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Sustainable Development from Resource Exploitation Perspective

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ABSTRAK

Pembangunan lestari melambangkan keinginan manusia untuk mengubah (bagi kebaikan atau keburukan) secara berterusan dengan tidak memberi kesan kepada alam sekitar. Walaupun sistem fizikal planet bumi mempunyai keupayaan untuk menampung proses kehidupan bagi jangka masa yang panjang melalui bebagai kitaran biogeokimia, gangguan terhadap proses ini dalam kegiatan pembangunan manusia boleh menjejaskan alam sekitar. Kadar pertumbuhan dan pembangunan yang tinggi boleh mengurangkan sumber seperti petroleum iaitu sumber tenaga yang terpenting. Terdapat beberapa pendapat yang bertentangan berkaitan kelestarian sumber untuk pembangunan, iaitu pendapat pesimis, optimis dan kesederhanaan. Asas pendapat-pendapat ini dianalisis. Eksploitasi dan kehabisan sumber oleh kegiatan syarikat transnasional juga dibincangkan. Artikel ini cuba meneliti perhubungan antara perjuangan manusia untuk mencapai pembangunan lestari dan keupayaan bumi untuk menampung perjuagan ini dan akhirnya membuat kesimpulan sama ada pembangunan lestari adalah sesuatu yang nyata atau hanya sesuatu hayalan yang boleh bertukar menjadi suatu igauan yang ngeri.

Kata Kunci: Pembangunan lestari, kitaran biogeokimia, kadar pertumbuhan, eksploitasi sumber, kehabisan sumber

ABSTRACT

Sustainable development denotes human desire to change (for better or worse) indefinitely without seriously affecting his environment. Although the physical systems of planet earth have the capacity to sustain life supporting processes for a long period of time through various biogeochemical cycles, interruptions of these processes by human development activities could cause impairment of the environment. A high rate of economic growth and development could cause depletion of resources, such as petroleum as one of the most important energy resources. There are opposing views on resource sustainability for development, the pessimistic, optimistic and moderate views. The basis of these views, is analysed. Resource exploitation and depletion by transnational corporations *activities are also discussed. This paper attempts to review and analyse the relationship between man strive to achieve sustainable development and the earth capacity to sustain this strive. It also attempts to draw conclusions whether sustainable development is real or is just a dream that could turn into a nightmare.*

Key words: Sustainable development, biogeochemical cycle, growth rate, resource exploitation, resource depletion.

INTRODUCTION

It has been generally accepted that man will continue to undergo the process of socio-economic change or development resulting in the improvement of living conditions in relations to physical requirements and also non-material wants. Apart from satisfying the basic human needs such as food, clothing and shelter, modern man strive for achieving better quality of life with all the amenities and services of modern living. In short, these social processes would reflect what we term as economic growth and development. The question is whether the physical environment of the earth can sustain economic growth and development. Thus, sustainability is currently one of the most important issues pertaining to environment and development, which in turn reflects human endeavour for progress and prosperity.

Sustainability suggests a steady state to the economists. Sustainability in development may be secured in two processes. The first is maintenance whereby inputs are required to continue with current level of production (Scott 1994). In agricultural production for example, he emphasised that fertilisers are required to replenish soils after their fertility has diminished due to earlier withdrawals through agricultural production. The second process is investment in all kinds of material and human resources to achieve growth. However, development in terms of economic growth has been thought to have resulted in degradation of environment due to the output of pollution and waste and depletion of natural resources (Beckerman 1992). Many conventional economists have considered that there is no limit to growth while others have realised the outcome of uncontrolled development on the environment and exploitation of the finitely available resources. Although the physical systems of the planet earth have the capacity to sustain the life-supporting processes, for a long period of time, through various biogeochemical cycles, interruptions of these processes by human development activities could cause impairment of the environment. A fast rate of economic growth would results in the potential depletion of resources, such as petroleum as one of the most important energy resources. This paper attempts to review and analyse the relationship between human strive to achieve sustainable development and the earth capacity to provide resources for sustaining this strive. It also attempts to draw conclusions whether sustainable development is achievable or the present trend would lead us to a global collapse.

DEFINITIONS OF SUSTAINABLE DEVELOPMENT

There exist many definitions of sustainable development in the literature (Bartelmus 1994; Lele 1991; Pearce et al. 1990; Pearce 1985; IUCN 1980). Some views simply affirms that sustainable development is development that does no harm to human kind. Others suggest that sustainable development must preserve the functioning of the ecosystem. There are also views, which contend that sustainable development is development that will not reduce the future productive capacity of the economy, including possible substitution of natural resources depletion by new man-made resources.

However, in general, sustainable development relates to development that does not negate the future productive capacity of the economy. Future productive capacity would depend on the stock of natural resources, and man made capital and technology used by the current generation. To maintain future productive capacity, none of these stocks should diminish over time or reductions in one stock should be counter balanced by increases in other stocks. Nevertheless, there are constraints to these substitutions. For instance, industries may compensate for lost income from forests and agriculture but not for lost biodiversity and quality of life. The taste and preferences of future generations may also be different from the current generation. We may therefore conserve for them the same set of preferences we currently have. Irreversible degradation of natural capital reduces both future availability and options and is therefore inconsistent with the general notion of sustainability, even if it can be compensated for by human-made capital.

