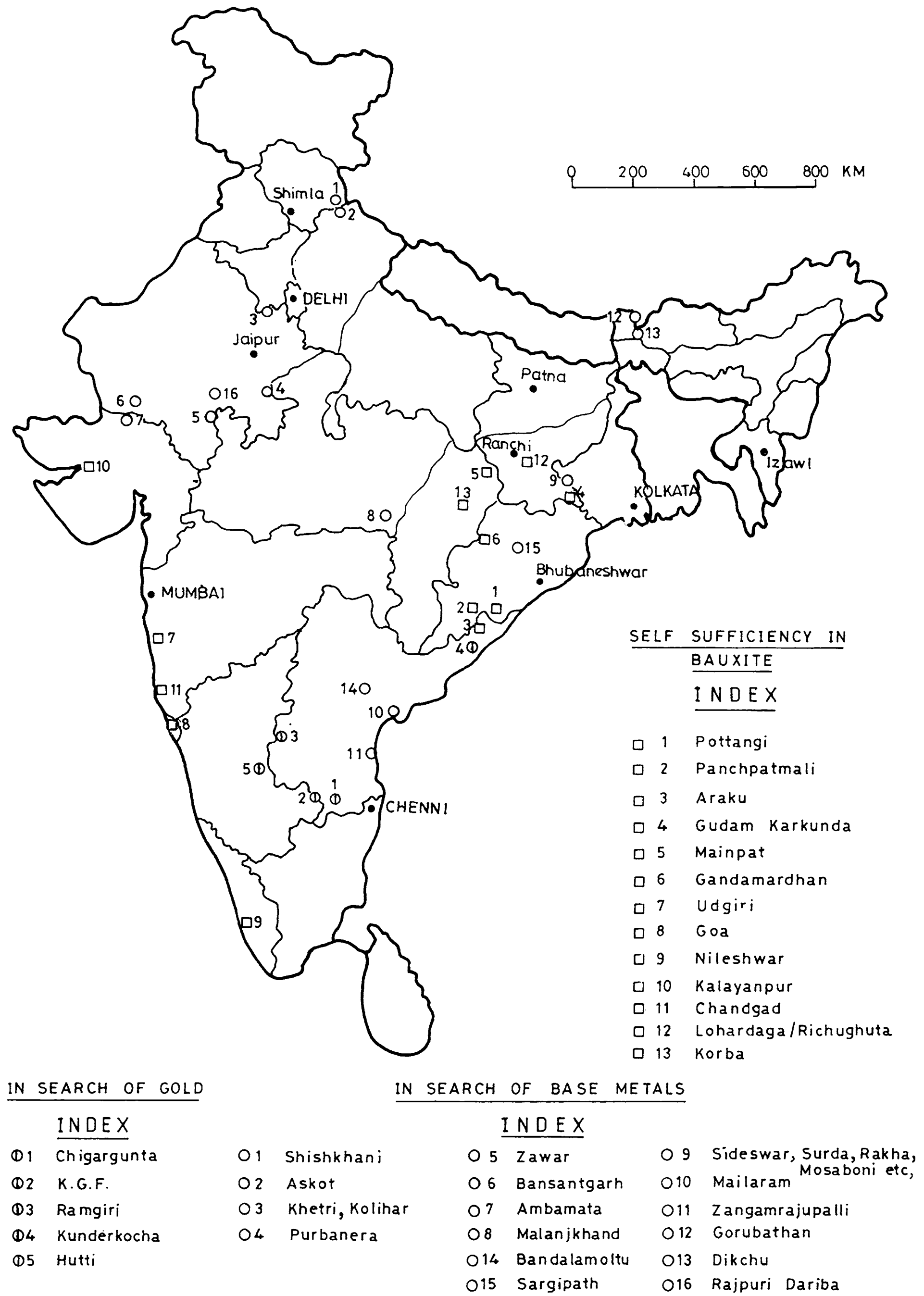


*Figure 1.* Indian mineral deposits suitable for small-scale mining.

malaria and other diseases. As a migrating form of mining it can contribute land degradation and deforestation. The adjacent traditional small-scale mining category represents the registered and licensed non-mechanized or semi-mechanized mines, operated on a regular schedule by organized society members or entrepreneurs with the use of hired labors. Principal constraints faced by this category include lack of professional skills and capital required for the mine planning, pre-production development, and mechanization. As a result, operations are usually limited to the shallow parts of deposits mines and productivity is low.

