CONSERVATION OF NON-RENEWABLE RESOURCES IN INDIA*

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Capital formation is the forerunner of the structural transformation of an under-developed country (Cairncross, A.K., 1953). Capital formation involves the establishment of heavy and basic industries that form the foundation on which the economy grows (Mathur G., 1965). With the economy, grows the domestic demand for natural resource inputs, including the demand for non-renewable resources (NRRs), i.e. crude petroleum and minerals. This is because oil and minerals form the bedrock of industrialisation. NRR inputs go into the production of goods in the heavy, basic and light sectors. Hence, as these sectors grows, the demand for NRRs also grows.

As NRRs are exploited, mines get depleted, and become uneconomic or even exhausted. The present pattern of development has been considered to be highly NRR intensive, and is leading to the rapid depletion of non-renewable resources (Meadows et al, 1972). Since petroleum and minerals are not renewable, it is necessary to conserve them and to ensure their sustainable use, so that their stock is not completely exhausted, and is available for future generations as well. Sustainable development requires that natural resources be conserved for future generations, and a pattern of development be evolved that will be resource-saving (Brundtland, 1987).

The Framework of the Study

This paper examines the need for conservation of NRRs in India, the sources of the demand for NRRs and attempts to provide insights for a conservationist strategy. Non-renewable resources (NRRs) are defined for the purpose of this study as: coal and lignite, crude petroleum and natural gas, iron ore, other metallic minerals, and non-metallic and minor minerals.[1] All NRRs are valued at 1989-90 prices, and aggregated.

This study is developed in six sections.

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*Based on a paper presented at the Fifteenth Annual Conference Of Andhra Pradesh Economic Association held at Osmania University between 14-15 December, 1996 jointly by Dr. Rahul A. Shastri, Dr. A.G. Moss, and Dr. Prabha Panth.

Section I examines the need for conservation of NRRs in India, utilising data drawn from CMIE, World Resources 1994-95, and the Limits to Growth 1972.

Section II analyses the demand for NRR inputs by types of final expenditure, utilising the 60 sector input output table prepared by the CSO (1989-90). Final Expenditure is defined here as: Private Consumption, Exports, Gross Final Investment, Public Consumption and Changes in Stocks.[2]

Section III brings out the importance of Imports as a conservationist device in India.

Conservationist strategies can be technical or economic. Technical strategies rely on invention, innovation and organisational improvements that aim at increasing the efficiency in the use of NRRs. Such strategies would have a higher pay off if they focus on sectors that account for a large share of the total NRRs consumed. Section IV attempts to identify such sectors.

Economic strategies to conserve NRR aim at reallocating final expenditure from NRR intensive goods/sectors to NRR-light goods/sectors. However, the sectoral pattern of investment expenditure and changes in stocks may be bound by technical and organisational considerations. Similarly, the sectoral pattern of public consumption may be determined by political and administrative compulsions, and consequently may be inflexible. On the other hand the sectoral pattern of exports and private consumption may be less rigid, and more amenable to change. It may be expected that the sectoral pattern of private consumption and exports may be altered at the margin by changes in fiscal and export policies. Hence, it may be useful to analyse the NRR intensities of sectoral private consumption expenditure and exports in order to identify priority areas for conservationist efforts. This is attempted in Section V.

Section VI summarises the results and concludes.

The Need for Conservation

Table-1 presents data on the important mineral resources in India, the rate of growth of their utilisation, and their expected life span. The data is drawn from CMIE (1992-93) World Resources (1994-95) and the Limits to Growth (1972).

It is evident from the table (col. 1) that India has a very small proportion of world mineral resources with the exception of coal and lignite. In fact, mineral availability in India is considerably lower than even India's share in the

world's land surface which is 2.3%. India's mineral reserve share ranges from 0.05% to 0.52%. The sole exception is coal and lignite (6.7%). However, most of the coal reserves are of low quality and the reserves of coking coal are limited.