Currently there is increasing agreement that sustainable development should consider economic, social and environmental objectives in a balanced manner (Beckerman 1992; Todaro 1994). This approach to the concept of sustainable development evolves from the experience of development efforts world wide. In the 1950's and 1960's the focus of economic progress in the developing nations was on growth and increases in economic output, based on the concept of economic efficiency. By the early 1970s, the lack of 'trickle-down' benefits to the growing numbers of poor in developing countries led to policies focused on improving income distribution. Equitable growth, were thus recognised as important as economic efficiency. Currently, protection of the environment has become a major development concern. While pollution is now considered a major threat to the quality of life in both the industrialised and industrialising countries, environmental degradation has become a serious impediment to economic development and poverty reduction efforts in the developing world.

In contrast to these issues described in environmental terms, the concept of sustainable development is also based on a societal oriented definition of problems. In other words, how can a society shape its development in such a way as to preserve the preconditions of development for future generation. This means not only the economic efficiency issue must be included but also those of social justice and political regulation as well. This is to say besides economic efficiency, which is producing the maximum-valued output possible, using cost-minimising techniques of production and considering effective market demand for profit maximisation, we must not forget the poor and the disables. Acting fairly and adequately to the society is important. This may include elimination of inequality, poverty and unemployment through various reforms of social, economic, and institutional structure. Of course political regulations to bring about order, method and uniformity is as important.

In light of these situations combined with rising consumption levels world wide, accompanied with high rates of population growth, the realisation of sustainable development, will be a major challenge. Much of the concern over environmental and social issues stems from the perception that we may reach a limit to the number of people whose needs can be met by the earth's finite resources. This may or may not be true, given the potential for new technological discoveries. However, it is clear that continuing on our present path of accelerating environmental degradation would severely compromise the ability of present and future generation to meet their needs.

The concept of sustainable development dates back to the early 1970s, when Forrester (1971) published his book 'World Dynamic' which described a dynamic model of world scope which interrelates population, capital investment, geographical space, natural resources, pollution and food supply. This was followed by the Club of Rome Report, The Limits to Growth' which was probably the eye-opener to the development problems (Meadows et al. 1972). The sustainability concern was initialised by World Conservation Strategy (IUCN 1980). The widely used definition of sustainable development has been introduced in the Brundtland Report World Commission on Environment and Development (WCED) 1987. It has been used as `the development that meets the needs of the present without compromising the ability of future generations to meet their own needs'. The needs of the present and the future may well mean a sustainable supply of resources. IUCN (1991) defined sustainable development as `improving the quality of human life while living within the carrying capacity of supporting ecosystems'. Pronk and Haq (1992) have come up with 'the economic growth that provides fairness and opportunity for all the people of the world, not just the privileged few, without further destroying the world's finite natural resources and carrying capacity', as a definition of sustainable development. Bartelmus (1994) considered the WCED's definition as rather vague as it gives no indication of the time horizon (future generation), the scope and substance of human needs and the role of environment. He introduced a new definition focusing on the maintenance of produced and natural capital. This is to ensure continued generation of output and value added by resource saving and environmentally sound technological progress, resource discovery or substitution of produced, natural or human capital inputs. Thus sustainable economic growth and development is defined in operational (quantifiable) terms as upward trend of EDP (environmentally-adjusted domestic product) based on the assumption that the allowances made for environmental depletion and degradation, can and will be invested into capital maintenance by taking into account that the past trend of depletion and degradation can be offset or mitigated by technological progress, discovery of natural resources and changes in production and consumption patterns. However, recently sustainable development has established itself as a new keyword of political discourse. According to Becker et al. (1997), sustainable development describes a new area that is social at its core. The so called 'human dimensions' of global change as a new field of social science is added more or less belatedly to a natural scientific description of the problem. These definitions explicitly or implicitly indicated the importance of natural systems in terms of natural resources and carrying capacity in supporting the sustainability of development, besides the need for knowledge about the interactions among society, economy, politics and environment.

WHAT MAKES THE WORLD TICK

The present earth system consists of natural, man-made and social components. The natural component in turn consists of the geographical zones in which the biogeochemical cycles occur. Implicit in the cycles is the interactions between biotic and abiotic components of the natural environmental systems. From the physical point of view, the planet earth has the capacity to uphold the life supporting processes through the biogeochemical cycles. These cycles are controlled by many rate processes, sustained by the energy from the sun and the gravity of the earth. On the global, regional and local scales, for example, the rates of evapo-transpiration and infiltration contribute to the hydrologic cycle. On the plant basis, the rate of photosynthesis and respiraton contribute significantly to the global carbon and oxygen cycles. On the minute scale, the rate of organic matter decomposition by microbial activities, although seems insignificant, plays important roles in many dynamic processes of the world. Human and human-made environments are considered implicitly as separate components in the socio-economic cycle. The man-made and social components are in fact the consequence of economic growth and development processes constituting a socio-economic cycle occurring in the overall earth system (Figure 1a). The natural component acts as the source of materials or resources for the man-made and social environments in which economic growth and development take place, as well as the sink for waste created by the socio-economic processes. The processes in the natural component that generate renewable resources are important for sustainable economic growth and development. The balance between the rate of natural resource generation and