Advanced small-scale mining encompasses the small mineral properties using sophisticated mining and processing techniques based on professional expertise and state-of-the-art engineering Design (Ghose 1997a). Mines of this category play an important role in the mining sector, particularly in the field of industrial and construction materials. Operations are frequently privately owned, highly competitive, superior to large mines in terms of financial performance. Market orientation and continuous research and innovation, together with enterprising spirit of the owners and engagement of skilled employees, are the key success factors. Members of this category provide the most valuable evidence of ways and means for successful small-scale mining. Necessarily, the classification of practices discussed is a simplification of realities and it is obvious that numerous mines exist in the transitional areas are between the categories. The number of mines using or on the way to introducing advanced mining techniques is growing steadily. While these operations are largely competitive without out side assistance, both micro mining and traditional small-scale mining will require supportive policies and programmes to improve working conditions and performance.

## 5. Indian policy on small-scale mining

This sector in India does not find any appropriate place in policy statement. India has, however, a very special place for small-scale industries (SSI) but no such place for SSM (Anon, 2000) and SSM is not considered as an industry for examining any benefit from the long least meant for SSI. In a way it is a neglected sector in Indian economy. This apparent neglect, without guidance and support, led the SSM sector to be developed so far in a haphazard manner. Although mineral wealth rests with the state government, the subject of regulation of Mines and Mineral Development is covered by the constitution of India. By virtue of this, the parliament has exclusive powers to make rules with respect to regulation of Mines and Mineral Development Rule making powers in respect of Minor Minerals had been delegated to the state governments under section 15 F of the Mines and Minerals (Regulation and Development) Act 1957. So, different states have framed rules under this provision. Mineral rights are granted in three ways: leases, quarry licenses and permits.

The Industrial Policy Resolutions of 1948 and 1956 recognized the important role of small-scale mining in Indian economy. A significant aspect of this resolution was that it did not place any hindrance on the operation of small mines by privately owned enterprise even for those minerals for which large-scale operation was envisaged through the public sector. The problem of small-scale mining has since been taken into consideration in the recently declared National Mineral Policy 1994. In paragraph 7.12 of the document, it is stated that small-scale mining with modest demand on capital expenditure and short lead-time provides employment opportunities for the local population. Efforts will be made to promote small-scale mining of small deposits in a scientific and efficient manner while safeguarding vital environmental and ecological imperatives. It further states that preference should be given to scheduled tribes for mineral concessions for small deposits in scheduled areas. As regards size of operation, paragraph 7.2 of the Mineral Policy emphasizes conservation and development of scientific methods and states that tenure, size, shape, disposition with reference to geological boundaries, and other conditions should be such as to favorably predispose the lease areas to systematic and complete extraction of minerals. The issue of environmental management industry was adequately addressed (Ghose, 2001).

For a major group of small mines covering minor minerals like building stones and sands, special provision has been made in the Mineral Conservation and Development Rules (MCDR) 1957 to relax the statutory qualification. The recently amended MCDR 1993 provides for systematic planning of this deposit through mining plan, and leaves implementation to those with lesser qualifications. In the mines, Act 1952, mines which do not go below the superjacent ground, opencast workings, where explosives are not used, opencast working which does not extend more than 6 m below the ground and mines, which do not employ more than 20 persons per day are not considered under the purview of the Act. While the mineral policy decision clearly advocates leasing to local tribal, it is an accepted fact that statutory provisions are generally complicated in language and operations and need a good understanding of the implications of law. Most of the scheduled tribes for whose benefit the mineral policy resolution has been taken will not be able to follow these provisions. As against these the provisions of all laws are not applicable in every case and depend on the location and extent of deposit. Qualified experts can prepare a systematic mining plan encompassing conservation, development, environment, and safety aspects. The local people through the persons experienced in mining can implement the annual action plan. Relaxation of legal provisions can be sought and granted by the statutory authority under the existing provisions of MCDR 1993 what is needed is an agency of government to help them get the lease through a single-window system. The Government of Gujarat has taken steps in this direction through the Department of Industry after setting up an Industrial Extension Bureau.

