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MEASURING THE ENVIRONMENTAL AND ECONOMIC IMPACT OF ALTERNATIVE TECHNOLOGIES[1/]

by

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In defence of the proposition that there is nothing new under the sun two quotations may be offered. Thus:

> "A device has been discovered...called social valuation and consists in replacing the conception of social welfare defined as the sum of individual satisfaction by the dictate of some agent who decides what relative weights are to be attached to the (unmeasurable) desires of the members of society. That this agent is nothing but the *volonte generale* of the 18th Century should be clear; so should the danger that this agent may become but a name for the interests and ideals of the analyzing individual",1/

and

> "Of all the quacks that ever quacked, political economists are the loudest. Instead of telling us what is meant by one's country, by what causes men are happy, moral, religious or the contrary, they tell us how flannel jackets are exchanged for pork hams, and speak much of the land last taken into cultivation".2/

In further emphasis of the antiquity of the concerns of the present paper the additional thought can be invoked that:

> "The story of man's relationship with the natural environment dates back to the dawn of man's emergence as the dominant species on our Planet. It is indeed

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1/ J.A. Schumpeter, *History of Economic Analysis*, Oxford University Press, New York, 1955, p.1072.

2/ Quoted by Jacob Viner in "The Economist in History" in *American Economic Review*, December 1962.

inseparable from the story of man's own development".[3/]

The long-standing character of the concerns and difficulties with which this paper wrestles established, a number of caveats are necessary. One of these may be entered graphically and briefly by reflecting that the Partnenon has substantially survived the vicissitudes of time and activities which span the period from Periclean Athens to the present. In this Century the remains of the Parthenon have been, increasingly, one of the most splendid and inspiring of all tourist attractions. Very recently, however, the Greek Government has been forced to take a number of measures to ensure the continued preservation of the ancient temple. These measures have been made necessary, for in effect the first time in over two thousand years, by at least three distinct but related factors: industrial pollution, vibration caused by low-flying aircraft, and the sheer increase in the number of visitors. This example suggests that the scale of the problems considered in this paper have increased greatly in the recent past.

Indeed one way of illustrating the fact that the relationship of man to his environment is "inseparable from the story of /his/ own development", is to see that development in terms of an increasing command by man over the environment

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3/ Maurice F. Strong in the Introduction to *Development and Environment*, Mouton, Paris/The Hague, 1972.

and to trace out some of the consequences of that phenomenon. It is true that man - distinguished by his capacity for thought and even forethought - has always in one sense been the active partner in the relationship between himself and his surroundings. It is still true, of course, that the 'elements' are far from being under man's complete control. Drought in sub-Saharan Africa in recent years and the difficulties of the 1976/1977 winter on the Eastern seaboard of the United States testify to this. Outwith the realms of theology, however, the influence of the environment on man has been random and permissive rather than purposive. It would, however, be possible to write the history of man in terms of an increasing and increasingly purposive control over his natural environment. Such a history would, *inter alia,* make distinctions between the natural and man-made environments; and would, in a related way, note that man as an individual in modern societies lives substantially in a physical environment that is man-made and in a social environment that reflects the character of his contrived physical surroundings.

To recognize this, and to accept that man's effort to control his environment is now so far-reaching and so rapid and rapidly changing in its impact as to raise some substantial questions to a degree not previously relevant, need not obscure the point of the two initial quotations and the first thought on man and his environment. The element of

novelty, the extent of present problems notwithstanding, the quotations serve as useful reminders of the difficulties and dangers of seeking to measure complex outcomes in a summary way - and, indeed, quantitatively speaking, at all. They also serve as a reminder, in their different ways, of the long-standing scepticism of many (naturally mostly non-economists) towards economics and economists. In particular the implied separation - to the detriment of the economist and his 'science' - of the material and the more-worthy-than-the-material made by Carlisle has a familiar ring to even a casual student of much of the recent literature on the environment. It is doubtful if the suggestion that economists have particularly narrow vision is either accurate or helpful. Even at this early stage two things may be said in defence of economics. The first is that since resources are limited and aspirations infinite then economics (as a 'science' of choice) is necessary. The second is that (without prejudice to particular arguments about the relevance or otherwise of economics to the environmental debate) most economists have seen their subject as being concerned with the eradication of poverty and the enlargement of the range of human choice.

