INTER-GENERATIONAL EQUITY: IRON ORE RESOURCES

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ORIGIN OF THE CONCEPT OF INTER-GENERATIONAL EQUITY

Termination of World War II resulted in catapulting economic and social fabric of the people world-wide. Establishment of peace and better health and education facilities and growth in population, particularly in the newly freed colonies, required re-engineering of the manufacturing process. During early sixties "re-engineering" of a company was a fashionable concept. However, in late eighties, a new and more catchy phrase "sustainable" was coined which has since become *sine qua non* for everything that one does or lives with. Its interpretation is as varied as that of "democracy".

2. The World Commission on Environment and Development, popularly known as Brundtland Commission (constituted in 1983), in its report submitted to UN in 1987 defined sustainable development "*to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs*". The Brundtland Commission's definition came out of a scare generated by Club of Rome which in 1956 warned that the rate at which the mineral resources were being exploited, a day was not far when the world will be left without any resources. This scare was repeated in 1974 when the Club of Rome argued that there would be limits to growth based on availability of resources. In the case of mineral resources, it was believed that global depletion of certain resources was imminent within the next few decades.

3. The alarmist attitude of Club of Rome was probably because of the fact that they had not anticipated the phenomenal technological developments. Minerals are elements of nature and are therefore re-cycleable. Today metals are being re-cycled upto 70-80% (more than 70% of the metals used in Europe are

from recycling) and there is also a better and more efficient utilisation of these resources. Over the course of time, the efficiency of usage of metals has increased by a factor of four and subsequently to a factor of ten. New technological developments have since taken place which has put the apprehension of Club of Rome way behind.

4. One therefore need not agree with the alarmist definition given by Brundtland Commission simply for the reason that there cannot be any unbridled exploitation even if one wants to because of limitation of market forces. One can exploit to the extent it is demanded and at an economic price. The myth that the present generation is exploiting resources unmindful of the future generation is not borne out by facts. This sort of thought-process will deprive the present as well as future generations of optimal utilisation of resources. Scientific and technological developments have made today's waste into tomorrow's resources. It may be what we preserve today, the future generation may not require that at all. We cannot envisage what the world will require, let us say, 100 years hence at that level of technological developments. We will therefore be depriving the present generation of the pleasure of utilising the known resources which the future generation may not require.

5. Further, there is constant pressure of environmentalists with regard to carbon emissions and commitments made in Paris Agreement to be achieved by 2030. For example, UK has brought down consumption of coal from as high as 7.7 megatons in December 2005 to 0.7 megatons in October, 2016. Coal output fell to just over 2 million tonnes of oil equivalent in 2016 and accounted for only 10.6% of electricity. Germany has declared its intension to end support for fossil fuels-fed heating systems. Its place is being taken by gas, nuclear and other renewable energy like solar and wind. In India, renewable energy from solar and wind are giving tough competition to fossil fuels like coal and lignite. The wind power is now quoted Rs. 3.46 per unit in recent bids for 250 Mw power

stations which is quite competitive with coal–fired power stations *(Business Standard, New Delhi : 25-02-2017)*. Further, the country is well endowed with bright sun-shine in most part of the year. Solar power tariff in India reached historic low of Rs 2.44 per KwH. In a bidding held for the 500-Mw Bhadla solar power park in Rajasthan, domestic company ACME won the top slot by quoting Rs 2.44 a unit for 200 Mw. It was closely followed by SoftBank Energy with Rs 2.45 for 500 Mw. As the tender followed a bucket-filling method, ACME will build 200 Mw and SBG Energy 300 Mw. The park is being developed by Infrastructure Leasing & Financial Services Ltd. (IL&FS). The rate was lower than the average coal-based price and the grid parity price for solar to match with coal. This rate was closer to spot power price as well *(Business Standard, New Delhi : 13 May, 2017)*. As per the road map developed by scientists more than 70% of the countries in the world – including India, UK, US, or China and other major economies – could run entirely on energy created by wind, water and solar by 2050.

(The Times of India, New Delhi : 25 August, 2017).

6. Until recently, the internal combustion engine has been the main way of powering vehicles on land and at sea for most of the twentieth century. There is now a gradual shift from fuel and piston to lithium-ion battery packs and electric motors. The electrification has thrown the car industry with turmoil. Compared with existing vehicles, electric cars are much simpler and fewer parts. It offers environmental and health benefits and according to America's National Resources Defence Council reduces carbon emissions by 54%.

7. Exxon Mobil, OPEC and Bloomberg have estimated differently electric vehicles sales ranging from 100 millions to 266 and 525 million vehicles respectively by 2040. Britain and France have both said that by that time, new cars reliant on internal combustion engines will be illegal. However, internal

combustion engine is likely to still dominate shipping and aviation sector for decades to come.