### 5.1. Role of the Government

While there is a delicate balance to be achieved between control and encouragement, the provision of a legislative and regulatory framework, which generates stability in the sector, will make it easier to improve the safety and health in small-scale mines, reduce wage exploitation, and improve working conditions. It is no less important that if technical and management expertise is improved and that conditions, which encourage open sales of the products are in place. Government has an important role to play in providing training opportunities and in ensuring that safety and health regulations are appropriate and are observed.

A developing country like India will be required to strive for industrial development. This will call for an increased production of minerals with due regard to safety, conservation and environmental management (Ghose, 1997b). States, being the first owner of the property and being the receiver of the 'royalty' and 'dead rent' should enter into an agreement with the entrepreneur, before the commencement of the mineral property development, on the following basic principles:

- Easiness in processing and timely granting of the mining lease.
- Assurance from the developer/entrepreneur through regional environmental impact assessment (EIA) and environmental management plan (EMP) for cluster of mines in the area, that the development will not pose a threat of irreparable environmental damage (Sen and Ghose, 1997a, b).
- Keeping provision of services as basic facilities such as approach road, power, water, community market etc, where a large number of small-mines are expected to come up, without over-legislating basic educational facilities (a minimum of high school level) should be available nearby, where the mineral properties are located.
- Opportunities should be given to local people, which is very important after all the local people will be on the land for time immemorial.
- There should be provision for direct employment-oriented training and widest possible opportunity of employment for such trained local people.
- Opportunity should be created for the development of small-scale ancillary industries surrounding the project.
- Emphasis should be given on the development of rurally located mineral resources this in turn, means the development of the rural area, which directly contributes to the development of rural economy, a responsibility of the state.

There is a need to educate the mine owner and workers and the statutory authorities may consider arranging free dialogue/workshops with them so that legal provisions are appreciated. This will go a long way in better observation of rules particularly by small mine owners. The training programme focuses on strengthening capacities for a participatory process in decision-making in order to provide incentives for local initiatives and enhance local management capacity; the strategy envisioned is to focus on specific problem in mineral resources management and capitalize on the existing databases, maps, and environmental and socio-economic studies that are available.

The specific training objectives should be:

- To provide the necessary tools techniques and methods that will assist local and national agencies in the assessment of environmental and socio-economic impacts of alternative strategies of resource management, and enable other interests, including, in particular, local communities, to formulate their concerns in way that can be integrated into the decision making process.

- To provide training in the application of management tools.

An adequate training infrastructure should also be created so that an integral aspect of eco-friendly mining should be covered.

Following task force should be implemented in a sequential manner for sustainable development of artisanal mining areas.

- To constitute a committee/working group of administrative personnel with delegative powers to remove the bottlenecks of policy (for example, demarcation of the forestland, Panchayat land & mining lease area etc.) and social issues (such as alternate employment and its potential).
- To constitute a task force of local people for creating awareness about advantages of environmental preservation and encouraging them to enlighten others. (NGO may call for this task).
- Regional mapping of the area and preparation of the location plans for each and every pit (area wise and zone wise).
- Preparation of Regional Environmental Management Plan (carrying capacity studies) for cluster of mines in an area by a scientific organization and work out the modules for environmental protection (Kundu and Ghose, 1994, 1997).
- Inviting experts/expert organization for solution to various problems identified in earlier steps periodically and as a regular practice.

Implementation and adoption of suggestions into actual practices and fix strategy for future course of action.

## 6. New configuration of small-scale mining

There is a need to ensure the existence of an adequate economic and social infrastructure at the remote sites where small-scale mining is often carried out. In this regard, Government has to establish special small-scale mining agencies in order to create the means to commercialize and legalize artisanal mine production and to raise living standards and employment opportunities in rural areas (Ghose, 1994). The creation of mining cooperatives has been one of the more successful ways in stimulating small-scale mining. Cooperatives have two significant advantages over individual mining activity. Through their greater financial power and long-term viability, they have made easier access to mining and processing equipment (Ghose, 1991). Encouraging the creation of central processing and transport facilities, including through cooperatives would help informal mining operations to be more efficient and productive. In the recent past, the role of minerals and metals in economic development in India has received much attention (Ghose, 1986, 1990b). The economic viability of the small-scale sector depends upon its ability to produce cost-effectively and market the products either in the local economy or for export. The need to strengthen the technological capacity is thus inescapable and for each breed of small-scale mining activity, be in the micro-scale family-owned mining operation or the more traditional mining activity on the small-scale, appropriate technological inputs have to be identified and deposit-specific models of small-scale mining have to be developed.

