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The Role of Technology in Sustainable Development

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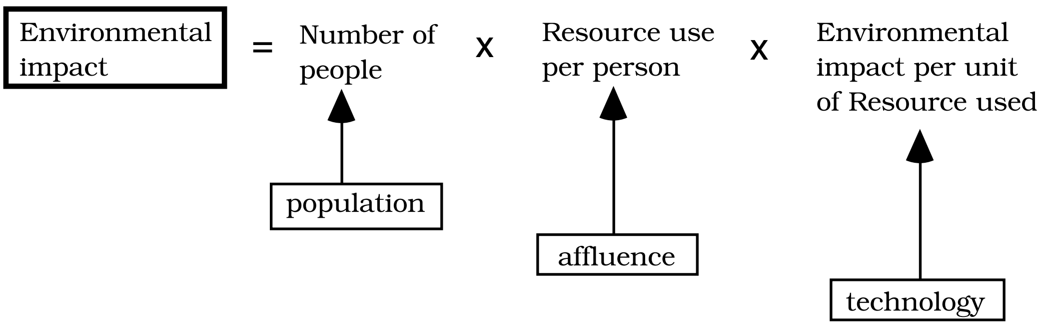
There is a great reliance on technology to solve environmental problems around the world today, because of an almost universal reluctance by governments and those who advise them to make the social and political changes that would be necessary to reduce growth in production and consumption. Yet the sorts of technological changes that would be necessary to keep up with and counteract the growing environmental damage caused by increases in production and consumption would have to be fairly dramatic. The technological fixes of the past will not do. And the question remains, can such a dramatic and radical redesign of our technological systems occur without causing major social changes and will it occur without a rethinking of political priorities? Technology is not independent of society either in its shaping or its effects.

At the heart of the debate over the potential effectiveness of sustainable development is the question of whether technological change, even if it can be achieved, can reduce the impact of economic development sufficiently to ensure other types of change will not be necessary.

Figure 1. The factors determining environmental impact.



Sustainable development policies seek to change the nature of economic growth rather than limit it. They are premised on the belief that continual growth in a finite world is possible through the powers of technology, which will enable us to find new sources or provide alternatives if a particular resource appears to be running out. Otherwise, technology will help us use and reuse what we have left in the most efficient manner. The tools of sustainable development—economic instruments, legislative measures and consumer pressures—are aimed at achieving technological changes such as recycling, waste minimisation, substitution of materials, changed production processes, pollution control and more efficient usage of resources.

The British Pearce Report [i] suggests that resource usage can be dealt with through recycling and minimising wastage, and that the damage to the environment from disposing of wastes can be minimised in a similar way: “Recycling, product redesign, conservation and low-waste technology can interrupt the flow of wastes to these resources, and that is perhaps the major feature of a sustainable development path of economic progress.”

CLEAN TECHNOLOGY VS END-OF-PIPE REMEDIES

In the past, efforts to clean up the environment have tended to concentrate on ‘cleaning technologies’ rather than ‘clean technologies’—that is, on technologies that are added to existing production processes to control and reduce pollution (end-of-pipe technologies and control devices). The alternative to end-of-pipe technologies is to adopt new ‘clean’ technologies that alter production processes, inputs to the process and products themselves so that they are more environmentally benign. Clean technologies are preferable to end-of-pipe technologies because they avoid the need to extract and concentrate toxic material from the waste stream and deal with it.

It is suggested by Cramer and Zegveld [ii] that process technologies should be used that require less water (for example, by alternative drying techniques), energy and raw materials, and that reduce waste discharges (for example by developing detection and separation machinery and process-integrated flue-gas cleaning and filter systems). Also, raw material inputs and processes can be changed so that, for instance, solvent-free inks and paints, and heavy metal-free pigments are used. The end products can be redesigned to reduce environmental damage during both manufacture and use, and waste flows can be reused within the production process rather than dumped.