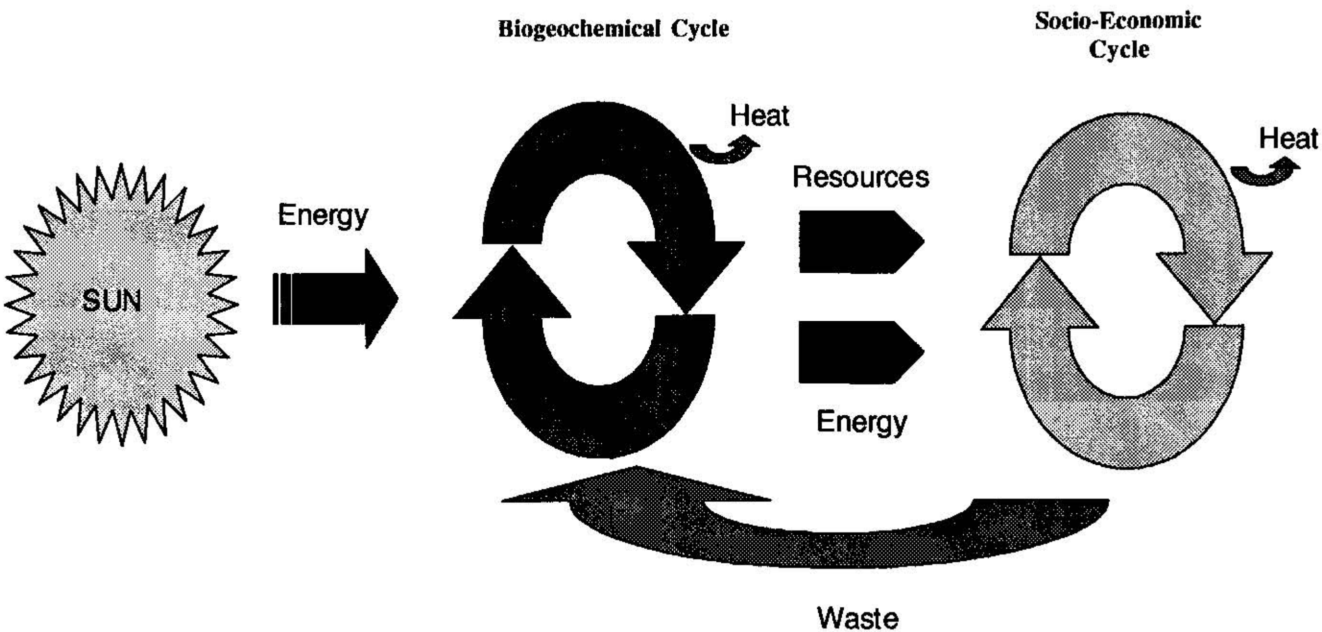

FIGURE 1a. Earth system consisting of biogeochemical and socio-economic cycles in balance

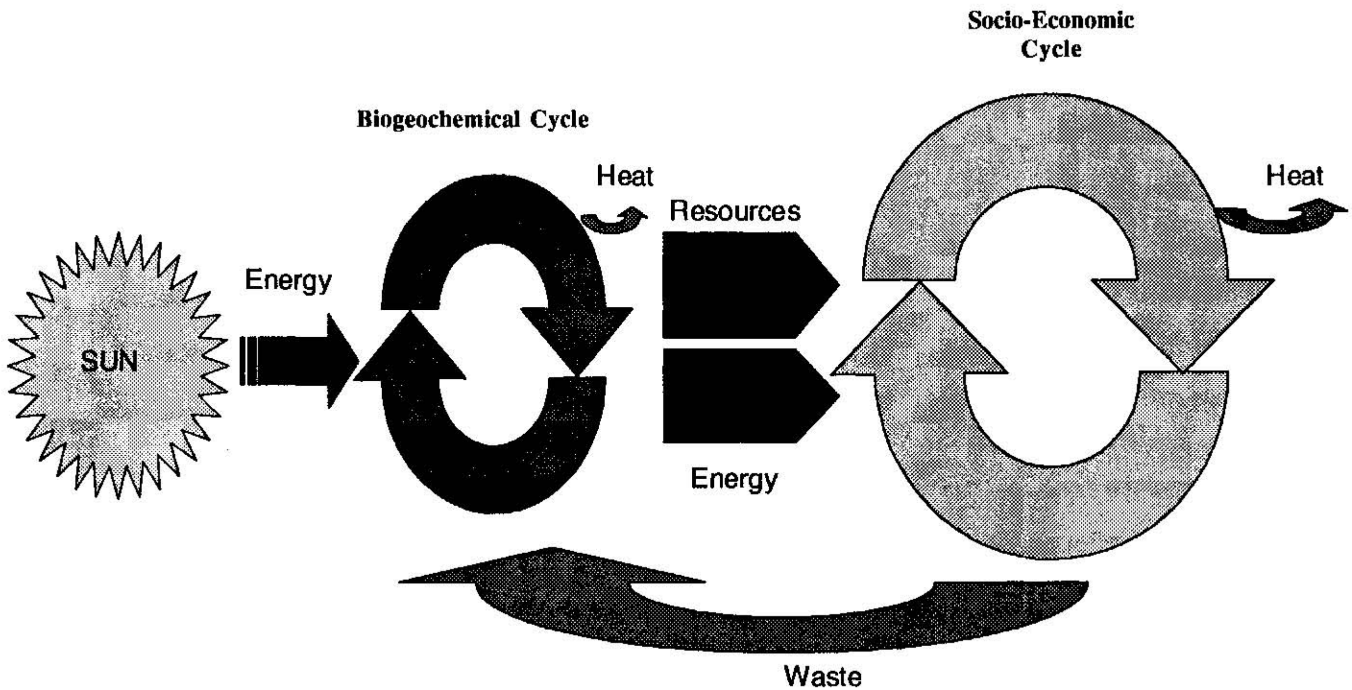

FIGURE. 1b. Earth system consisting of biogeochemical and expanded socio-economic cycles and increased resources and energy demands

