A POSSIBLE CLASSIFICATION OF RENEWABLE RESOURCES IN THE CONTEXT OF SUSTAINABLE DEVELOPMENT

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Abstract:
In this paper is intended to achieve a classification of resources according to their sustainability. Every resource is classified according to the scarcity and the place where they are. The concept of sustainability is then examined critically and described in its constituent parts in order that each resource can be analysed in terms of its contribution to each element of sustainability. The total contribution - or impact – of each resource to sustainability is depicted in a sustainability classification wich differs in several respects from conventional theory and provides a basis for practical policy-making.

Key words: *environment, sustainability, classification, resources*

JEL classification: Q01

The key economic problems which occur and recur when considering all types of natural resources are scarcity, efficiency of allocation, depletion rates, intergenerational equity, and pollution externalities. Sustainability could be added to the list, although, unlike the aforementioned concepts, a precise definition of the term is not yet universally agreed. Progress towards a clearer vision of the concept of sustainability may be achieved by an analysis of the interrelationships which exist between ideas such as depletion, recycling, intergenerational equity and environmental impact. Consideration could be given to whether some combination of these interrelationships could form a usable definition of resource sustainability.

Conventionally, depletable and renewable resources have been treated very differently, and indeed certain types of renewable resources have been subject to a different analysis from other types. The traditionally accepted resources classification tends to define three types of natural resource with apparently quite different characteristics. First, there are non-renewable resources, into which category all minerals are placed. The second category comprises renewable resources, such as fish and forests, and thirdly, there are the renewable resources which depend on solar as water, wind and tide. Rees (1985) develops a relationship between the latter two classifications and describes renewable resources as either "critical zone" or "non-critical zone". Critical zone resources require management of demand in order that the critical regenerative capacity is not exceeded. If this capacity is exceeded, these resources become a stock – they cease to be renewable resources, and become depletable in the same way as coal or metal ores are depletable.

Some resources, however, do not require such careful management if they are to endure over the long-term. These resources, which we shall refer to as "continuous natural resources", traditionally include solar energy, wind energy and wave/tidal energy. Some forms of river hydropower schemes require infrequent maintenance to prevent silting, but this form of energy is sufficiently similar to the others in the "continuous natural resources" category to include it here. Energy producing schemes utilizing these resources will require periodic replacement of capital equipment, but their common future is that the energy source will endure over a very long time, with or without careful management by humans. As such, they are the ultimate sustainable resources and, potentially, they provide the solution to the problem of the depletion of more conventional energy sources. Such resources have the added advantage that, in the main, their environmental impact is often considered to be less than that of conventional fossil fuel or nuclear energy sources.

CLASSIFICATION OF RENEWABLE RESOURCES

With perfect foresight and perfect markets, as depletable resources become exhausted their prices will rise and at some “switch” price the transition will be made to a renewable, sustainable resource. So, as fossil fuels become more scarce, the increased cost of this form of energy would lead to a switch to even comparatively expensive (with current technology) solar energy.

Unfortunately, the true extent of many resources is not certain, not least because they lie beneath the surface of the earth. It was partly for this reason that, in the Limits to Growth, Meadows predicted that supplies of many resources would be rapidly depleted. The dire predictions of the imminent exhaustion of oil have proved thus far to be over /pessimistic because of discoveries of new reserves, new technologies allowing exploitation of hitherto inaccessible fields (and making each barrel of oil go further) and the substitution of oil by other fuels or renewable energy sources. That these changes were not foreseen only 25 years ago gives all indication of just how imperfect is our knowledge of resources.

The concept of uncertainty featured prominently in the conventional classification of resources devised by McKelvey (1974). This classification system distinguishes between reserves and resources. Reserves are geologically identified sources of minerals, while resources comprise those deposits not yet discovered or which current technology cannot exploit. Uncertainty is reflected in this geological dimension, while there is also an economic dimension which considers some resources to be subeconomic (recoverable only at more than 150% of current price levels) and some to be paramarginal (recoverable at between 100 and 150% 0f current price levels – Tabel 1).

Table 1: Classification for depletable resources

		Identified		Undiscovered	
		Demonstrated	Inferred	Hypothetical	Speculative
	Measured	Indicated			
Economic		Reserves			
Subeconomic	Paramarginal				
	Submarginal				

The terms and definitions used are:

Identified resources - Specific bodies of mineral-bearing material whose location, quality are know from geological evidence, supported by engineering measurements

Measured resources - Material for which quality and quality estimates are within a margin of error of less than 20%, from geologically well-known sample sites.

Indicated resources - Material for which quality and quality have been estimated partly from sample analyses and partly from reasonable geological projections.

Inferred resources - Material in unexplored extensions of demonstrated resources based on geological projections.