It would be desirable to expand the philosophy of the new technological configuration by considering a hypothetical example from India. Currently, a small gold rush is on at Bandwan Block in South Purulia district of the state of West Bengal, where extensive gold panning operations have been undertaken along the river valleys to Totko, Jamuna, Kumari, and Sona, by an estimated work force of 2000. The gold miners earn a pittance of about Rs. 20 per day (less than a half of one U.S. Dollar) and eke out a miserable existence. However, if a group of workers could be provided with such simple hand concentrators like the Mighty Miner (marketed by David Mathieson & Associates Pvt. Ltd., of Australia and priced at U.S. $500), which uses a 44 gallon drum and special sieves, the throughput could be increased to 3 t per day or more, with improved recovery of micro fine gold and concomitant higher earnings. For example, one could use the Prospector (from Goldfield Engineering, Provo, USA, which can wash 2–4 yards per hour) or a heavier transportable gold washing plant (for example, Alaskan Models 10, 25, and 35 manufactured by the same company which may cost US$ 12,000–30,000) as the operation gets organized either with an entrepreneur or a cooperative which can raise appropriate capital.

Essentially, therefore, the search for a new configuration converges on raising the production through simple aids, to partial and finally to full mechanization appropriate to the scale of operations. There is a need for tools and artifacts and modules of mechanized equipment complement, which should be simple, maintenance-free, and at the same time environment-friendly. For each level of small-scale operation, one must identify the appropriate technology, the criteria for which have been discussed by McDivitt (1990). At the other end of the spectrum, the new configuration will seek to promote reasonably capital-intensive but environmentally compatible mining systems, which could exploit small deposit through mining 'circus' in a mineralized district. The industrial minerals sector could rightly be targeted for a massive input of such new technological options for small-scale but profitable operations. In the case of stones particularly, significant quantities will continue to be required for aiding the development process in most developing countries. We may be witnessing the emergence of a new stone age as construction material consumption has now reached a level of over 10 tonnes per capita in developed countries and some 1–2 tonnes per capita in developing countries. Be it as a basic raw material like limestone or dolomite, construction stone, crushed aggregate, or dimension stone, the sheer volume of the operations calls for major technological inputs in appropriate technological modules. The material, after being quarried, needs to be trimmed to specified sizes and shapes, which as a downstream processing operation can also provide a basis for employment. Stone extraction and processing, which hitherto had a local rather than an international image, has undergone a sea change with the rising demand of high unit value dimension stone. The reassessment of stone extraction technology has currently focused on energy considerations and environment-friendliness and whether in the quarry or in the processing plant, new types of rock splitters, new extraction technology using expansive cements, and improved rock-breaking devices must increasingly find use.

The transition to new technological modules in the small-scale sector should be matched by appropriate and supportive promotional policies, legislation, and technical and processing services. The new configuration, or even 'cosmetic' changes, can only be possible trough a massive organized effort on the part of organizations, which will focus on financing, technical services, and administrative and environmental control. The use of machinery pool and of regional processing facilities is also envisaged. An organized small-scale mining sector may be better able to take advantage of the opportunity.

Therefore, the new configuration of small-scale mining in developing countries will lead to a metamorphosis of the 'do-it-yourself' type of artisanal mining. Given an enabling environment with increasing intervention of State and non-government organizations, an organized sector with much greater input of technology may emerge viable, self-reliant, and better able to move up the gradient from artisanal to high-tech mining. Using deposit-specific and mineral-specific exploitation plans and environmental control measures, we can foresee increasing proliferation of such small-scale mining activity, supported by promotional policies of the state.

The attributes of the modular mining systems for small-scale operations should include:

1. Appropriateness to the level of operations, including skills profile of the workers, low maintenance requirements, and user-friendliness;
2. Low energy requirements, preferably using regenerative energy supply; and
3. Mobility or transportability for use in different mine sites.