the rate of resource use must exist for continued development to occur. All these have not been understood by many people. An expanded socio-economic cycle, as a result of increasing population, and a greater demand for economic growth and development, would mean a greater requirement of supply of resources and energy (Figure 1b). Exploitation of resources will in turn result in the output of wastes, which when concentrated by economic process, can be detrimental to the environment. The amount of waste generated, whether in the form of solid, liquid or gas is directly proportional to economic activities augmented in many cases by technological and innovative advancement. Based on the principle of mass conservation, all materials either return to the natural environment or can be recycled back into the economic process. By understanding these cycles, one can gauge whether our present economic system can sustain growth and development, keeping in mind the above definitions of sustainability. Figures 1a and 1b show systematically the integration of the physical and the socio-economic processes in striving for sustainability of growth and development. It is pertinent, to examine whether the natural component is capable of supplying indefinitely the resources for sustainable development, at this point.

PERCEPTIONS ON NATURAL RESOURCES AVAILABILITY AND SUSTAINABILITY

Based on the above definitions of sustainable development it can be seen that material resources availability is one of the ingredients of sustainability. The question is 'Are our world resources infinite ?'. From the principle of biogeochemical cycle one can say that as long as the sun still exists it seems that renewable resources supply is perpetual. This is quite true if the world systems are in the state of dynamic equilibrium (Figure 1a). Both the natural and man-made cycles are controlled by their rate processes. The natural rate processes have been discussed earlier and they vary very little. The problem arises when one or more of the socio-economic rates processes change (normally increase) (Figure 1b). The rate of population increase would result in the increase of the rate of resource use to cater for human needs and wants. The world systems will adjust themselves to new sets of dynamic equilibria. During the period of adjustment, the environmental conditions can be catastrophic to human lives.On the other hand, non-renewable resources will be gone forever once they are depleted. Table 1 indicates the number of years known reserves of non-renewable resources excluding oil will last at the prevailing exploitation rate. Lead, zinc, sulphur, aluminium and gold will be depleted very shortly if known reserves are not replenished from ultimate recoverable resources. Table 2 shows the 1994 estimates of world reserves of non-renewable resources. Comparing Y(Res) of Table 1 and world resource life of estimates of Table 2, with a lapse estimates period of about 16 years, one can see that we should have run out of lead in 1988, but the resource life has been extended by 29 years until 2017. The same goes to zinc with a resource life extension of 36 years. This could mean several things: (1) the estimates are not correct, (2) development of more accurate reserves estimates, (3) findings of new reserves. One should realise that there are elements of uncertainty in all the reserves estimates.

There are two extreme schools of thoughts concerning the availability of natural resources for economic growth and development. One is the pessimistic neomalthusian (Forrester 1971; Meadows et al. 1972), and the other is the optimistic Julian Simon (1981) and Herman Khan (1976) school of thought.

TABLE 1. Years of potential annual consumption of resources

Resource Type	Y (Res)	Y (Rec)	Y (EC) (M)
Copper	45	340	242
Iron	117	2657	1815
Phosphorus	481	1601	870
Molybdenum	65	630	422
Lead	10	162	85
Zinc	21	618	409
Sulphur	30	6897	n.a
Uranium	50	8455	1855
Aluminium	23	68066	38500
Gold	9	102	57

Y(Res) = Known reserves/annual consumption
Y(Rec) = Ultimate recoverable resources/annual consumption
Y(EC) = Amount estimated in earth crust/annual consumption
M = Million
Average base year 1978
Source: Nordhaus (1974), Griffin and Steele (1980), Simon (1981)

TABLE 2. 1994 Estimates of world reserves of non-renewable resources

Resource Types	World Reserves (000 metric tons)	Annual Production (000 metric tons)	World Reserve Life (Years)
Aluminium	23,000,000	111,024.2	207
Copper	310,000	9522.6	33
Lead	63,000	2764.7	23
Mercury	130	2.9	45
Nickel	47,000	802.5	59
Tin	7,000	169.4	41
Zinc	140,000	6895.1	20
Iron Ore	150,000,000	988797.0	152

Source: World resources 1996-1997.

Pessimistic Points of View Given the above definition of sustainable development, a number of questions arise, one of which is "Are current trends of resource use for economic productions and services, sustainable"? To environmental scientist the answer is clearly no. Current rates of exploitation of essential resources - in the range of 100 percent a century or more in various regions, especially the developed countries (Brown et al. 1986) - have far exceeded sustainable rates. Although environmental scientist would agree unanimously on this issue, many economists would dispute even the relevance of the question.

The pessimistic view is based on a large-scale computer model, developed by Forrester (1971), that can simulate likely future outcomes of the world economy. This model can describe a wide range of complex behaviour of the global economic system. The model depicted three main scenarios. The first showed that within a time span of less than 100 years with no major changes in the physical, economic, and social relationships that have influenced development, the world will run out of non-renewable resources. Major economic activities depend on many non-renewable resources. Resource depletion will inevitably results in the collapse of the economic system, manifested in massive unemployment, decreased food production, and a decline in population. The system is characterised by overshoot, collapse and disaster (Figure 2).