Undiscovered resources - Unspecified bodies of mineral-bearing material surmised to exist on the basis of broad geological knowledge and theory.

Hypothetical resources - Undiscovered materials reasonably expected to exist in a known mining district under known geological conditions.

Speculative resources - Undiscovered materials that may occur either in know types of deposits in favourable geological settings where no discoveries have been made, or in as yet unknown types of deposits that remain to be recognized.

A common feature of the analysis of all natural resources in the past has also been the lack of emphasis on the environmental costs of exploitation, and particularly the dynamic relationships which develop between environmental costs and both recycling and resources substitution.

An evaluation of the total cost of resource exploitation should therefore take into account not only conventional construction, labour costs, operating costs and resource scarcity, but also pollution costs and the dynamic relationship which exists between all these factors. In particular, the scope for recycling, which is depend not just on available technology but on the level of demand for the resource, its relative scarcity, price and physical characteristics, needs to be built into the cost formula. As a starting point in the quest for an holistic concept of sustainability in relation to natural resources therefore, it is necessary to move away from the traditional view of resources falling into separate defined compartments, and to consider all resources as occupying relative positions within a single natural resource classification system which places the near-exhausted zone) and the other (the green sustainable zone).

At first glace, it is difficult to take issue with such a resource classification. Clearly, the solar resource is incapable of depletion and, broadly speaking, globally available. At the other extreme despite continued upward revision of the global hydrocarbon reserve as new discoveries are made and extractive technology improves, the relatively limited nature of the resource, coupled to high global demand and the lack of any possibility of recycling, means that ultimately there is not escaping the depletable nature of the resources. However, the midrange resources in the classification are capable of moving left or right along the continuum as a result of changing price, demand, technological utilization and the volume of recycling. Thus, certain fish stocks could become so depleted through over-fishing or ecological change that they are incapable of renewal at previous rates, effectively moving to right in the resource classification. Equally, a significant rise in the price of a metal such as copper or aluminium, perhaps as a result of a fuller consideration of the environment costs of mining, processing and final disposal, could promote a much more intensive recycling programme which effectively moves the resource to the left on the resource classification.

Definitions of sustainability generally focus on the need to avoid environmental degradation, habitat and biodiversity loss and to ensure that natural capital (the resource base) is not squandered. The resources classification shown in Table 1 is a useful starting point for a more rigorous analysis of sustainability in relation to natural resources. Several factors need to be taken into account in order to formulate a spectrum of sustainability which represents not just the static but also the dynamic considerations mentioned earlier. First, the relationship between supply and demand must be considered. Supply is best considered in terms of McKelvey's definition of total resources, the total quantity of the resources, including as yet undiscovered quantities and disregarding exploitation costs. A spectrum of resources based on the ratio of demand to the resource base can be established. Resources that are almost depleted and which now require careful management of both supply and demand, score highly and will clearly be at the opposite end of the spectrum to solar energy, where the resources base massively outstrips current demand and a low score is achieved.

Second, the feasibility of recycling needs to be considered. The continuous natural resources – notably solar, hydro and tidal energy – effectively recycle themselves. On a crude rating of recyclability, based on a score of 1 representing resources that are totally recyclable by wholly natural forces and a score of 4 representing, the continuous natural resources score 1. Next, the critical zone resources such as forestry, fish stocks and wildlife need to be classified. Since their natural propensity to regenerate can be boosted by human intervention, these score value of 2. Resources which are capable of recycling but only through human intervention, when timescales shorter than geological and considered, score 3; examples are all metal ores, industrial minerals and aggregates. Finally, the fossil fuels, because of their incapacity for recycling within human time-horizons, score 4. Thus, a second axis can be added to the resource supply: demand ratio which classifies resources according to their recyclability score. This classification takes no account of the cost of recycling, merely the physical ability of the resources to be recycled. When the resources are examined in this light, it can be observed that the converse of the recyclability factor in the depletability score (a highly recyclable resource) the greater its resistance to depletion.

All the renewables have a recyclability score of 1 or 2, all non-renewables score 3 or 4. Equally expected is the position of renewable energy resources (such as solar and wind energy) in relation to the fossil fuels, oil and gas. The position of the sustainability arrow clearly indicates increased sustainability at a higher level and to the left and less sustainability lower down and to the right. It is the relative position of some of the mid/range resources which proves most notable. In particular, non-renewable stock resources of biomass, fish and forests. Whilst their individual characteristics clearly remain, what emerges from the analysis is that careful husbanding of the latter and increased attention to recycling in the former case / both of which are technically achievable at the current time - will render all these resources effectively sustainable.

