
Environmentally Sound Technologies: Some Policy Perspectives

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Introduction

Technology plays a crucial role in accelerating development. So far, there is not a single agreed definition of what constitutes technology. According to the UNIDO Manual on Technology Transfer Negotiation, "technology" has been defined as a "system of knowledge, skills, experience and organisation that is used to produce and utilize goods and services".

In most literature, technology is considered to have a hardware component (physical product or means such as machines or processes) and the software component (know-how). Most recently though, technology has been defined as an embodiment of the following four major components:²

- (i) object-embodied form or the technoware (i.e physical facilities such as machines, equipment, tools etc.);
- (ii) person-embodied form or humanware (i.e human abilities such as skills, experience, knowledge, diligence etc);
- iii) document embodied form or infoware (i.e recorded facts such as designs, specifications operating procedures, theories, manuals etc.); and
- (iv) institution embodied form or organware (i.e organisation framework such as management practices, linkages, organisational arrangement etc.);

The above four components interact with each other in the production of goods and services.

As described above, technology is usually conceived and developed to operate in a particular environment. Among the major technology suppliers are the industrialised countries [ICs] of Europe, North America, Japan and the newly industrialised countries (NICs) of the South such as Brazil, Argentina,

Mexico, India, South Korea, China, etc. These countries generate technologies first and foremost for their own local needs and in order to remain industrially and economically competitive. Some of the technologies are, however, exported to other countries for varying reasons under special terms and conditions as part of the international technology trade. Thus the horizontal transfer of technology from one country (technology supplier) to another country (technology recipient) constitutes what is generally known as the international transfer of technology (ITT). The other form is the vertical transfer of technology which essentially involves translating local R & D results into usable products, their dissemination and diffusion to the society.

So far developing countries are the major importers of technology from the industrialised and newly industrialized economies. Tanzania does not possess adequate local technological capability to generate her own technology for production of goods and services. Therefore, to a large extent Tanzania will continue to rely on foreign sources of technology for a long time to come. The same can be said of many other developing countries. Although imported technologies are desirable insofar as they help developing countries to achieve their production capabilities and allow them to achieve economies of scale and offer opportunities for economies of scope, some of the imported technologies have contributed significantly to the environmental pollution problems in these countries.

There are other obvious positive factors associated with imported technology. However, it is not the intention of this paper to discuss these. Rather, the paper is aimed at discussing the introduction of technologies or processes which have negative environmental consequences to the recipient countries and the extent to which the negative effects could be avoided or minimised.

Technologies and Industrialisation

It is hard to talk of industrialisation in isolation of the technology being used. Technology should, in this context, be seen as one of the main proponents of industrialisation process. Similarly, through the process of industrialisation and incremental changes, further technology is generated. Therefore, like any process of change, industrialization has both the good side and the bad side. The bad side is linked with the use of bad technology and/or processing techniques which result in environmental pollution and other negative social consequences. Among well known problems of industrialisation is perhaps the emission of carbon dioxide (causing the green-house effect) and sulphur dioxide (producing acid rain), all due to the burning of fossil fuels (coal/oil) as a major source of non-renewable energy.

The North, which accounts for only 20% of the world population consumes 85% of the global non-renewable energy and, therefore, contributes substantially to global environmental pollution. Other environmental pollutants emitted into the atmosphere include the chlorofluoro-carbons emitted due to widespread use of aerosols and refrigerators. This form of pollution greatly threatens the earth's ozone layer. On the other hand, industrial effluents and

toxic wastes pollute rivers, lakes and the sea and, therefore, threaten the marine life.

To most developing countries there is very little choice as to the source of technologies being used and their deleterious effects. In most cases the choice of the technologies has been made by financiers or donor agencies, or by politicians in these countries. Coupled with the lack of information on sources, types, appropriateness and up-to-datedness of the technology being sought and/or supplied, developing countries are at a disadvantage and often find themselves at the mercy of donor countries and technology suppliers.