Nevertheless Carlisle's view for many puts economics and the economist in their place. On a more objective view, however, not the least of the difficulties in dealing with the subject matter of the present paper is that of deciding of what

the scope for economic analysis is. This difficulty is compounded by the fact that much contemporary economic thought aspires to the status of a positive science; whereas the problems of the environmental and economic impact of alternative technologies are to a substantial extent normative.

The problem of the relevance of economics is further compounded by the association between economic growth, on the one hand, and science and technology on the other. Thus, in the words of Professor Kuznets, the distinguished anatomist of modern economic growth, "science-based technology and the broad views needed for its successful exploitation by human societies were so dominant in the countries that sustained modern economic growth as to constitute a distinctive feature of the modern economic epoch". The 'broad views' referred to are worth cataloguing even if only *en passant*. They are suggested by three terms: secularism, egalitarianism and nationalism. The first means concentration on life on earth and consequent assignment of high rank to economic attainment. Egalitarianism is the denial of any innate differences among people except as these manifest in human behaviour. Indeed, again in the words of Kuznets, "one could go further and, at the danger of oversimplifying sociology, argue that it is the increased power of man over resources provided by science that constituted the basis for the view of man as captain of his destiny in this world (secularism) and erase the need for

mythological basis to justify the otherwise necessary higher economic returns to an upper-class minority (egalitarianism), since the general rise in per capita economic product made the remaining inequality tolerable on purely rational grounds". Nationalism is basically the claim of community of feeling on a variety of grounds. This said the essential point is that modern economic growth has resulted from the application of science and technology to the problems of production. Some insight into what this has meant can be had quickly from a brief glance at technological progress in the textile industry. The production of textiles formed the leading sector in the British (and first) industrial revolution. The original expansion of this production was based on a series of fairly crude mechanical improvements in shuttles and looms. In the present century technical progress in the production of textiles has been based increasingly on a scientific understanding of the properties of fibres, on electronic rather than mechanical improvement and in the application of computers to the problems of production and design.4/

The connection between science and technology and economic growth has been emphasised because the scepticism about economics has been repeated (often with interest - in the economic sense!) about the effects of science and technology. Certainly there is, many think, a case against contemporary technology. It depletes non-renewable resources at an unacceptably rapid rate, it pollutes and it dehumanises.

4/ A convenient statement of Kuznets' views are to be found in his *Modern Economic Growth*, Yale University Press, New Haven and London, 1966, pp.1-33.

At its most lurid, this case leads to the inference that "Faustian man will be dragged to death by his own machine".[5/] Less luridly and nearer to home, "the poisoning of one's local river by industrial effluent, the lung-disease induced by working with asbestos over many years, the sclerosis of our cities caused by the private motor car, or the sight of a Vietnamese child permanently scarred by the pellets of a fragmentation bomb" have all - properly - been laid at the door of modern technology. There is, however, another side to the coin. The detrimental effects of technology notwithstanding, life expectation is everywhere greater than it was 50 or 200 years ago, and, for many, levels of living are quantitatively and qualitatively better than those of their forefathers. This contrast between the advantages and disadvantages of science and technology based economic growth raises the question of the extent to which the application of science and technology to the problems of production can be made more purposive than hitherto. In a thoughtful essay one critic of the growth approach as embodied in the convention that economic welfare can be measured by the gross national product per head, has conceded that the GNP does serve as a faithful indicator of the "aggregate supply capacity of the country". He further concedes that, this being so, the subsequent

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5/ The quotation is from Spengler's *Decline of the West*. It has been widely quoted including by David Dickson in his *Alternative Technology*, Fontana/Collins, Glasgow, 1974. The case against contemporary technology is made out in this latter work (pp.15-40).

question is whether it would be possible to devise ways of improving the uses to which this capacity is put. He himself sees the answer to this question largely in terms of the institutional limitations of capitalism; but others see it differently.[6/]

In such circumstances of controversy and complexity to elaborate objective measures of environmental *and* economic impact of alternative technologies is clearly an extremely difficult undertaking; to have such measures accepted as objective is probably impossible. In the hope, however, of steering a course between unrestrained polemics and sterility the remainder of this paper is in three parts. The first discusses briefly the problems of the environment in the context of developing countries; the second considers the conceptual and practical limitations of economic analysis in the appraisal of alternative technologies; and the third, in the light of this, searches further for guidelines which might illuminate project appraisal in the developing countries when alternative technologies are considered and when environmental and economic considerations are taken into account.