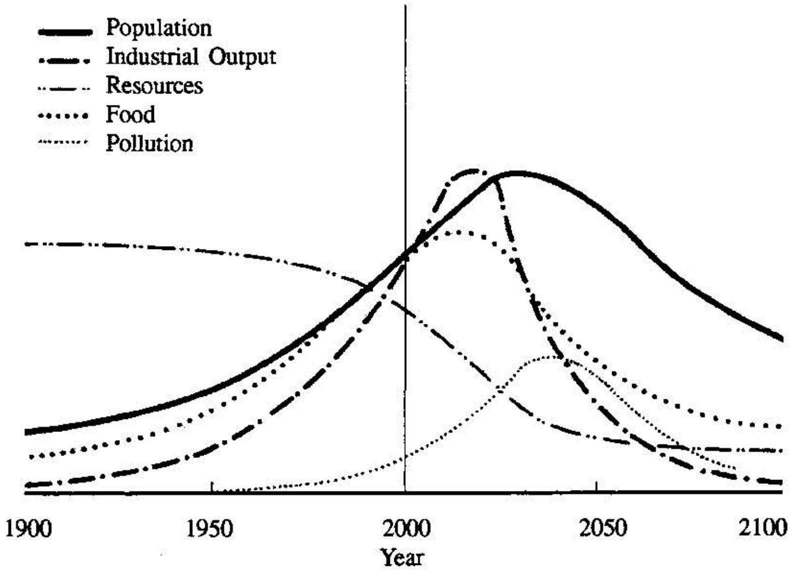

FIGURE 2. With business as usual, world economic system is characterized by overshoot, collapse and disaster, due to non-renewable resources depletion.

Source: Forrester (1971)

The second scenario demonstrate that even by doubling the resource base the collapse still occurs, but this time it is caused by excessive pollution generated by the increased rate of resource use. Even if the depletable resource and pollution problems were solved, population would grow unabated and the availability of food would become more pressing with the occurrence of world-wide famine (Figure 3).

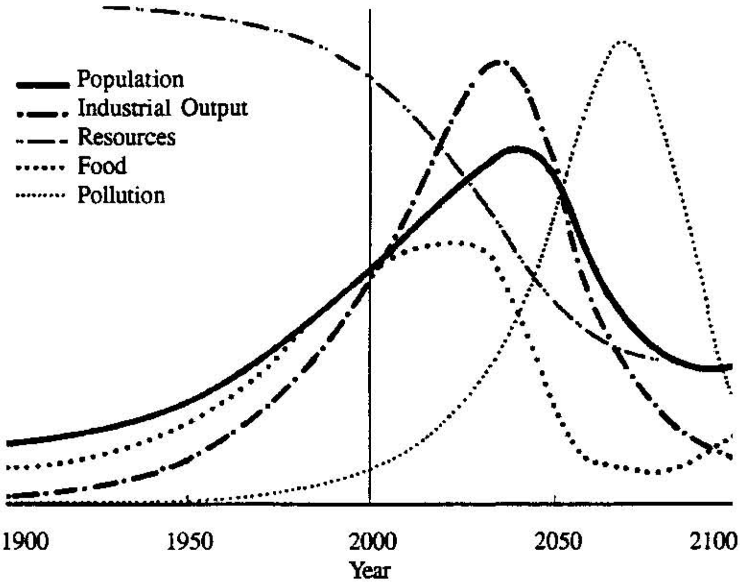

FIGURE 3. The characteristic of collapse is still inevitable even with doubling the resource base.

Source: Forrester (1971)

The final scenario suggest that overshoot and collapse can be avoided only by an immediate limit on population and pollution, as well as a slow down of economic growth. These scenarios showed only two possible outcomes: the termination of growth to avoid global collapse by self-restraint on resource exploitation or the termination of growth by transgressing natural limits, resulting in misery (Figure 4).

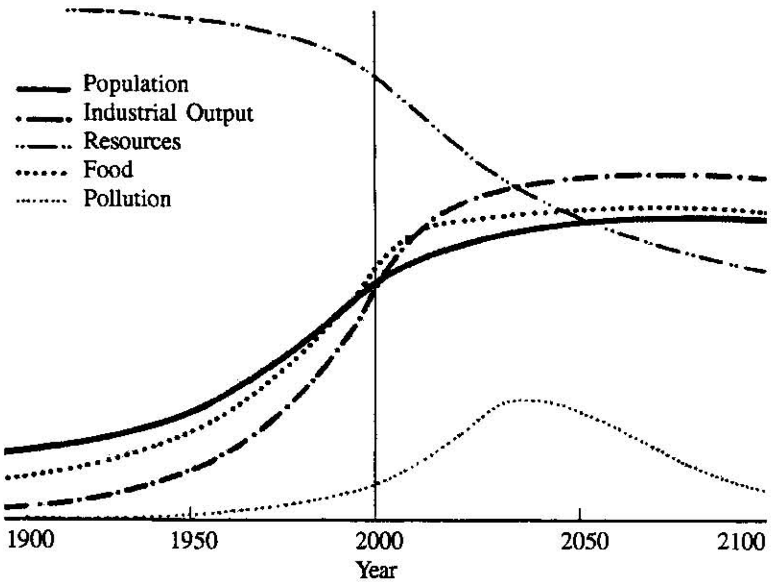

FIGURE 4. Collapse avoided with limits on population, pollution and economic growth
Source: Forrester (1971)