8. One can visualise its effects on oil industry. Roughly two-thirds of oil consumption in US is on roads and a fair amount of rest is used in by-products of refining crude to make petrol and diesel. With more electric cars in times to come, petrol will become surplus, putting the economy of many oil producing countries into great strain. *(Economists, London – 12 August, 2017).*

CASE OF IRON ORE RESOURCES

9. Iron is the earliest metal to catch the human imagination; iron age followed just after Stone age. Since iron ore (Fe_2O_3) is one of the most wide-spread mineral (other being alumina (Al_2O_3)) constituting 5% (alumina 8%) of the earth crust upto a continental depth of 75 kms, human civilization has not so far faced any scarcity of the ore / metal; nor is it expected that it ever will.

10. However, the level of exploration and subsequent mining depend on the demand for iron and steel. As R.P. Sheldon observed that "mineral resources are created by human activities in response to human needs from rocks that make the earth". The inventory of iron ore that we have today is directly linked to the level of exploration which depend on the level of mining activities which again depends on market (outlet) and the forecast of resources at a particular point of time will never be accurate. The following table will illustrate this :

Indian Iron Ore Resources and Production between 1980-2013

(Qty: Million Tonnes)

	Resources as on 01-04-1980	Production between 1980-1990	Resources as on 01-04-1990	Production between 1990-2000	Resources as on 01-04-2000	Production between 2000-2005	Resources as on 01-04-2005	Production between 2005-2010	Resources as on 01-04-2010	Production between 2010-2013	Resources as on 01-04-2013
Haematite	11469		12197 (+728)		11426 (-771)		14630 (+3204)		17882 (+3252)		20575 (+2693)
Magnetite	6095		10590 (+4495)		10682 (+92)		10619 (-63)		10644 (+25)		10747 (+103)
Total	17564	465	22787 (+5223)	656	22108 (-679)	532	25249 (+3141)	997	28526 (+3277)	512	31322 (+2796)

Notes: (i) Figures in parenthesis indicate decrease (-)/increase (+) in resources over previous Figures

(ii) The resources are with a cut-off grade of +55% Fe and roughly estimated upto 50 metre depth with sparse and far-between drilling. Cut-off is now 45% Fe while iron ore in many cases occurs much deeper.

(iii) These resources do not include around 1000 million tonnes of hematite iron ore recently discovered by DMG, Chhattisgarh in Kabirdham district.

Source: Indian Bureau of Mines (IBM), Nagpur

11. As will be observed, between 1980 and 1990, the increase in resources as on 1.4.1990 was basically in magnetite resources when Kudremukh mine was under operation. During the period 1990-2000, the demand for haematite iron ore, both domestic and export, was subdued because of which there was hardly any exploration activity. As a result thereof, there was a reduction in haematite iron ore resources by 679 million tonnes. Between 1.4.2000-1.4.2005 (five years), when the domestic demand was subdued and export demand from China went up, inspite of having produced 532 million tonnes, the total iron ore resources increased by 3141 million tonnes. The increase in hematite resources was 3204 million tonnes. However, subsequently between 1.4.2005 to 1.4.2013, despite having mined 793 million tonnes, the haematite iron ore resources increased by 3132 million tonnes. Since magnetite production got discontinued, further exploration stopped and no additional resources could be identified.

12. At the time of liberation of Goa in 1961, Geological Survey of India (GSI) had estimated iron ore resources at around 350 million tonnes and had opined that resources will be exhausted in next 20 years. However, since 1961, Goa is estimated to have exported about 1000 million tonnes and its iron ore resources as on 1.4.2010 have increased to 927 million tonnes. Same is the position in other States and their resources have increased depending on the level of exploration, output and market. One therefore cannot presume at a particular point of time, that these resources will remain static and make projections on that basis. It very clearly proves that when the demand for iron ore increases, there is intense and scientific exploration to meet the level of production to match demand. It would be worth mentioning that during the last about 20 years, no big mine has come into operation. The increase in production and in iron ore resource position have mainly come from non-captive stand-alone mining units.

13. The situation is not different if we analyse world situation about iron ore resources. More demand leads to more production, leading to more intensive exploration through modern state-of-the-art technology, application of better and scientific mining technologies, leading to the discovery of more resources of iron ore. This will be evident from the following table:

World Iron Ore Resources and Production between 2000-2010

(in Million Tonnes)

Resources as on 1.1.2000	Production from 2000-2004	Resources as on 1.1.2005	Production from 2005-2009	Resources as on 1.1.2010
140,000	5700	160,000	7560	170,000

Source: U.S. Geological Survey

Further, technology leads to utilisation of low grade iron ore resources, better agglomeration and beneficiation techniques and lower to zero wastage.