It also appears that the growth of utilisation of the limited mineral reserves has been very high. (col 2). With the exception of manganese ore, the rate of growth of production of minerals generally ranges from about 2 to 5 times the "Hindu rate of growth". Thus it is evident that the growth of utilisation of mineral reserves is several times faster than the growth of GNP (estimated at 1.9%, 1965-90 CMIE) in India.

The estimated life span of the Indian mineral resources based on the 1996-97 levels of use (CMIE, 1993) are presented in col. 3 of Table-1. It is evident that the balance life of the reserves ranges from 16 to 678 years if their rates of use remain frozen at the 1996 level.

TABLE - 1

Production, Reserves and Reserve Index of Major Minerals.

Mineral	% of World reserves [a] (1950-91)(*r*)[a]	Growth rate of Prodn. in India [g]	Static Reserve Index (*s*), yrs.	Exponential Reserve Index (*e*)	
				India, yrs.	Exponential Reserve World[b], yrs.
	1	2	3	4	5
1. Iron Ore:	0.05%	7.4%	135	32	136
2. Coal & Lignite	6.70%	6.6%	56[d]	22[d]	125[c]
3. Crude Oil	0.06%	12.0%	16	9	25[c]
4. Natural Gas (Bn.Cu.M)	0.05%	15.5%	23	10	-
5. Bauxite	0.09%	10.8%	281	32	78
6. Manganese Ore		1.1%	36	36	69[c]
7. Copper Ore	0.5%	6.6%	64	25	17
8. Chromite		10.4%	51	18	130[c]
9. Lead & Zinc		11.4%	38[f]	15	37
10. Lime-stone		8.8%	678	47	-

[a] Source: CMIE, 1992, 1993.; [b] Source: World Resources (1994-95), [c] Exp. Index calculated for five times the world reserves in 1970, Limits to Growth (1972) ; [d] coking coal only; [f] lead alone has a life of 14 yrs. [g] Balance life at 1996-97 level of production, CMIE, 1992.

However, the rates of use of mineral reserves are unlikely to remain frozen at the 1996 level. The exponential index of their life span (col. 4) allows for the exponential growth of their use based on the formula (Limits to Growth, 1972) :

$$e = ln\{(r \times s) + 1\}/r$$

where e = exponential reserve index.

r = average annual rate of growth.

s = static reserve index.

Our estimates show that at the past rates of growth, the Indian mineral and oil reserves may have a much shorter life span ranging from 9 to 47 years. The shortest exponential life index is that of crude oil which is estimated to be only 9 years.

However, Indian NRR reserves do not present an absolute limit to growth because NRRs can be imported. Owing to this possibility, col. 5 of the table presents the exponential reserve index of the world mineral reserves. These estimates are based on data drawn from World Resources (1995-96). Where the relevant data was not available, the gaps have been plugged with the estimates of the exponential reserve index calculated at 5 times the known reserves in 1970, prepared by the Club of Rome Report. Col. 5 of the table shows that the life span of the world reserves ranges from 25 years to 136, and is generally higher than the Indian reserves. Thus, even after the exhaustion of domestic reserves, Indian economic growth can continue to be supported for some more decades by imports of minerals and oil.

Our analysis suggests the following conclusions:

(a) The utilisation of domestic mineral and oil reserves has grown several times faster than the GNP.

(b) At this rate of growth, the Indian NRR reserves may be estimated to have a life span ranging from 9 to 47 years.

(c) Even after the exhaustion of domestic reserves, imports can continue to support India's economic growth.

(d) However, even this mode of supporting economic growth may reach its limits between 25 to 136 years.

These limits to growth suggest the need for conservation of non renewable resources like minerals and oil. A viable conservationist strategy calls for an analysis of the demand for NRRs in India.