Optimistic Points of View Julian Simon (1981) has conducted a through study of charges that the world is running short of natural resources and that there is growing disproportion between our available resources and the increasing world population. Contrary to pessimistic views that we are running out of raw materials and natural resources, Simon found that the most direct measure of rising scarcity - rising relative prices - does not support the notion of growing shortages. Relative to other prices paid by consumers, raw materials and natural resources are growing cheaper, not more expensive. Taking oil as an example, Simon claimed that our oil supply is non-finite. This is because the number of oil wells that will eventually produce oil, and in what quantity, is not known or measurable at present and probably never will be, and hence is not meaningfully finite. Moreover, although petroleum prices have been rising in relative terms, Simon notes that the production cost per barrel of oil have probably fallen in relative terms. Economists, using the elementary laws of supply and demand, argue that when a natural resource becomes short in supply, the relative price will rise, and the higher relative price will reduce its quantity demanded. They therefore maintain that a freely functioning price system will retard the depletion of scarce natural resources. They also argued that the world economy in the next millennium may very well develop new energy-saving technologies or may discover good substitutes for natural resources that are rising in relative price. If the world supply of petroleum and natural gas threatens to run out, scientists may discover new energy sources that will be economically feasible.

Similarly Kahn (1982) had an optimistic vision based on the assumption that there will be a continuing technological progress that serves to overcome natural limits. They contended that population growth would come to a halt in the next 200 years and at that time the world economy would provide and average person an annual earning of US$20 000, as compared to US$1 300 in 1976.

Moderate View The pessimistic view is based on world models. It should be strongly emphasised that models are not capable of representing the real world. The world systems are just too complex to be 'really' modelled. It should follow that the results or outputs generated by the models are not real and thus the over-pessimism is quite unfounded. However, the pessimistic view must be taken as a warning of a possible environmental degradation, which could lead to catastrophe. As of today, we could see indications and signals of the predicted disaster, such as depletion of some of our resources, overpopulation and shortages of food, and pollution, occurring in certain areas of planet earth. Evidence of these environmental degradations are numerous in the literature (Miller 1994). Petroleum, which is our most important non-renewable energy resource in terms of economic growth, is depleting at an alarming rate. This will be discussed in detail later. Steps should be taken to reduce over-consumption of resources especially the non-renewable ones, to satisfy lavish human needs and wants.

On the other hand, over-optimism is unrealistic. In the normal frame of mind one cannot reject the reality of finite availability of non-renewable resources. It is felt that Simon and Khan optimistic views on sustainability were based on facts and figures of the developed countries. These countries are highly industrialised and have high average GNPs per capita. Based on 1993 data from United Nations the developed countries have average GNP per capita of $18900 compared to $870 of the undeveloped countries. These countries, with population of 1.2 billion (22% of the world's population), command about 85% of the world's wealth and income. They use 88% of world's natural resources and 73% of its energy, and generate most of its pollution and wastes (Miller, 1994). Data from the United Nations has also shown that the gap since 1980 between the rich and poor in GNP per capita has widened. It must follow that much of the blame for the damage or degradation that has been and will be done to the world's environment in terms of resource depletion, should rest on these rich countries. Nonetheless, the rich countries have grown much richer, while the poor have stayed poor or even grown much poorer. From the global stand point, Simon and Kahn's over-optimistic views are grossly irrelevant.

The finiteness of non-renewable resources is difficult to be ascertained. The changing values of world's oil reserves over the years, proves this fact. This could well mean that the world's natural processes have not been totally understood. There is a lot more to be learned about the biogeochemical cycle. Nevertheless, with the exponential increase of population the demand for resources should increase at the same rate. At this moment the resources from the environment can still support this demand for development. As such the existing resources have to be managed in such a way that the future generation will not suffer of resource depletion. This can only be done if population growth can be regulated, earth-sustaining rather than earth-degrading forms of development can be encouraged, and human poverty and misery can be minimised.

RESOURCE EXPLOITATION AND DEPLETION BY TNCs

While looking at the optimistic and pessimistic views on resource availability, it is important to see the role of Transnational Corporations (TNCs) with regards to resource exploitation and depletion. Essentially the charges against TNCs revolve around three issues. Firstly, the economic and political power concentrated in the hands of these large organisations. Secondly, their actual or potential use of that power to their advantage. Finally, as a consequence of that power, their ability to shape demand patterns and values as well as to influence the lives of the people and the policies of the government (Siddayao 1978).

It is a known fact that the Trans-National Corporations (TNCs) accounts for the largest part of global economic activity and are the main entities responsible for the global environmental crisis. Many in the South are justifiably indignant, that the blame seems to be put on their countries. In reality the rich North nations contribute about four-fifth of the world's resource depletion and pollution, although they account for only a fifth of the population (Khor 1996). The TNCs said to be the important players involved in resource exploitation and depletion and environmentally damaging activities can be gauged from the following ways:

1. Liberalisation policies and global market integration have facilitated the institutions and activities that contributed to greater exploitation and depletion of biological diversity and resources such as forests and fishery resources. They can promote and expand environmentally harmful land-based activities, that lead to continue depletion of biodiversity. According to WRI (1996), TNCs have virtually exclusive control of the production and use of ozone-destroying Chloroflorocarbon (CFCs) and related compounds.
2. Other resources continue to be depleted beyond sustainable rates, such as minerals and petroleum. Liberalisation has opened up more mining concessions and a new wave of environmentally damaging mining activities. According to WRI (1996), in mining, TNCs still dominate key industries and are intensifying their activities. In aluminium, for example, six companies control 63% of the mining capacity.
3. The lack of financial flows, and resources in most developing countries, and the persistence of structural adjustment restrictions and policies have meant a

great lack of resources in many of these countries to implement or change towards environmentally sound production.