The Organisation for Economic Cooperation and Development, OECD[iii], found that most investment in pollution control was being used for end-of-pipe technologies, with only 20 per cent being used for cleaner production. Cleaner technologies are not always available and, even when they are, companies tend not to replace their old technologies until they have run their useful life. Also, companies prefer to keep to a minimum the organisational changes that need to be made; they like to play it safe when it comes to investment in pollution management.

The problem with measures such as end-of-pipe technologies is that they are technological fixes that do not address the cause of the problem. Such fixes can often cause other problems:

> A target for improving the efficiency of the combustion of fossil fuels is to convert all available carbon in the fuel into carbon dioxide. On the other hand, carbon dioxide is a major greenhouse gas. Moreover, our means of achieving better thermal efficiencies is

> by increasing the temperature of the combustion process. A result of increasing temperature, however, is that more oxides of nitrogen are formed from the air used in combustion. Oxides of nitrogen are an important element in the formation of photochemical smog. Thus, in the pursuit of more efficient energy usage, it is possible other potentially undesirable side-effects may arise.[iv]

Barry Commoner [v] argues that a spiral of technical fixes occurs because of the failure to correct the fundamental flaw that technology is subject to in our society. He says that “if technology is indeed to blame for the environmental crisis, it might be wise to discover wherein its ‘inventive genius’ has failed us—and to correct that flaw—before entrusting our future survival to technology’s faith in itself.”

A common reaction to the litany of problems attributed to technologies is to argue that the problem is not so much in the technology but in how it is used or abused. Technologies themselves only become environmentally harmful if they are not applied with due sensitivity to the environment. Another reaction is to argue that technologies often have unexpected side-effects or second-order consequences that were not originally designed into the technology. Pollution is one such side-effect that is never intended by the designers of technology. However, Commoner does not accept these views, arguing that: “These pollution problems arise not out of some minor inadequacies in the new technologies, but because of their very success in accomplishing their designed aims”.

Commoner points out that plastics do not degrade in the environment because they were designed to be persistent; similarly, fertilisers were designed to add nitrogen to the soil, so it is not an accident that they add to the nitrogen reaching the waterways. Part of the problem, he argues, is that technologists make their aims too narrow; they seldom aim to protect the environment. He argues that technology can be successful in the ecosystem “if its aims are directed toward the system as a whole rather than at some apparently accessible part”.

He gives sewerage technology as an example. He says that engineers designed their technology to overcome a specific problem: when raw sewage is dumped into rivers, it uses up too much of the river’s oxygen supply as it decomposes. Modern secondary sewage treatment is designed to reduce the oxygen demand of the sewage. However, the treated sewage still contains nutrients which help algae to bloom; and when the algae die they also deplete the river of oxygen. Instead of this piecemeal solution, Commoner argues, engineers should look at the natural cycle and reincorporate the sewage into that cycle by returning it to the soil rather than putting it into the nearest waterway.

Commoner advocates a new type of technology that is designed with a full knowledge of ecology and the desire to fit with natural systems.

APPROPRIATE TECHNOLOGY- A DEAD MOVEMENT?

Attempts to invent and design different types of technology that fit with natural systems are not new. The appropriate technology movement which blossomed in the 1970s attempted to do just this. Appropriate technology has been defined as "technology tailored to fit the psychosocial and biophysical context prevailing in a particular location and period".[[vi]] It was designed not to dominate nature but to be in harmony with it.

Appropriate technology involves attempting to ensure that technologies are fitted to the context of their use—both the biophysical context which takes account of health, climate, biodiversity and ecology, and the psycho-social context which includes social institutions, politics, culture, economics, ethics and the personal/spiritual needs of individuals.

One of the best-known early proponents and popularisers of appropriate technology was the British economist E. F. Schumacher [[vii]], who talked about 'intermediate technology' in his book Small is Beautiful: A Study of Economics as if People Mattered. He was principally concerned with development in low-income countries, and recommended a technology that was aimed at helping the poor in these countries to do what they were already doing in a better way.