The Demand for NRR Inputs by Types of Final Expenditure

This section uses the Leontief Inverse to estimate the demand for NRR inputs generated by different types of final expenditure, viz., private and public consumption gross fixed investment, exports and changes in stock. The estimates are based on CSO's input-output tables (1989-90), and the equation.

$$[\mathbf{I} - \mathbf{A}]^{-1}[\mathbf{F}] = [\mathbf{X}] \qquad \ldots \quad (1)$$

TABLE-2

Effect of Types of Final Expenditure on Demand for NRR Inputs (1989-90)

	Pvt.Cons. Exp.	Gr.Fxd. Inv.	Exports	Pub.Cons. Exp.	Changes in Stock	Total Exp.
	1	2	3	4	5	6
1. Share in Total NRRs Demand	45.4%	28.3%	12.0%	8.5%	4.8%	100%
2. Share in Total Expenditure	60.27%	19.0%	7.6%	10.9%	2.0%	100%
3. NRRs Demand/ Final Expenditure	.044	.085	.088	0.45	0.013	0.057

Table-2 analyses the share of different types of final expenditure in NRR demand. As may be seen from row 1, private expenditure accounts for nearly 1/2 of the NRR demand, followed by investment (28.0%), exports (12.0%), public consumption (8.5%) and changes in stock (4.8%). Thus private consumption, investment and exports together account for nearly 86% of the total demand for NRRs in India. Of these, private consumption accounts for the lion's share.

Although private consumption accounts for half of the demand of NRR inputs, it has a low NRR intensity, since its share in the NRR demand is less than its share in final expenditure which is about 60% (Row 2). In contrast, the shares of investment and exports in NRR demand are more than their respective shares in final expenditure. Thus the contribution to NRR demand is not proportional to the share of each type in total final expenditure.

This disproportionality is because of differences in the NRR intensity of each type of final expenditure. Thus, we find that exports and investment expenditure are highly NRR-intensive (Row 3, Cols.2 & 3). One rupee of investment or exports generates on an average, a NRR demand of about 8-9

paise. In contrast, an average rupee of private consumption, generates an NRR demand of about 4 paise only .

Thus, the average NRR intensity of exports and investment is twice that of private consumption. All types of final expenditure together generate an average NRR demand of 6 paise per rupee (Row 3, Col.6).[3]

The total demand for NRR generated by final expenditure in l989-90 was Rs.2695.9 crores. Only a part of this demand was met by domestic production.

III

Imports as a Conservationist Device

India does not have adequate reserves of all minerals, and depends on imports for much of her mineral requirements. Table 3 analyses the contribution of imports and domestic production to meeting of the demand for NRR inputs in l989-90.

Row 1 shows that domestic production accounted for only about 49% of the total NRR demand in that year. The balance of the demand of 51% was met from imports (Row 2). About 35% of the NRR demand was satisfied by directly importing NRRs. The rest - 16%, was met by importing NRR using goods (Rows 3 & 4). Thus, direct NRR imports supply over 1/3 of the domestic demand while indirect NRR imports supply about 1/6 of the domestic demand for NRR inputs. Together, they meet about 1/2 of the total NRR demand in the economy.

Indian imports are clearly a strong conservationist device. Row 5 shows that about 28.4% of the total imports go to conserve NRRs. Even if we consider the imports other than NRRs, we find that their NRR intensity is quite high at 0.11 (Row 6). Thus a rupee of imports other than NRRs, conserves on an average about 11 paise of NRRs, whereas a rupee of exports uses on an average about 9 paise of NRRs. This, suggests that India's foreign trade has a clear conservationist bias.

Whereas, the reliance on imports to conserve Indian NRRs may continue, it is likely to be hamstrung by the foreign exchange constraints faced by the country. For this reason, it is useful to explore other strategies for conservation as well. Broadly speaking, these can be technical or economic.

TABLE-3

Contribution of Imports and Domestic Production of Meeting the Demand for NRR Inputs (1989-90)

1.	NRR Inputs domestically produced/NRR Demand	48.5%
2.	Total NRR Inputs Imported/NRR Demand	51.5%
3.	Direct Imports of NRR Inputs/NRR Demand	35.3%
4.	Indirect NRR Inputs Imports/NRR Demand	16.3%
5.	Total NRR Inputs Imported/Imports	28.4%
6.	Indirect Imports of NRR Inputs/Non NRR Imports	0.111

IV

Technical Conservationism: Sectors Consuming a Large Part of NRRs

The technical approach to conservation relies on innovation and improved organisation to reduce the consumption of NRRs per unit of output produced. Such an approach is likely to have a better pay-off if it concentrates on sectors that consume a large part of NRRs.