The question of whether such an analysis amounts to a convincing definition of resource sustainability remains. A factor which has not yet entered the equation is the environmental impact of resource utilization. The Brundtland Report (World Commission on Environment and Development, 1987) have demonstrated that the issue of the environmental effects of resource utilization is at least as critical as the issue of depletion. Thus, this aspect must be addressed in and incredible attempt to definine resource sustainability. Difficulties of definition emerge at this point. Do we try to classify each resource by its impact on the different media of air, water, land, etc.? Do we classify impacts by intensity or extent? How do we set, for example, sulphur dioxide pollution of the atmosphere against loss of agricultural land or loss of cherished view? Also, should we consider not just the immediate impacts of exploitation but the ensuing impact of reduced stocks, reduced biodiversity and possible exploitation of substitute resources?

Clearly, a great degree of uncertainty will exist about these “second-stage” impacts. Where the resource has a large supply relative to the demand for it, as for example with aggregates, there is little likelihood of development of substitutes and therefore of consequent indirect environmental effects. With relatively limited supplies, however, the development of substitutes becomes increasingly likely, with an increasing probability of consequent knock-on environmental effects. The problems which may result from biodiversity loss are impossible to predict. Potential life-saving drugs may already have been lost because of tropical rain-forest destruction. The Conference on the Environment and Development in Rio de Janeiro in 1992 led to the signing of a treaty recognizing that nations should conserve the diversity of plant and animal species, and the Global Environment Facility Fund can provide funds to developing countries for this purpose. Setting a value on such potential losses or even predicting their occurrence is, however, difficult in the extreme.

Comparison and weighting of different types of impact is complex and beyond the scope of the present discussion. One useful method of impact classification which arguably encompasses some of the above-mentioned factors is a spatial analysis. Impacts can be assessed spatially – with:

1 - representing local;

2 - regional;

3- national/international;

4 - global – with some degree of confidence.

For each resource, the scores for supply: demand ratio and recyclability/depletability are totalled and divided by 2.

This analysis suggests that the vast majority of natural resources are capable of being regarded as sustainable, the only exception being those which are both scarce and completely incapable of being recycled. The established view of renewables and nonrenewables being separate and subject to different analysis is show to be largely irrelevant and unhelpful, as far as sustainability is concerned. Much more important in the consideration of the environmental cost of resource exploitation and the degree of commitment to recycling, either on the basis of environmental cost consideration alone, or on the basis that continued exploitation may have detrimental knock-on effects on the environment which are as yet unknown or unqualifiable. Thus, a precautionary principle needs to be considered, perhaps as a further element in the representation of sustainability.

This analysis is helpful in two ways. First, it provides an alternative view of resource classification, with the focus on the determination of what constitutes sustainability; it is a useful addition to theory. Second, it ascribes a relative position to specific resources on the basis of a multidimensional relationship, and provides a basis for policy making. Governments and agencies which had hitherto concentrated on attempts to diversify their energy bases away from fossil fuels into the classic technologies that use renewables can be seen to be acting very much in accord with this analysis. Their policy are sustainable. Perhaps more surprisingly, however, those who continue to exploit natural minerals such as aggregates, metal and diamonds may not be acting in an unsustainable fashion. As the environmental impact of mining these resources affects more and more areas, then in effect the growing environmental cost will force an increase in recycling or less intrusive methods of exploitation – underground hard rock mines, as opposed nature of some of these resources, the market is likely to produce a sustainable outcome.

Aggregates, for example, will continue to be exploited, with increasing attention given to environmental effects, until the point is reached where recycling of aggregate material becomes more economic than exploitation of fresh deposits. Metals and diamonds, which are much less common in terms of their natural occurrence, are likely to be subject to a similar process although, in this case, more as result of their relative scarcity than as a result of the environmental impact of their exploitation.

CONCLUSION

Incorporating longevity and recyclability in one scale –the resources sustainability classification allows us to also take into account environmental impact in our assessment of the sustainability of the resources. The spatial environmental impact value used here is limited and does not fully assess to impact on the environment of resource usage. A more complex analysis of environmental impact, taking into account not just spatial extent but also issues such as whether impacts are direct or indirect, beneficial or adverse, their duration and their intensity, could form an extension to the model set out here.

Nevertheless, the spatial measure of environmental impact allows us to construct the sustainability classification. All of the main contributors to resource sustainability are now incorporated within one diagram: recyclability/depletability, longevity and environmental impact. The sustainability classification accords with the tradition view of resources in that it sets depletables at one extreme and renewables at the other.

Breaking down the concept of sustainability into its constituent parts and analyzing resources in terms of how they impact upon each element of sustainability ought to result in a more precise understanding of the nature of resource sustainability. The correct assessment of how sustainable is the use of a resource has important policy implication which should be considered before decision are taken on issues such as energy policy, mineral extraction, agricultural regimes and in many other areas.

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