4. TNCs dominate the trade in (and in many cases the extraction or exploitation of) natural resources and commodities that contribute to depletion or degradation of forests, water and marine resources, and toxic wastes and unsafe products (Khor 1996).

TRENDS OF RESOURCE USE (PETROLEUM AS A CASE EXAMPLE)

Petroleum is one of the world's most important energy resources. Petroleum reserves are of particular importance, given the central role that petroleum plays in world energy supplies and world energy market. Petroleum continues to dominate world's commercial energy production, providing 40% of the world's commercial energy, which is about 22 billion barrels per year (WRI 1996). Petroleum dominates the international trade in energy because of its ready portability. As reported by WRI (1996), estimates of global petroleum reserves have increased over the past decade (up 43% between 1984 and 1994). This is primarily due to major re-evaluations of petroleum reserves in 1987 and 1989 in the middle east where more than 65% of the world's petroleum resources are located (Lynch 1995). If energy consumption do not change from current levels, present reserves could only supply world petroleum requirements for 40 years. All these facts justify petroleum as a case example of global trend in resource use analysis.

Regionally, reserves have been declining in many energy consuming countries. At present, there is little short-term concern over petroleum supplies; production capacity is enough and as a result oil prices are relatively low. The world petroleum resources are finite, however, and global production will be exhausted. The crucial question is 'How large is the total petroleum resource?'. No one in this world could give the exact answer. Thus there is vigorous argument between petroleum geologist, economist, oil companies and others about the size of the total petroleum resource and when the resource will be exhausted. Most of the world's petroleum resources are concentrated in a few countries (Figure 5). Short-term regional political instability could cause interruptions in petroleum supplies. Petroleum experts estimate the amount of oil that will ultimately be produced in a region (Table 3). Such estimate normally show an increase in production until a peak is reached and followed by a decline, which is called Hubbert Curve (Hubbert, 1976) (Figure 6). It was showed by such estimate that a peak would occur between 1998 and 2002. More conventional estimates suggest that global petroleum production will not peak until for another decade or two, somewhere between 2010 and 2025 (WEC 1995; Master et al. 1991). Table 3 also indicates regional imbalance in petroleum utilisation.

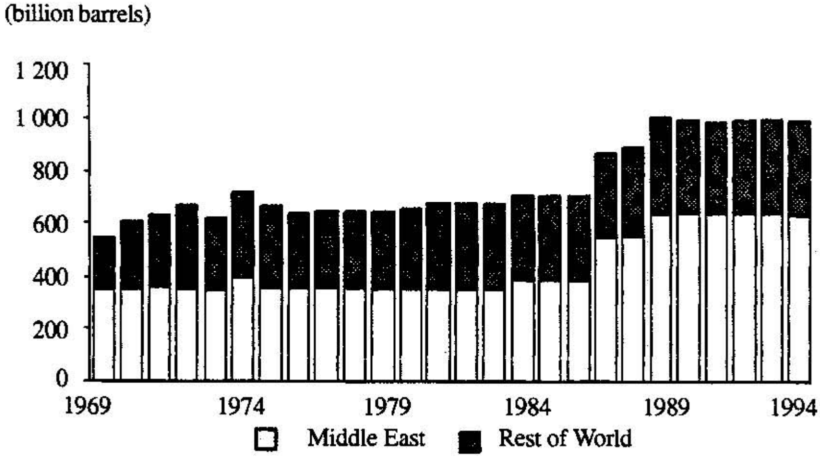

FIGURE 5. Proved petroleum reserves, 1969-94

Source: WRI (1996)

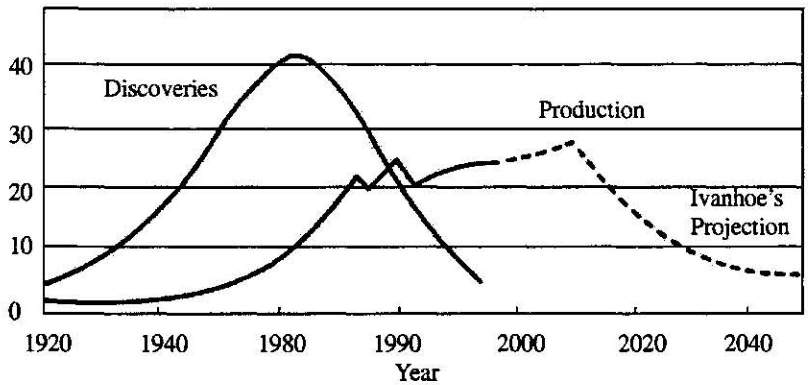

FIGURE 6. Discoveries and production of world oil

TABLE 3: State of the petroleum resource estimates of major producing countries (1994)

Countries	Cp (Gb)	Dis (Gb)	Undis (Gb)	Rem (Gb)	Ult (Gb)	MOD (Yrs)
Abu Dhabi	19	75	5	61	80	31
Algeria	17	26	3	12	29	NA
Canada	13	25	5	17	30	-8
China	21	49	7	35	56	5
FSU	124	209	21	106	230	-3
Iran	45	98	17	70	115	4
Iraq	33	90	21	78	111	30
Kuwait	17	86	5	74	91	22
Libya	18	50	5	27	45	5
Mexico	46	70	3	27	73	3
Nigeria	21	40	2	21	42	4
Norway	26	40	3	17	43	4
Saudi Arabia	75	264	16	205	280	25
UK	20	29	7	16	36	2
USA	168	200	7	39	207	-22
Venezuela	48	79	7	38	86	-5