Table 4 lists the major consumers of NRRs in India using the data published in the input output table (1989-90) published by the C.S.O. It is evident from the table

TABLE-4

Sectoral Consumption of NRRs/Total NRRs Available*

1	Petroleum Products	38.2%		
2	Construction	13.6%	25.3%	53.5
3	Electricity Etc.	11.2%		
4	Oth. Non Met. Mineral Prod	5.6%		
5	Iron & Steel	5.3%		
6	Coal Tar Products	4.5%	22.8	86%
7	Fertilizers	2.9%		
8	Non Ferrous Metals	2.3%		
9	Cement	2.2%		
10	Other Chemicals	1.3%		
11	Other Services	1.2%		
12	Paper & Paper Products	1.1%		
13	Rail Transport Service	1.1%		
14	Cotton Textiles	1.0%		
	TOTAL	**86.0%**		

*Total NRR available = Gross Output of NRR + Import of NRR - Exports of NRRs.

that 86% of the NRRs available for domestic use, is consumed by 14 sectors only. Of these sectors, petroleum products alone consume nearly 38%. Construction and electricity etc. consume about 25% of the NRRs six other sectors including metal, coal, coal tar, fertilizers, cement, consume about 23%. Thus, 9 sectors account for about 86% of the NRRs consumed in the country.

From the above, it is evident that NRR consumption is highly skewed, with the top three sectors accounting for more than half, and the top nine sectors accounting for 86% of the NRRs consumed in the country. It follows that the technical approach to conservation should focus on the efficiencies of NRR use in these nine sectors.

V

Economic Conservationism: Sectors with Highly NRR Intensive Final Expenditure

Although the remaining 51 sectors may not use NRR inputs directly in significant quantities, they may use NRR consuming inputs. Hence final expenditures in these sectors may be quite NRR intensive, inspite of their not figuring in table 4 above.

An economic approach to conservation would be to encourage reallocation of Final Expenditure from highly NRR-intensive sectors into less NRR-intensive sectors. Any such attempt is likely to encounter techno-economic rigidities that bind final expenditures on investment and changes in stocks, and the institutional pressures that constrain public consumption. In contrast to these, the sectoral patterns of private consumption expenditures and exports may be less rigid. It may therefore be useful to look at the NRRs-intensities of the sectors catering to private consumption and exports.

NRRs Intensity of Sectors Catering to Private Consumption

Table 5 presents estimates of NRR-intensity of the subsectors that cater to private consumption expenditure. NRR intensity of a sector is the ratio of the NRR demand generated directly or indirectly by final expenditure in that sector, to the final expenditure in that sector.

It can be seen from the table that private consumption is confined to 36 out of the 60 sectors in the economy. The average NRR input demand generated per rupee of private consumption expenditure is about 4.4 paise. Table 5 shows that 20 of the sectors accounting for about 30% of the private consumption have a higher than average NRR-input intensity. Seven of these NRRs-intensive sectors have a substantial share in private consumption ($\geq$1.5%). The shares of these seven sectors have been Italicised in the table.

Table 5 also shows that 16 sectors accounting for nearly 70% of private consumption have a lower than average NRR-intensity.

Table 5.