In many developing countries the process of technology acquisition and transfer is conducted in an ad hoc manner with no or little coordination and close monitoring of the transfer process.

Industrial development in Tanzania

The impact of industrial activities on the environment in Tanzania is now being felt through pollution of rivers and the atmosphere. It is a well known fact that most of the industries have been conceived without taking into account environmental considerations. About 80% of Tanzania's industries are located in urban areas and over 50% of these are found in large cities. Furthermore, the concept of environmentally sound technologies is still new and unfamiliar to industrialists, policy, and decision makers in developing countries.

The industrial establishment in Tanzania dates back to the 1950s when a rudimentary industrial base for processing a limited range of consumer goods, based on cash crops export began. These included sisal processing, coffee curing, cotton ginning, tea processing, meat canning and wax extraction industries. A few manufacturing industries like aluminium, iron and steel rolling mills were also established during the same period as were three chemical plants and two textile mills.

After independence, in 1961, the government pursued a policy of import substitution. New industries sprung up including fertilizer and cement production, the oil refinery, textile mills and others. The desire to provide goods and services was given a higher priority in setting up such industries. The introduction of these modern industries was made possible through the importation of foreign technologies.

With the structural adjustment programmes advocated by the World Bank and the International Monetary Fund (IMF), the main emphasis is now on the privatisation of the existing industries. Most of these industries are beset with numerous problems such as lack of capital, aged and outdated machinery and equipment, lack of spare parts, lack of routine maintenance, poor management and lack of technological capability for innovation.³¹

Environmental Pollution

Although Tanzania is not highly industrialised, environmental pollution is already emerging as a serious problem. Man utilises his environment in his

struggle for development. It is therefore important to ensure the continued availability of the natural environment for sustainable development. Technology plays a crucial role in this regard.

Previous trends in technology transfer arrangements in Tanzania never took into consideration the environmental aspects of such technologies. This has had a major repercussion on what we see today; a good number of industrial activities being highly polluting to the environment, including those in such sector as agriculture, energy and transport. On the other hand, these may have been the best technologies at that time and were probably not as deleterious to the environment as we see them today.

It is worth noting however, that technology that may initially appear clean may not eventually be environmentally-friendly due to mal-operations by poorly qualified technical personnel, low level of maintenance, lack of spare parts and absence of environmental legislation. Technologies currently generating liquid and solid wastes as well as gaseous emissions containing chemical compounds pose enormous hazards to the environment, and are in such sectors as industry, agriculture, energy, transport, etc.

The most known type of pollution experienced in Tanzania so far is aquatic pollution (i.e pollution of lakes, rivers and sea). Other forms of environmental pollution include air and noise pollution. However, from the number of people affected, water pollution can be singled out as the major environmental pollution problem in the country.

Industries are a major source of water pollution. This is perhaps due to poor planning resulting into poor factory location and adoption of inappropriate manufacturing, waste recovery and process technologies, dumping into aquatic environments industrial wastes whose recovery and process technologies result into industrial wastes that are laden with toxic compounds such as mercury, lead, pentachlorophenol, chromium, sulphide, contaminating drinking and irrigation water. The subsequent sections will focus on pollution problems and possible technological innovations required to reduce wastes.

Agro-Industry

These include sugar, sisal, vegetable oil/fat refineries, dairies, breweries, abattoirs, cotton ginneries, distilleries, starch and coffee processing factories, tanneries, etc. Many of these industries are located in rural areas.

(a) Food Processing

Food processing industries produce high organic wastes containing nitrogen and fermentable starches, fats and blood, spent molasses, etc. Most of these industries do not have treatment facilities for their effluents and solid wastes end up in the nearby rivers and in other water bodies adversely affecting fisheries and other life forms.