6/ Shigeto Tsuru, "In Place of GNP", in the *Political Economy of Environment*, Mouton, Paris/The Hague, 1972, pp.11-25.

I. THE ENVIRONMENT

As could be inferred from the foregoing discussion, the debate on environmental questions was initially a phenomenon of the now developed countries. This was partly because the levels of affluence attained in these countries made it possible for eyes to be raised, as it were, from the hard grinding task of wringing a living from nature, partly because the technological underpinnings of the affluence had themselves dilaterious effects, and partly because the social consequences - such as urban decay and congestion - of development were also unpalatable. Given this origin developing countries were in the beginning suspicious and concerned. Part of the concern was that developed country efforts to improve the 'quality of life' in such countries would be undertaken to some extent at the expense of efforts to improve standards of living in the developing countries. Moreover, it was natural, to believe that the environmental problems being discussed were largely those that were manifest in the richer countries of the world.

Further discussion and reflection lead to a realization that the developing countries also had their environmental problems. To some extent these were problems that they had in common with the developed countries. For this there are two explanations. On the one hand, much development that has taken place in the poorer countries of the world has been

consciously or otherwise modelled on the developments of the richer countries. This has resulted in an economic and social dualism of which one manifestation has been extremely rapid urbanization. As a result of this the developing countries, it has been pointed out, suffer from the environmental problems of both medieval and modern European cities - they lack clean water, often and proper sewage facilities at the same time as they experience growing traffic congestion;[7/] and on the other hand there are some environmental problems which are global in their impact - nuclear fallout being perhaps the most graphic case in point.

Again, it has to be recognized that traditional activities in the developing countries also have their environmental hazards. This is perhaps particularly true of traditional agriculture which "in many tropical regions is characterized, particularly under stress of expansion, by a large range of environmental hazards".[8/] The hazards are serious. Thus, "the fragility of tropical ecosystems may cause environmental deterioration to proceed rapidly and their recovery to be slow. In one instance, the establishment of an agricultural colony failed when deforestation resulted in the hardening of lateritic fields within five years; restoration on the other will take decades. In another case previously ungrazed

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7/ This and many of the other points discussed in this section are made in *Development and Environment, op.cit.*

8/ *Op.cit.*, p.15.

savanna was destroyed by overgrazing in two to three years, and will probably be lost to production for a very long period."[9/]

To be reminded of these obvious links between the physical environment (natural or man-made) and development is useful. Perhaps, however, the most useful outcome of the period of reflection on the relationship between the environment and development has been the opportunity it afforded to stress that the main environment with which the developing countries should be concerned is that of poverty itself. In the developed countries it is appropriate to talk of improving the quality of life. In the developing countries the question is still much more one of sustaining life itself.

The environment of poverty is one which if it is to be replaced by a better environment requires that economic growth takes place. To be sure economic growth without development is to be avoided. There is, however, a very sharp limit on the extent to which development without economic growth is possible. This emphasis on the growth element in attempts to improve the developing country environment is extremely important. At the very least it makes it clear that the status quo is not acceptable; and that, when all

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9/ *op.cit.*

due regard is paid to tradition, distributional requirements and a strong emphasis on the basic needs (however these are defined) of the mass of the population, it is still necessary that economic activity should be so organized as to produce year in and year out a surplus available to add to the size and sophistication of the capital stock, the skills of the labour force and the arability of the land.

With this in view, it is convenient now to recognize that the distinction between the environmental and the economic in the context of the developing countries is somewhat artificial. It nevertheless serves analytical purpose to maintain it and in what follows a distinction will be drawn, at least to some extent between the economic and the environmental, where the latter adjective will be used to refer largely to the physical surroundings in which developing country people live and work.