A wide range of modular systems could be envisaged, but the focus must primarily be on cost-effectiveness and environmental compatibility.

For the dimension stone industry, for instance, one could adopt the rock mass, subdividing the blocks into smaller blocks, equating by dress drilling, and finally squaring the blocks for customer requirements. A range of methods – from expansive cements to flame jet cutting – could be conceived for each scale of operation. For the new configuration of ore mines, one could select appropriate capacity of caravan mills, which are essentially reassembled concentrating plants on trailers. Such compact, easily transported units for crushing, grinding, separation, dewatering, and power supply can serve for a group of small-scale operations in a mining region (e.g., Sala Caravan Mill).

## 7. Need for technology diffusion-road to survival

Major barriers to technological inputs, especially of incremental innovations, in the small-scale mining sector are the problems of technology diffusion and resistance to change. The progression from any incremental technological change to innovative systems and then on to the stage of imitation or diffusion can be painstakingly slow for lack of effective communication and exchange of ideas in the small-scale sector. While a technology can improve and develop during the diffusion process itself, in the small-scale mining environment for any new technology to be successful, it has first to be implemented and then learnt by use (Ghose, 1997a). Another impediment is that any equipment or technique is exploitable if and only if the recipient has attained a certain technological level. Infusion of new technology in the small-scale mining sector will call therefore for a major effort at training in specific fields, the key concept being that of learning. The major effort at training in specific fields, the key concept being that of learning. The major difference between technological systems in the developed and developing world relates to the very different manpower, training, work ethic, and employment traditions. For the rapid implementation of new techniques for the new configuration of the small-scale mining sector, emphasis on involvement and attitudinal change will be necessary.

Thus it is obvious that irrespective of location, size and type of the mine, there is much scope of application of science and technology for techno-economic improvement of Indian small-scale mining sector to be more self-reliant, economically viable, and sustainable. There is a wrong notion that application of any technology is always a capital-intensive affair (Rathore et al., 2000). On the contrary, a technology is said to be successful only when it suits to a given condition and yields positive economic result. In Indian socio-economic perspective it would be irrational to think of high-tech capital intensive small mining ventures like those in advanced countries, e.g. Ankele opencast dolomite mine in Finland, a highly mechanised mine with automation, produced 82,408 tonnes of mineral in 1989, with only two miners working for 3763 h in the year (Matikainen and Pukkila, 1990). But it would be irrational to plan such mines for Indian system.

Obviously, Indian small mines should basically be a labour-intensive industry, to make use of the huge manpower readily and economically available in the country. Moreover, deployment of larger manpower reduces the capital requirement of any project. In turn, it would promote the regional socio-economic development. At the same time, to optimise the economic benefit of any small-scale mining venture within its given limits of infrastructural facilities and resources, necessary operational support should be provided by appropriate technology. The word appropriate means set apart for a purpose; peculiar; suitable. By appropriate technology we do not identify any particular level of technology. It may be conventional, even primitive, or sophisticated and ultramodern. The only condition of any technology to be appropriate for any given system is its fitfulness to the system and purpose under condition.

While application of conventional and indigenous, but costly machineries may not be appropriate for many Indian small mines, use of sophisticated computer based mine design techniques may be safe, scientific and economic, thus appropriate as well, for planning of those mines by external mine design agencies. For overall improvement of Indian small-scale mining sector, it is very much essential to adopt this philosophy at all levels. It is evident that small-scale mining has much in common with industries such as construction and agriculture. Many of these processes are rather simple and direct, involving earthmoving, breaking and sorting of materials, drainage, water and power supply, and transportation of bulk materials over short distances. So far as gaps in equipment availability are concerned larger and more sophisticated units have presently replaced much of the rather simple equipment, which was used in the past. But, slightly upgraded versions of this early equipment can be of much use in small-scale mining sector even today.

For technological up gradation in Indian small mines through mechanisation, the criteria for equipment to be used or introduced must be in tune with the socio-economic and technological backdrop of the country.