During the mid-1970s, the appropriate technology movement expanded from its initial focus on low-income countries to consider the problems in industrialised high-income countries. Advocates of appropriate technology were concerned about social as well as environmental problems.

Robin Clarke [[viii]] differentiated between the appropriate technology response and the 'technological fix' responses to environmental problems. For example, he characterised the technological-fix response to pollution as "solve pollution with pollution control technology"; the appropriate technology response, instead, would be to invent non-polluting technologies. Similarly, the technological-fix response to exploitation of natural resources was to use resources more cleverly; the appropriate technology response was to design technologies that only used renewable resources.

The appropriate technology movement has been going for more than twenty years in many countries, and today involves an extensive network of organisations, projects and field experiments, and an identifiable literature of its own. Despite this, it has failed to influence the pattern of technology choice exercised by mainstream society. Kelvin Willoughby [8], a US scholar who has studied this movement, points out that it has:

> achieved a modestly impressive track record of successful projects which lend weight to the movement's claims. Despite these facts, however, together with the appeal and commonsense nature of the movement's core ideas, the movement has largely failed to evoke the transformation of industrial and technological practice in most countries in accordance with the principles of Appropriate

> Technology. In other words, while becoming a significant international movement Appropriate Technology has remained a minority theme within technology policy and practice.

WHY ALTERNATIVE TECHNOLOGIES ARE NOT ADOPTED

Not all technological options and alternatives are developed or explored. Although this is often because alternatives are more expensive or less economical, there are often other reasons, too. Even today many firms are not implementing technologies aimed at waste reduction and minimisation, despite their availability and probable cost savings. The reluctance of many engineers to take up alternative technologies can be explained partly in terms of technological paradigms. This is a term borrowed from Thomas Kuhn [[ix]] who postulated in 1962 that science progresses through periods of 'normal science,' which operates within a scientific paradigm, interspersed with periods of 'scientific revolutions'.

Several writers have applied the concept of a paradigm to technological development. Edward Constant [[x]] argued that the routine work of engineers and technologists, which he called 'normal technology', involves the 'extension, articulation or incremental development' of existing technologies. A technological paradigm or 'tradition', Constant said, is subscribed to by engineers and technicians who share common educational and work experience backgrounds.

Giovanni Dosi [[xi]] described a technological paradigm as an 'outlook', a set of procedures, a definition of the 'relevant problems and of the specific knowledge related to their solution.' Such a paradigm, Dosi said, embodies strong prescriptions on which technological directions to follow and ensures that engineers and the organisations for which they work are blind to other technological possibilities. Richard Nelson and Sidney Winter [[xii]] also observed that a technological paradigm or regime will define for the engineer what is feasible or at least worth attempting:

> The sense of potential, of constraints, and of not yet exploited opportunities, implicit in a regime focuses the attention of engineers on certain directions in which progress is possible, and provides strong guidance as to the tactics likely to be fruitful for probing in that direction.

As a result, technological development tends to follow certain directions, or trajectories, that are determined by the engineering profession and others (see Figure 2). Ideas are developed if they fit the paradigm; otherwise, they tend to be ignored by the mainstream engineers, the bulk of the profession. An example is the development of sewerage engineering. The range of ways of treating sewage is limited by a sewage treatment paradigm that assumes that sewage will be delivered in pipes to centralised locations near waterways. Treatment is classified into three stages—primary, secondary and tertiary, which build upon one another. The first stage is to remove some of the solids from the sewage; the second stage is to decompose the sewage; and the third stage either removes more solids or decomposes the sewage further. Any new technology will only be thought of or developed if it can fit within this system.