II. THE RELEVANCE OF ECONOMICS[10/]

One of the most impressive intellectual achievements of neo-classical economics is the perfectly competitive model. Given the distribution of income and consumer tastes, and granted certain critical assumptions concerning knowledge and foresight, this model 'predicts' something like an ideal allocation of resources and consequently output from both an individual and social point of view. The model took a long time to build and it has never been without its critics. Even Alfred Marshall, who contributed much to the foundations of neo-classical economics, conceded the theoretical possibility that the distribution of resources and output resulting from competitive equilibrium could be 'improved' if industries subject to decreasing returns were taxed and those subject to increasing returns were subsidized. Marshall's recognition of externalities - the fact that costs might be incurred by and benefits accrue to individuals and institutions other than those originating them - came subsequently to play an important part in the thinking of economists about the social implications of resource allocation. In his *Economics of Welfare*, Marshall's famous pupil, Pigou, invoked the example of the

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10/ The discussion in what follows is confined to joint appraisal of environmental and economic impact. For a discussion of the methodology and difficulties of purely economic evaluation see J. Pickett, *A Report on a Pilot Investigation into the Choice of Technology in Developing Countries*, University of Strathclyde, 1975, Chapter III and for an economic evaluation of alternative sugar technologies see R. Alpine *Impact of Different Sugar Technologies on the Economic Environment*, UNIDO/UNEP Seminar, Nairobi, 18-22 April, 1977.

smoke belching forth from the industrial chimney stack. This smoke clearly represents a cost. It is, however, one which in normal circumstances would not be borne by the industry which generated it. Thoughts of this kind led to the distinction between social costs and benefits and private costs and benefits.

Although it may seem like an abrupt shift in the discussion it is nevertheless now appropriate to note that in the context of project appraisal (of which comparison of alternative technologies can be taken to form a part) the most widely known economic technique is that of cost-benefit analysis. In the present century at least this form of analysis owes more, in terms of its origin, to administrative necessity in the American public sector than it does to economic theory[11/]. In its most general form cost-benefit analysis informs project appraisal by seeking answers to the following questions: which costs and which benefits should be included in the appraisal? How should these be valued? What should the rate of discount be? And what are the relevant constraints?

There are at least two links between the competitive model and cost-benefit analysis. If perfect capital markets are assumed and are, as is logical, embodied in a perfectly competitive economy with a market rate of interest, then this rate can be taken as a measure of individuals' (equal) time

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11/ For a brief account of the origins, character, problems and applications of cost-benefit analysis see A.R. Prest and K. Turvey "Cost-Benefit Analysis: A Survey in *Survey of Economic Theory*, Vol.3, Macmillan, London, 1966, pp.115-203.

preference, and hence adopted as the social discount rate. In this circumstance market prices could also be used to put values on costs and benefits and on some views there would be no need for social as distinct from private cost-benefit analysis. Neither capital nor product nor factor markets are perfect in developing (or indeed in developed) countries. There are consequently some powerful limitations on the relevance of the competitive model. Nevertheless there is considerable temptation, sometimes yielded to, to simulate the competitive in order to seek to determine the prices at which costs and benefits should be valued. Such simulation underlies, at least implicitly, some guidelines widely used in project appraisal and it also underlies one of the first attempts (by Tinbergen) to estimate shadow prices.12/

The problems of valuation and discount rate apart, it is necessary to ask whether the general method of seeking to identify all relevant costs (regardless of by whom they are to be incurred) and all relevant benefits (regardless of to whom they are to accrue) and make them commensurate so that a single measure would be available either to yield a stop-go decision for a single project or to make possible the choice among alternative ways of carrying out a given project is an appropriate method of dealing with environmental and economic appraisal. The short answer to the question is, at best, up

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12/ For a critical consideration of this and other questions see A.K. Sen, *Employment, Technology and Development*, Oxford University Press, 1975, Chapter 11.

to a point. There are both conceptual and practical difficulties in seeking to extend project appraisal beyond the economic comprehensively to embrace the environmental.13/ Further, in the absence of perfect competition there is a danger that the use of cost-benefit analysis would give a pseudo-scientific character to value judgements and that it would telescope (and hence remove from the decision-taker's view the various elements which should be considered). Indeed it can be argued that even when applied to more narrow economic evaluation cost-benefit analyses the results of which are summarized in a single statistic such as the net present value of a project, obscure much information that would be useful to a decision-taker. Thus even in this case it could be argued that in addition to the single summary statistic, information on capital investment, employment and skill creation, the use of local resources etc. should be also placed before the decision-taker.