The equipment should

- Require small amounts of capital,
- Emphasise locally available materials,
- Be relatively labour-intensive, but more productive than many traditional technologies,
- Be small enough in scale to be affordable to local groups,
- Be easy to underground, operate and maintain by local people without high-level training,
- Be of simple design to be produced in local workshops,
- Be flexible and adaptable to local circumstances,
- Be in harmony with local needs, traditions and environment,
- Extend human labour and skills rather than replace or eliminate them,
- Place emphasis on self-reliance to meet local needs,
- Minimise the impacts of infrastructure limitations and shortage of trained manpower.

These criteria, emphasising simplicity and self-reliance, are difficult to build into the programme of large organisations but are well suited to projects carried out by small groups.

## 8. Environmental management

In developing countries like India, small-scale mine owners generally do not have the technical or financial capabilities for proper exploitation, mining development, mineral extraction, or processing. They are also often lacking in sufficient mechanical equipment and adequate maintenance facilities. Safety, health and environmental protection are rudimentary at best, and mine owners usually do not receive near-market places for their products. At the same time, however, small-scale mining can be highly inefficient. Poor working conditions, problems with safety and health and environmental degradation are rampant in prospective mining regions. Much small-scale mining activity is also carried out illegally and is thus difficult to monitor and control. India, however, is not a unique case, as it is a well-known fact that most small-scale mining adversely impacts the environment. Several countries have adopted different strategies for tackling pressing environmental problems in the industry. The following sections describe how India is working to address some of the aforementioned impacts.

It is mandatory to draft an environmental management plan (EMP) before commencing such projects in India (Ghose, 2001). The socioeconomic environment has been considered as one of the most important parameters in an EMP report and even international funding agencies like World Bank emphasize on it (Ghose and Lal, 1998, 2001). A number of NGOs are also working in this sector and coordination is being made with social experts and technocrats. An EMP helps to ensure that the potential environmental impacts of a project are assessed and incorporated into the early stages of development planning. The procedure of preparing an EMP has been accepted as a statutory requirement for granting a permit from the environmental angle (Ghose, 1997b). In India, the Public Investment Board requires an environmental clearance from the Department of Environment (DOE), Ministry of Environment and Forests, Govt. of India, for sanction for funding for all major projects. All such mining projects need to be cleared by DOE to ensure that effective safeguards are in place to prevent environmental hazards (Sen and Ghose, 1997a, b). DOE has issued guidelines for the preparation of an EMP report for mining projects. Finally, the Environmental Appraisal Committee for mining project (EAC-M) formed by DOE examines the EMP report before granting clearance for the project.

The application of efficient pollution control technology is an important means for controlling environmental impacts; sound management, however, must support technology to increase its efficacy (Ghose and Kumar, 1997). An EMP report describes the pre-project environmental scenario, making specific reference to socio-economic profile, land use pattern, and environmental quality with respect to air, meteorology, water, noise, soil, flora, and fauna. Socio-economic impact, land oustees, effect on flora and fauna, solid waste management, the impact of water pollution, and noise pollution are discussed in the report. More specifically, it addresses the following:

(i) Land acquisition area,
(ii) Land required for rehabilitation of the land oustees,
(iii) Item-wise details of the rehabilitation package,
(iv) Number of families to be rehabilitated,
(v) Land required for compensatory afforestation and amount provided,
(vi) Value of compensation for existing forest wealth to be paid to the Forest Department,
(vii) Amount provided for compensatory afforestation,
(viii) Capital provision for land reclamation,
(ix) Capital provided for other environmental protection and antipollution measures at mine site,
(x) Capital provision for biological reclamation,
(xi) Provision for antipollution measures in township area,
(xii) Organization for environmental and rehabilitation work,
(xiii) Manpower for environmental control and rehabilitation work,
(xiv) Recurring expenditure for environmental control and reclamation work.

As per DOE, it is also obligatory on the part of a mine, either new or old, to prepare an EMP and to get sanctioned, which is why it includes the following four important aspects.

(i) Description of premining (existing) environmental setting in the core zone and buffer zone of 10 km radius.
(ii) Identification and prediction of potential impacts due to the project.
(iii) Evaluation of significant impacts.
(iv) Mitigation measures to minimize the detrimental effects of negative impacts.