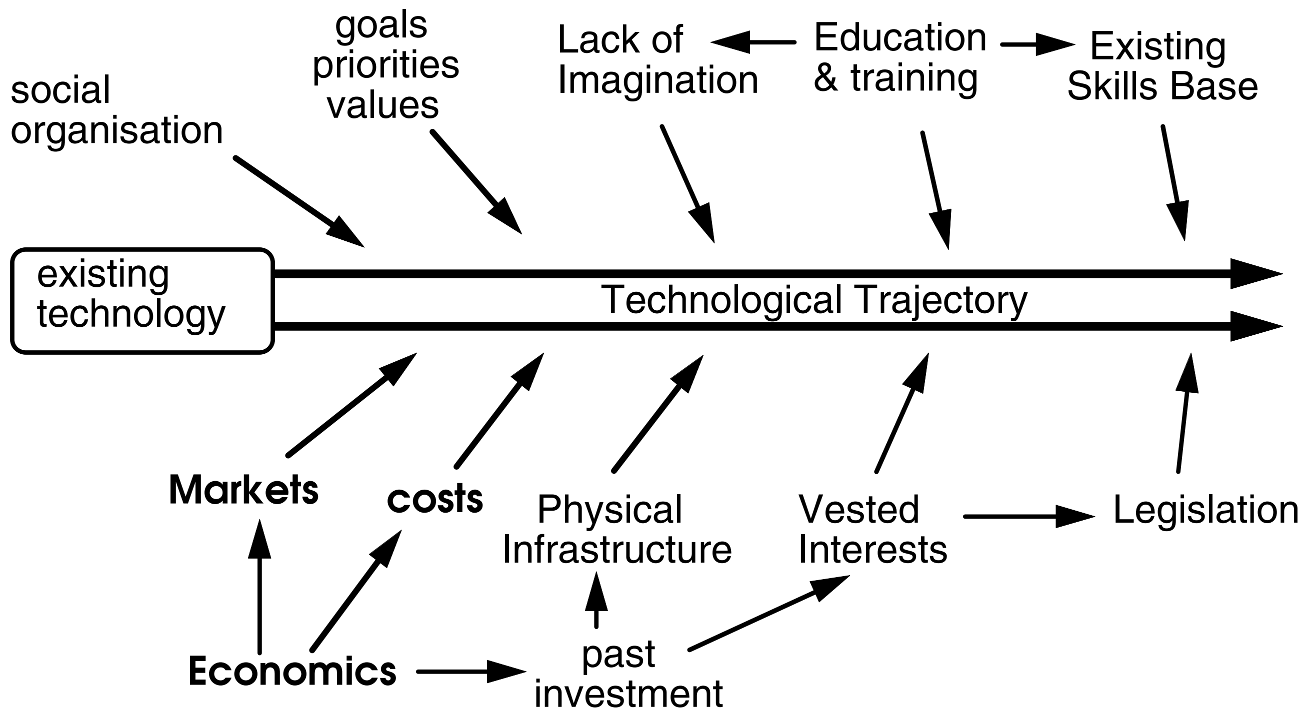


Figure 2: Factors that constrain the direction of a technological trajectory

Generally, technological change is gradual and occurs within technological paradigms. Radical technological innovation is often opposed by firms because of the social changes that may need to accompany it—for example, changes to the work and skills of employees, to the way production is organised, and to the relationships between a firm and its clients and suppliers.[4] Dutch scholar Johan Schot [xiii] argues that radical technological change can only occur if the social context also changes.

Firms may also have vested interests in particular technological systems. According to McCully [xiv]:

> The reason that the USA is the most polluting nation in the world has little to do with a lack of energy efficient technologies or renewable methods of producing electricity: it has a lot to do with the size of the country's oil, coal and automobile industries and the influence they have on the political establishment. In the UK, the public transport system is expensive, unreliable and infrequent, not because the government cannot afford to improve it

> or does not know how, but because the vested interests behind public transport have negligible power compared to the influential road and car lobbies.

Because of the reluctance of governments to act against business interests, legislation and economic instruments are seldom tough enough to foster technological change of the type required for ecological sustainability. Although such regulation would probably strengthen business in the long run, business people see strong government intervention as an infringement on their autonomy. Commoner [xv] argues that business people are supported in this because there remains a strong public conviction "that the decisions that determine what is produced and by what technological means ought to remain in private, corporate hands."