13/ For one relevant discussion see D.W. Pearce "Measuring the Economic Impact of Environmental Change" in O'Riordan and Hay *Environmental Impact Assessment*, Saxon House, 1976, pp. 142-166.

III. GUIDELINES FOR PROJECT APPRAISAL

If cost-benefit analysis is an inadequate instrument for the purposes on hand, alternatives have to be considered. These could include mathematical programming approaches which, in ideal circumstances, could provide a coherent treatment of many and interdependent variables and be used to supply information in considerable detail to decision-takers. Unfortunately, computational and data difficulties (and perhaps also the intrinsic complexity of the method) make this approach in practice less promising than its intellectual rigour would suggest.

Given this it is natural to turn to two related alternatives. If the search is for environmentally sound and economically viable projects, then it is certainly worth considering whether or not the decision-taking can be ordered by means of a filtering process. Certainly it is not difficult to imagine that some environmental tests would rule out even the most profitable of technologies. Thus, *if* it were certain that the use of the fast-breeder reactor would lead to widespread devastation of the earth and its inhabitants in a short period of time, then this would presumably rule out this technology even if it were vastly superior in economic terms to alternative ways of generating energy. It is unlikely, of course, that matters will either be as dramatic or as clear-cut as this, so that the judgemental element and a certain

arbitrariness in the procedures would probably be unavoidable. One interesting way of envisaging the filter approach is reproduced in Figure 1.[14/] The main difficulties of this approach are that it oversimplifies and it, of itself, cannot satisfactorily answer the question about the time ordering of the various elements in the filter. The main advantage is that it does set out in a coherent way many of the elements that somehow or other should be taken into account.

An alternative but broadly similar approach requires again a specification of stages and the construction of an impact assessment matrix. The columns of the matrix would refer to the various stages in the construction and operation of the project - the clearing of land, the planting sugar cane, the harvesting, transporting and processing of this cane, for example - and the rows would relate to the environmental and economic elements that would be affected by the project. Clearly such a matrix could be used to choose among alternative technologies as well as to give a simple go or no-go decision for a single technology.[15/] Again the main advantage of the approach is that it provides an explicit catalogue of the elements which have to be considered. The identification of a relationship between rows and columns neither, by itself, gives

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14/ This is taken from UNEP *Methodology for Selection of Environmentally Sound and Appropriate Technologies*, Discussion Note for Expert Group Meeting, August 30-September 3, 1976, Nairobi. This note contains an excellent discussion of the problems associated with the approach.

15/ For a discussion of the approach in a developed country context see B. Clark "Evaluating Environmental Impacts" in O'Riordan and Hay, *op.cit.*, pp.91-103.

indication of the intensity or character of the relationship nor does it yield any means of weighing advantages and disadvantages in order that a decision can be taken.

The most secure conclusion that can be drawn from the foregoing is that much remains to be done in the elaboration of an operational methodology. In the meantime it may be suggested that, particularly given the importance of the economic environment in developing countries, alternative technologies can be compared first by means of extended and explicit cost-benefit analysis and subsequently examined for particular environmental effects that escape - necessarily - the net of such analysis. In this approach the question of valuation is, of course, left open and the more straightforward environmental impacts could be accommodated in the analysis. Thus accommodated they should, of course, remain explicitly before the decision-taker at the point of decision. The coverage of the cost-benefit analysis would clearly vary from case to case. In principle, however, the method - with, to repeat, due emphasis on making as much explicit as possible - amounts to chosing the economically viable technology subject to a somewhat informal constraint that it is also an environmentally sound one. Much subsequent work could be directed to increasing the formality of the constraint.