OPPORTUNITY LOSS TO INDIA: AUSTRALIAN EXAMPLE

14. The table below depicts, where we, as a nation, have lost out in a listing of a few commodities vis-à-vis Australia.

RESERVES	INDIA		AUSTRALIA	
	1980	2010	1980	2010
Iron Ore (hematite) (million tonnes)	11470	17882	15000	40000
Diamond (million carat)	—	2.6	0	270
Gold (metric tonnes)	56.1	326.7	400	9800
Coal (billion tonnes)	111 (inferred)	276 (inferred)	29 (Proved)	75 (Proved)
Bauxite (million tonnes)	2489	2636	3000	8700

Source: Indian Bureau of Mines (IBM), Nagpur, U.S. Geological Survey

15. With the exception of coal, no other commodity has seen significant mineral exploration in India. The opportunity cost lost as a consequence is significant. As an example, had India between 1980 and 2010 followed a proportional growth path as Australia, then in value terms, the tangible opportunity loss works out to:

- For iron ore is approximate 20 billion tonnes equating to about US$ one trillion (at mine gate price of US$ 50)
- For gold is 500 tonnes equating to about US$ 25 billion (at a price of US$ 1400/ounce)
- For bauxite is 4 billion tonnes equating to about US$ 80 billion (at a mine gate price of US$ 20)

16. Experience in other parts of the world shows that reserves can increase significantly with additional exploration and beneficiation driven by state-of-the-art technology. Australia's known iron ore resources increased hundred fold in 40 years, from around 400 million tonnes in 1966 to 40 billion tonnes in 2005 after having extracted and exported more than 4 billion tonnes in the interregnum.

EXPLORATION DEPENDENT ON MARKET DEMAND FOR IRON ORE

17. What we explore / exploit today is based on market demand at a particular point of time. If indexing of unit cost is done, probably it may be cheaper or costlier but there has to be market demand. Resources that are not demanded by the market forces can be dubbed "neutral stuff". The demand plus technology and advancement of knowledge turn these "neutral stuff" into resources which are replenished upon use by further advance of technology and knowledge that enable us to tap into resources previously beyond reach.

18. Market forces are the best instruments for proper allocation of natural resources. If the unit price, being the main yardstick, goes beyond the reach of the consumer, there will be resistance. Efforts then get initiated in the direction of finding a viable substitute or alternative resource. This is very well borne out in the case of mica where India had monopoly at one time. When the market forces were interrupted and the item was canalized through MMTC, which made it costly, a synthetic substitute was developed with better chemical and physical properties. India, the sole producer of mica, lost the market for ever. There is hardly any production of mica now in India.

TECHNOLOGY MAY MAKE TODAY'S RESOURCES REDUNDANT

19. From the beginning of human history, innovations have been experimented with all kinds of elements, from the ordinary to the invisible, to try to come up with new, improved materials. The invention of plastic in 1907 inaugurated an era of synthetic materials that are stirred up in laboratories, greatly expanding the possibilities for creating an endless variety of useful products. One cannot envisage the pace of technological developments or quiet revolution taking place without much fanfare world wide. Already work is on full

pace on the development of nano-technologies[1] leading to production of light, low-density and high strength materials to replace steel and other metals. Prof. Ray Baughman of University of Texas created a material in 2004 which is stronger than steel, transparent and very light. A hectare-size sheet would weigh just 280 grams.

20. Carbon in the form of graphite is soft, malleable and easily broken. But carbon nanotubes, a very thin sheet of graphite formed into a tube – a tiny strawlike cylinder as small as half a nanometre wide – are upto 100 times stronger than steel and six times lighter. These are hardest, stiffest, strongest materials known and are among the world's best conductors of heat and electricity. They can carry some 1000 times more electrical current than copper wire. Further, there are technologies under development to derive energy from nuclear fusion which may make coal redundant for energy generation. The most recent 787 Dreamliner aircraft has almost done away with the usage of aluminium or steel and is made of composites, high tech ceramics and carbon-plastic material to save fuel. Efficient and better usage of these elements of nature would almost ensure that the world will never be able to foresee a time when there is a possible danger of resource exhaustion, renewable or non-renewable.

SUPER MATERIALS: SOME RECENT TECHNOLOGICAL INNOVATIONS

21. Sometimes, though scientists concoct materials that have no clear use at first. Aerographite is a forum of carbon with a sponge like structure. It is water-repellent, highly resilient and extremely light. It also conducts electricity. Its inventors believe it could be used in electric car batteries – a lighter load cuts

[1] Nano comes from the Greek word for dwarf. Usually nanotechnology is defined as the study and manipulation of matter smaller than 100 nanometres - that's the scale of things like molecules and viruses. Ten hydrogen atoms nestled up against each other are just one nanometre long. And one million nanometres fit into a millimetre. Hard to grasp? Think of it this way: if a person was a nanometre wide, then 13 million of them, standing shoulder to shoulder, would fit on your thumbnail.

operating costs. They have yet to determine how to profit from its ability to absorb almost all light, which makes it blacker than coal.