NRRs input Intensities in sector Catering to Private Consumption

Average NRR Input Intensity Of Pvt. Consumption Expenditure			***0.044***
S.No.	Sector	NRRs Intensity	Share In Private Consumption
1	Petroleum Products	0.558	***1.5%***
2	Oth. Non Met. Mineral Prod	0.236	0.5%
3	Electricity Etc.	0.197	0.6%
4	Paper&Paper Products	0.092	0.4%
5	Rail Transport Service	0.090	1.2%
6	Other Chemicals	0.081	***2.3%***
7	Other Transport Service	0.078	***4.9%***
8	Motor Vehicles	0.075	0.1%
9	Khandsari Boora	0.070	0.2%
10	Cotton Textiles	0.068	***5.1%***
11	Electrical Machinary	0.066	0.2%
12	Oth. Manufacturing	0.065	1.2%
13	Hydrogenated Oil	0.064	0.6%
14	Art Silk & Synth.Fibre	0.062	***3.7%***
15	Wheat	0.056	***4.0%***
16	Sugar	0.049	1.9%
17	Plastic Products	0.049	0.1%
18	Rubber Products	0.046	0.4%
19	Oth.Transport Equip.	0.046	0.3%
20	Woollen Textile	0.046	0.4%
	Total Share Of NRR Intensive Sectors		***29.5%***
21	Paddy	0.038	8.8%
22	Other Textile	0.036	2.3%
23	Oth. Food & Beverage Ind.	0.036	6.9%
24	Other Cereals	0.035	2.4%
25	Electronic Equipment	0.031	0.4%
26	Sugarcane	0.031	1.1%
27	Leather& Leather Prod.	0.030	0.4%
28	Other Crops	0.021	7.3%
29	Pulses	0.018	2.2%
30	Wood & Wood Products	0.017	0.1%
31	Other Services	0.014	17.0%
32	Animal Husbandry	0.011	9.6%
33	Trade	0.011	8.5%
34	Communication	0.009	0.7%
35	Forestry & Logging	0.007	1.6%
36	Fishing	0.007	1.0%
	Total Share of NRR Light Sectors		***70.4%***

A conservationist reallocation of private consumption expenditure would have to focus on these twenty three (7 + 16) sectors. Obviously, since the products of these sectors are not technical substitutes, the shift in the expenditures between these sectors can only be marginal and not total. Moreover, the efficacy of fiscal and price policies in achieving such a reallocation would also depend upon the price elasticities of demand for the products of these sectors. The analysis of price elasticities of demand however, falls outside the scope of the present paper.

NRRs Intensities of Sectors Catering to Exports

Table 6 (overleaf) presents estimates of NRR-intensities of sectors catering to exports. It can be seen from the Table that 41 of the 60 sectors cater to export demand. The average NRRs input demand generated per rupee of exports is about 8.8 paise, the highest among all types of final expenditure.

The Table-6 shows that only 11 of the 41 sectors are NRR-intensive, with more than the average NRR-intensity. Together, they account for only 1/5 of the exports. Of these eleven sectors, Other Non-metallic Mineral Products alone account for 13% of the total exports. Petroleum Products is the other important export.

In spite of their small share in exports, the NRR intensive sectors pull up the average NRR intensity of exports because they have a very high NRR demand generated per rupee of final output. Thus, for instance, they include sectors producing minerals whose NRR intensity is more than one. This is because a rupee of final expenditure in these sectors represents a rupee demand for NRRs directly, and about 3-7 paise of demand for NRRs indirectly (see S.Nos.1-3, Table 6). Apart from these sectors, petroleum products and metallic products which have a very high NRR-intensity, also contribute to pulling up the average NRR-intensity of exports.

It is interesting to see that most of the export sectors with a high NRR-intensity are minerals, mineral based metal products, petroleum or pertoleum based products.

Table 6 also shows that 30 of the 41 export sectors are NRR light. Together they account for 4/5 of the exports.

A conservationist approach to export promotion would have to consider a movement away from minerals, mineral based metal products, petroleum or petroleum product based sectors and towards the large number of NRR-light sectors.