CP = Cumulative production - produced to date
Dis = Discovered to date - the sum of the cumulative production and the reserve
Undis = Undiscovered or yet to find - the ultimate less the discovered
Rem = Remaining - the ultimate less the produced or the reserve plus the undiscovered.
Ult = Ultimate - the cumulative production when production ends
MOD = Midpoint of depletion (years)
Gb = Gigabarrels = 1,000,000,000 barrels

* Predictions the exact amount is a dubious undertaking. The oil data bases in the public domain are weak and there are many uncertainties

Source: Data estimated and calculated from Campbell (1995)

Proved petroleum reserves between 1969 – 1994 are shown in Figure 5. It can be seen that a large proportion of proved petroleum reserves can be found in the middle east compared to the rest of the world. Data in Table 3 also shows that petroleum resource estimates can be found in the Middle East, in countries like Saudi Arabia, Iran, Iraq, Abu Dhabi and Kuwait. These countries export most of their petroleum. Countries like United States of America, United Kingdom and Venezuela are also producing large amounts of petroleum.

It cannot be denied that petroleum indeed plays a vital role in the development process of a particular country. Returns from the export of petroleum contribute a large proportion of the gross domestic product and income of a country (example Malaysia 1995). Petroleum is needed in all aspects of human activities, such as transportation, manufacturing, infra-structural development, as an energy resource that is vital to the development of a country. Hence, in order to achieve a better quality of life in a society, sustainable use of petroleum must be part of the management programme of natural resources.

Petroleum experts strongly held that oil prices and improved technologies would not influence petroleum exploration and discovery as suggested by many economist. For example, the discoveries of major oil fields in Alaska and the North Sea, were made when prices were relatively low. On the other hand, oil prices now are relatively high compared with the costs of producing conventional oil, but no new major oil fields have been discovered in recent years (Campbell 1993). Furthermore, the main impact of technology is to accelerate depletion. Technologies for higher levels of extraction already exist, and higher oil prices will make them more widely used (Ivanhoe 1995).

On the contrary, economists contested that resource estimates and prediction made by petroleum experts are often inaccurate. Forecasts of when the decline in petroleum reserves will occur have been revised and pushed further into the future (Lynch 1995). Higher oil prices have led to new oil discoveries and higher levels of production.

The shortage of oil would be expected to lead to drastic increase in petroleum prices and also affect the prices of other forms of energy. This scenario could have an adverse consequence on the transportation systems now largely dependent on petroleum and also hamper the development process of many developing nations.

CONCLUSIONS

The economies and lifestyles of the industrialised world are dependent on energy resources such as petroleum. Petroleum is a big business both for private enterprise and state revenue. Seager et al. (1995) showed that most of the industrialised economies which include USA, Canada, United Kingdom, France, Germany, Japan, Spain, Italy, Russia and other countries like China, Brazil, Saudi Arabia and India were the major petroleum consumers which together account for 75% of all petroleum consumption in the early 1990s. This also means that the TNCs were monopolising and controlling most of the worlds energy resources. It can be said that TNCs impact on development is very uneven and therefore create or reinforce dualism and inequality of income (Siddayao 1978).

Apart from what has been discussed about TNCs, because of their greater technological capacity, the use of production techniques or substances that are often more ecologically damaging, and the larger volume of production that they characterise TNCs usually have a negative effect on the environment when they newly produce in, or export to (or increase their activities in) an area. With the increasing spread and market penetration and share of TNCs and big business concerns, the damaging environmental effects have increased.

There are clear differences in opinion between the economists and scientists regarding sustainable development. These differences in viewpoint arise in part from ambiguities in and disagreements about the real meaning of sustainability in terms of differing assumptions, perceptions and knowledge about:

- the importance of environmental conditions and processes in supporting the biogeochemical cycles,
- the sensitivity of these cycles to disruptions by human activities.

The rate of resource use exceeding the rate of resource generation by the biogeochemical cycles in the natural component would mean disaster to growth and development. IUCN (1991) in the 'Strategy for Sustainable Living' proposed that 'sustainable use means, use of an organism, ecosystem, or other renewable resources at a rate within its capacity for renewal'. Operating within the capacity for renewal is one of the key elements of sustainability. Daly and Cobb (1994) gave a wider scope of rate of resource use by specifying:

- rates of use of renewable resources must not exceed regeneration rates,
- rates of use of non-renewable resources must not exceed rates of development of renewable substitutes, as ingredients of sustainability.

It can be seen that whether sustainable development is an illusion or reality depends on the time frame attached to its definition. The definition given by Brundtland Report does not specify which future generation should be considered in the consequence of today's human actions. Nevertheless, it has an implication on resource use. Sustainable development could be a reality in the next 100 years as non-renewable natural resources are still available for the generations to come within the given time frame.

One can take a moderate view on sustainable development considering that models do not represent real world and infinite availability of non-renewable resources is an illusion.

The present reserves of energy resources should be managed to buy time for new technologies to be developed for harnessing other renewable energy resources. Depletion of petroleum resources is real and if no new feasible technologies for utilising other forms of energy resources are in sight, sustainable development is deemed unachievable and living in this world would be a nightmare for future generations.

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