22. Further, scientists crushed a naturally occurring kind of carbon called buckminsterfullerence (the molecules look like soccer balls) to create a material strong enough to dent diamonds. As yet unnamed, it may find use in industrial manufacturing and deep-well drilling.

23. A human hair is almost a million times thicker than a layer of graphene. The material is made of a single layer of carbon atoms arranged in a honeycomb pattern. In theory, a string of graphene with a diameter of just one-tenth of a square millimeter — the size of a very sharp pencil point — could hold up a thousand — pound piano. To take advantage of that incredible strength though, scientists will have to figure out a way to embed this atomic-scale element in other materials.

24. In a US$ 3.5 billion sponsored R&D programme in the campus of Lawrence Livermore National Laboratory, near San Francisco, Dr. Edward Moses, who calls his lab National Ignition Facility (NIF), has developed a model of a size of tiny pellet which is supposed to provide an endless supply of safe and clean energy. The real version of pellet will contain a few milligrams of deuterium and tritium, isotopes of hydrogen that can be extracted from water. If one blasts the pellet with a powerful laser, one can create a reaction like the one that takes place at the centre of the sun. After harnessing the reaction, it would be possible to create a star on earth, and with the heat from that star, one can generate electricity without creating any pollution. What Moses is working on is controlled nuclear fusion — fusing nuclei rather than splitting a nucleus as happens in ordinary nuclear-fission power plants. In a fission reaction, the nucleus of a uranium atom is split into two smaller atoms, releasing energy in the form of heat. The heat is used to make steam, which drives a turbine and

generate electricity. In fusion energy, the second half of this process (heat makes steam makes electricity) remains the same. But instead of splitting the nucleus of an atom, one is trying to force a deuterium nucleus to merge, or fuse, with a tritium nucleus. When that happens, one produces helium and throw off energy.

25. Dr. Moses has already branded the product as Laser Inertial Fusion Energy or LIFE and believes that by 2020 utility companies could be building prototype power plants called "LIFE engines". By 2030, real fusion plants would start running which by 2050 could be common. It is estimated that by 2100, as many as 1000 fusion reactions could be operating in the United States, if utilities embrace the technology and invest in it. If this materializes, there would be no need for nuclear plants, coal, oil, or wind or solar power.

26. The invention of these types of super materials in all branches of human activities may make use of many minerals and metals redundant. It is thus not wise to deprive the present generation of materials which the future generation may not even require.

STEEL RECYCLABABLE: MAY REDUCE DEMAND FOR IRON ORE

27. It is also important to distinguish between resource renewability and material renewability. Wood fibers come from a renewable resource but because of degradation, their properties are not retained when recycled i.e. they are a non-recyclable material. On the other hand, metals come from a non-renewable resource but because they are elements, their properties can be fully restored when recycled i.e. they are recyclable material. Most metals and industrial minerals are not `consumed' while in use. Actual recycling rates vary across metals and markets depending on market size, collection facilities and many other factors. Approximately 60-80% of the metals, including steel, used

in Europe are recycled. This makes minerals infinitely finite. This puts any apprehension about the future availability of iron ore at rest.

28. A recent study by Metal Bulletin Research has estimated that some 40 countries jointly account for more than 95% of the generation and consumption of four key sources of iron units in steel industry : iron ore, pig iron, DRI/HBI and scrap. All these 40 core steelmaking nations are expected to use more scrap in steelmaking by 2020 than they do now; some will actually use less iron ore by then than they do now. Once the economy is on path of maturity, there is a tendency of life cycle and recycling playing an important role in its economic growth. It is also quite possible that China could become significant net exporter of steel scrap by 2020 depending on the changes in Chinese tax code.

CONCLUSION

29. The concept of inter-generational equity, which has caught judicial attention in India of late, has been long forgotten in US and West European countries because of above scientific advancements. It is a concept which will not only deprive the present and future generations of the fruits of resources utilisation but, by its very nature, is anti-development. While on the one hand recyclability of steel and the abundance of iron ore resources make iron ore infinitely finite, on the other, the so-called renewable resources i.e. fish, agricultural land and fresh water are under intense pressure and threat of scarcity.

30. The motivation for setting up of domestic steel / aluminium industry is due to strong domestic demand for these metals and not the raw materials availability. Not many countries in the world have developed its steel / aluminium industry based on the availability of domestic raw materials i.e. Japan and South Korea. They invariably import them. However, it is evident that

there will no shortage of iron ore to meet the projected domestic demand and future capacity expansion of the steel industry. If efforts are made to stall development of raw material industry, neither steel / aluminum industry will come up nor could our resources develop and they would remain unutilized.

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