Table 6

NRRs input Intensities in Sector Catering to Exports

S.No.	Sector	NRR Intensity	Sectoral Share In Exports
Average NRR Input Intensity of Exports			***0.088***
1	Iron Ore	1.069	0.7%
2	Other Metallic Minerals	1.046	0.4%
3	Non-met. & Minor Minerals	1.029	0.2%
4	Petroleum Products	0.558	1.4%
5	Non-ferrous Metals	0.255	0.25
6	Other Non-met. Mineral Prodn.	0.236	***13.1%***
7	Iron and Steel	0.178	0.6%
8	Machine Tools	0.102	0.6%
9	Synthetic Fibre & Resin	0.099	0.2%
10	Paper and Paper Products	0.092	0.1%
11	Rail Transport Service	0.090	***2.1%***
	Total Share of NRR Intensive Sector	***19.8%***	
12	Other Chemicals	0.081	4.0%
13	Other Transport Service	0.078	6.3%
14	Motor Vehicles	0.075	1.0%
15	Other Non-Electrical Mach.	0.071	2.9%
16	Cotton Textiles	0.068	3.5%
17	Electrical Machinery	0.066	1.4%
18	Other Manufacturing	0.055	2.3%
19	Art Silk and Synthetic Fibre	0.062	1.3%
20	Cotton	0.059	0.3%
21	Jute, Hemp, Mesta Textiles	0.056	0.7%
22	Pesticides	0.056	0.2%
23	Sugar	0.049	0.1%
24	Plastic Products	0.049	0.3%
25	Rubber Products	0.046	1.8%
26	Other Transport Equipment	0.046	0.9%
27	Woollen Textile	0.046	0.1%
28	Paddy	0.038	1.0%
29	Other Textile	0.036	9.6%
30	Other Food & Beverage Ind.	0.036	2.9%
31	Communication Equipment	0.031	0.1%
32	Electrical Equipmment	0.031	1.3%
33	Leather & Leather Products	0.030	4.7%
34	Rail Equipment	0.028	0.1%
35	Coffee	0.022	0.6%
36	Other Crops	0.021	4.3%
37	Other Services	0.014	16.2%
38	Animal Husbandry	0.011	0.3%
39	Trade	0.011	10.4%
40	Communication	0.009	0.2%
41	Fishing	0.007	1.5%
	Total Share of NRR Light Sectors		***80.1%***

Summary

The analysis so far, reveals the following:

a) The consumption of minerals and oil reserves has grown several times faster than the GNP. This has reduced the reserves of several NRRs, and estimated life spans vary from 9 to 47 years.

b) Private consumption expenditure generates half of the demand for NRRs, followed by investment (28%) and exports (12%). However, the NRR intensity of investment expenditure and exports is twice as high as that of private consumption. The average NRR intensity of final expenditure as a whole is about 6 paise per rupee at 1989-90 prices.

c) Imports meet about half of the NRR demand generated in the economy. Direct NRR imports constituted about 28% of the total imports in 1989- 90. The satisfied about 35% of the NRR demand. Other Non-NRR imports meet about 11% of the NRR demand. The NRR intensity of other non-NRR imports is much higher than the NRR intensity of exports, indicating that India's foreign trade has a conservationist bias.

d) NRR consumption is highly skewed with the top three sectors accounting for about half, and the top nine sectors consuming 86% of the NRRs consumed in the economy. These sectors have a claim to priority in any technical conservationist strategy.

e) The NRR intensity of final expenditure is higher than the average in 20 sectors catering to private consumption. Of these twenty, seven sectors are 'large'and account for more than 1.5% of the private consumption expenditure in 1989-90. An economic conservationist strategy would do well to attempt reallocation of final expenditure from these to the sixteen less NRR intensive sectors.

f) A conservationist approach to exports would do well to attempt reallocation of exports from 11 NRR intensive sectors, to the less intensive ones.

Notes

[1] These correspond to sector numbers 15, 16, 17, 18 and 19 in the 60 sector input-output table prepared by CSO (1989-90).

[2] Imports are considered separately in a subsequent section because of their role in conserving NRRs.

[3] The differences in NRR intensities of different types of final expenditure results from the differences in the sectoral pattern of final expenditure and sectoral NRR intensities. Final demand in different sectors generates different NRR demand per rupee of expenditure. Differences in sectoral NRR intensities are examined in a later section.

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