Existing environmental settings within the study area are determined through field survey, census reports and other secondary sources. For some of the attributes (air, water, noise and soil), continuous monitoring is carried out (Kundu and Ghose, 1994, 1997). Predicted impacts are expressed in appropriate units, to gain an aggregated picture of the predicted impact of a project. An evaluation of the predicted impact is carried out using a Matrix Methodology, which depicts the causes and effects of environmental attributes. It also helps to identify the environmental impacts of various activities. The magnitude and the importance of the cause- effect interaction in the Matrix is decided subjectively on the lines set by the Environmental Evaluation System (EES).

For effective implementation of an EMP, a mid-term corrective measure is essential, such as a time bound action plan. This includes a programme for land reclamation, afforestation, mine water treatment, surface drainage and check dams, and sewage treatment. A separate department is established to evaluate the performance of the programme. It specially monitors pollution control equipment, emissions from sources, and the quality of the surrounding environment. The programme also includes the safety measures inside the project and horticulture cell for the development of green belts and afforestation. For this purpose, a multi-disciplinary task force is formed that undertakes the following tasks:

(i) Environmental data generation.
(ii) Evolving environmental management plan for the project in close collaboration with other agencies and consultants.
(iii) Monitoring of project implementation from the environmental angle including rehabilitation and compensation.
(iv) Creation and maintenance of nursery for timely supply of sapling for afforestation.
(v) Coordination with other project activities to ensure early implementation of the project.
(vi) Coordination with the Department of Environment, Central/State Pollution Control Board.

The responsibility to improve environmental management rests with the Project Officer of the project. As far as air, water, noise and soil pollution control measures are concerned, samples are collected and tested at strategic places covering all four seasons. The implementing authority is guided and advised as per the feedback data received from the laboratories.

Presently all the new mining projects and those undergoing reorganization and reconstruction involving more than 5 hectare of land are required to take environmental clearance from the Central Government. The policy relating to the promotion of environmental improvement, hence, cleaner production in small-scale mining sector in India is governed by the respective State Government, where is done. The mineral (environmental) policies do not vary from state to state. As all the states in India are working under the umbrella of the National Policy, there is no basic difference of environmental legislations from one state to the other. The policy formulated by the Central Government is to be implemented by the respective State Government.

## 9. Conclusion

India will be required to strive for with the increased production of minerals. Small-scale mining provides a wealth of socio-economic benefits to the rural inhabitants of India, generate employment, income, fit in well with the existing infrastructure, and can act as resistant urban migration. It also makes a significant contribution to development objectives but there is no nationally accepted criterion for this. This paper identifies that this sector is still considered as an unorganized sector and does not find place in the policy statement of the Government. The socio-economic significance of operations is often overlooked. There is a need to ensure the existence of economic and social benefit. The creation of mining cooperatives can be one of the more successful ways in stimulating small-scale mining. There is a need to educate mine owners and workers with establishment of a mining centre consisting of shared mining and processing facilities plus a practical mining advisory service. Thus, the operations, which make an essential contribution to economic growth and social benefit, need to be integrated fully into their respective economics.

## 10. Recommendations

1. In order to be prosperous and safe, small-scale mining needs to be raised from being an unorganized unsupervised industry to one that is modernized, monitored and organized, and supported so that specific goals can be set and met.
2. The tax regime and the conditions of purchase of mine output can be very important. The involvement of government in purchasing arrangements, plus the means to ensure for the deposit of material for sale, can not only reduced illegal dealings, but also stimulated additional mining activity to the lasting of national economics.
3. The second step to be undertaken by the government to provide social and technical assistance. This can often be easier in case of mining cooperatives

than for individual or small groups of miners who are widely dispersed geographically.
4. The presence of regional assay office can help the miners to determine a viable search strategy.
5. India has to establish mining centres consisting of shared mining and processing facilities plus a practical mining advisory service, which would provide information, and training.
6. Small-scale mine workers in the region would obtain free technical advise from the resident mining engineers, the use of drilling and blasting services, access to a custom milling plant to process ore at a competitive price. One major factor that can inhibit the successful economic development of small-scale mines is the economic processing of the ore.
7. Artisanal miners need to receive technical training and advice on the assessment of the ore grades and on mining practices so that the output the processable mineral can be increased.
8. Another important task of the government is to create the geological base necessary to provide small-scale miners with information to assist their prospecting. This includes the need to train the miners in prospecting techniques.

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