Langdon Winner [xvi] has argued that most people in the appropriate technology movement ignored the question of how they would get those who were committed to traditional technologies to accept the new appropriate technologies. They believed that if their technologies were seen to be better, not only in terms of their environmental benefits but also in terms of sound engineering, thrift and profitability, they would be accepted.

Winner says that appropriate technology was generally seen as a way of effecting change without challenging the established power structure of western societies. This allowed a sense of optimism that had been lacking in the ranks of those who were unhappy with the direction and values of the societies they lived in. They believed that, as the new technologies caught on, social change would follow:

> As successful grass-roots efforts spread, those involved in similar projects were expected to stay in touch with each other and begin forming little communities, slowly reshaping society through a growing aggregation of small-scale social and technical transformations. Radical social change would catch on like disposable diapers ... or some other popular consumer item.

Not all advocates of alternative technologies ignored the social and political dimensions, however. David Dickson [xvii] recognised the difficulties that would be encountered by those proposing radically different types of technology when he proposed the name 'utopian technology'. He said that he used the word 'utopian' because an alternative technology could "only be successfully applied on a large scale once an alternative form of society had been created".

However, many of the advocates of appropriate technologies made no attempt to understand how modern technologies had been developed and why they had been accepted or why alternatives had been discarded. Winner claims that "by and large most of those active in the field were willing to proceed as if history and existing institutional technical realities simply did not matter".

It is important not to put too much emphasis on technological factors without considering the social, political and economic factors that can be crucial in the shaping and implementation of technologies. It seems that those pinning their hopes on technology to deliver to us a sustainable future may well be doing the same thing. Having the technological means to reduce pollution and to protect the environment does not mean that it will automatically be used.

CONCLUSIONS

Sustainable development relies on technological change to achieve its aims but will governments take the tough steps that are required to force radical technological innovation rather than the technological fixes that have been evident to date? Such measures would require a long-term view and a preparedness to bear short-term economic costs while industry readjusts.

Even if cleaner technology can be implemented will the reductions in pollution be enough? Cramer and Zegveld [4] argue that they will not, if production continues to grow. Giving the example of their own country, where the purchasing power of the average person is expected to increase by 70 per cent by the year 2010, they argue that "an incredible reduction in discharge levels and waste flows per product unit would have to be realised to achieve the aim of a sustainable society". They believe this is not realistic. On top of this, production would need to increase ten times if everyone in the world were to live at the same standard of living as those who live in affluent countrie. They claim that the growth of both production and freely disposable income would have to be restricted if pollution levels are to be reduced.

It would appear that so long as sustainable development is restricted to minimal low-cost adjustments that do not require value changes, institutional changes or any sort of radical cultural adjustment, the environment will continue to be degraded. Unless substantial change occurs, the present generation may not be able to pass on an equivalent stock of environmental goods to the next generation. "Firstly, the rates of loss of animal and plant species, arable land, water quality, tropical forests and cultural heritage are especially serious. Secondly, and perhaps more widely recognised, is the fact that we will not pass on to future generations the ozone layer or global climate system that the current generation inherited. A third factor that contributes overwhelmingly to the anxieties about the first two is the prospective impact of continuing population growth and the environmental consequences if rising standards of material income around the world produce the same sorts of consumption patterns that are characteristic of the currently industrialised countries." [[xviii]]

Even if people put their faith in the ability of human ingenuity in the form of technology to be able to preserve their lifestyles and ensure an ever increasing level of consumption for everyone, they cannot ignore the necessity to redesign our technological systems rather than continue to apply technological fixes that are seldom satisfactory in the long term.

Technological optimism does not escape the need for fundamental social change and a shift in priorities. That was the mistake many in the Appropriate Technology Movement made. It takes more than the existence of appropriate or clean technologies to ensure their widespread adoption.

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