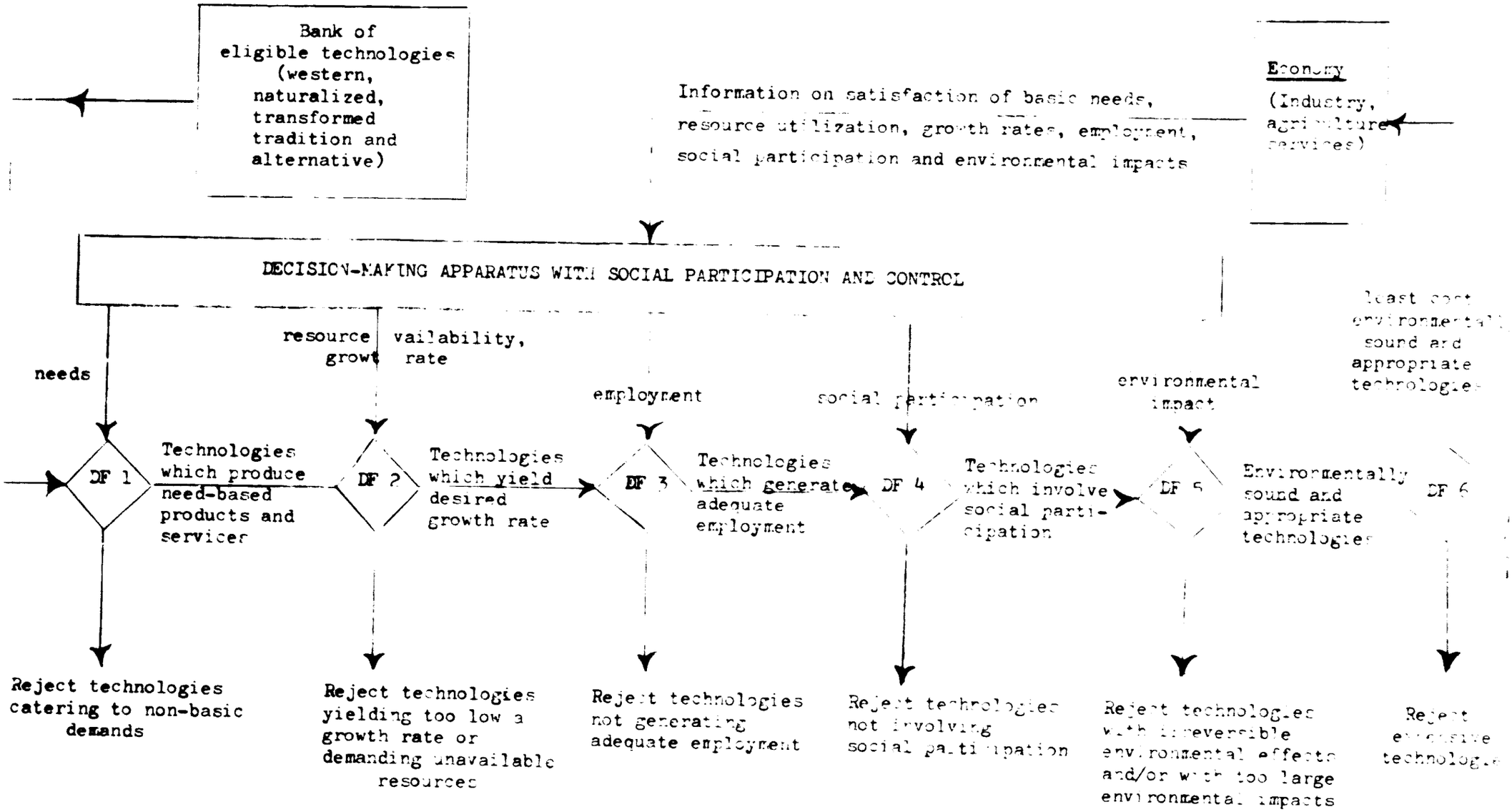

Figure 1: Design Filter approach to the selection of environmentally sound and appropriate technologies

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