(b) Sugar Production

The sugar factories are located where sugarcane is grown. Molasses and other by-products are discharged into streams and ponds. The factories do not have

treatment plants for their effluents and the waste water recycling techniques are not practised.

(c) *Tannery*

Chromium is one of the chemicals used in the tanneries process. Rinsing of hides/skin involves running water continuously through revolving drums. Water required could be cut by half by introducing a process of three sequential washes.

Heavy Industry

These include Tanzania Fertilizer Company (TFC), the Southern Paper Mills (SPM), Tanzania and Italian Petroleum Refinery Company, (TIPER) and the three cement factories, in Dar es Salaam, Tanga and Mbeya.

(a) *Tanzania Fertilizer Company*

TFC is located in Tanga about 2km off the town centre and 200m away from the sea. It used to manufacture different types of fertilizers. The major types included triple superphosphate and compound fertilizers which contain nitrogen, potassium and phosphorous. Sulphur dioxide and sulphur trioxide, hydrogen sulphide and ammonia gases and dust used to be emitted into the atmosphere through a 100m high stack. The gases caused environmental and health hazards for the people living adjacent to the factory. Effluent from the factory was discharged into the sea. TFC is now out of production.

(b) *Southern Paper Mills*

SPM is located at Mgololo in Iringa region. The mill discharges sulphur dioxide, sulphide and dust through its 70m stack. These pollutants are dispersed into the villages and the nearby tea plantations. In the bleaching process, chlorine, caustic soda and sodium hydrochloride are used. Chlorinated compounds resulting from bleaching are coloured and non-biodegradable and the gas is extremely poisonous. Liquid effluents emanating from the bleaching section are coloured and, to a certain extent, toxic. An estimated 27 million litres of treated water is used for washing and cooling purposes in the mill per day.

(c) *The Tanzania and Italian Petroleum Refinery Company*

TIPER is situated at Kigamboni, some 3km from the city centre. The refinery is designed for a through put of 750,000 t/p.a., process. Through the oil refinery process, sulphur compounds (i.e hydrogen sulphide, sulphur dioxide, minor quantities of mercaptans, etc) are emitted to the atmosphere through a 30m high stack thus causing air pollution. Hydrogen sulphide and mercaptans are known to be the source of odours in the nearby areas frequently causing nausea, frequent headaches, stomach upsets, etc.[4].

(d) *Cement Mills*

Cement plants are characterised by dust discharge especially during production of cement. Dust is an air pollutant. In these factories, the principal pollutants

include particulates, carbon dioxide and sulphur dioxide. The point sources of pollutants are the kilns which operate at high temperatures; the dry drilling operation in limestone quarries (fine silica dust); and cement mill chimneys. Dust is also a nuisance at cement discharge points over cement silos. For example, due to poor performance of electro-precipitators at the Wazo Hill cement factory near Dar es Salaam, the factory loss is estimated at 100t/day from the three kilns at full production.

Intermediate and Light Industry

Intermediate and light industries in Tanzania include the textile mills. Waste water from textile mills contains fibres, a variety of chemicals such as inorganic salts, organic acids, starch, hydrogen peroxide, detergents, alkalis, urea and waste products from dyes of the Polyester and Canvas Mills in Morogoro which use an fluent treatment plant consisting mainly of stabilization ponds and chlorination. This treatment is quite inadequate. The other mills do not have waste water treatment facilities.

Energy Sector

The majority of the Tanzania population use wood fuel as a source of domestic energy but energy conservation has not received adequate attention. The ever increasing wood energy demand has resulted in forest clearing leaving large areas treeless.

Transport Sector

The poor state of the economy has resulted in a decline in the state of the transport system. Maintenance is more often not carried out on roads or on vehicles as a result of which the poorly combusted gases are emitted from vehicles. Heavy traffic congestion, especially in Dar es Salaam, could be responsible for large quantities of emissions into the atmosphere.

Constraints to Mitigation Fund

The underlying causes of industrial pollution problems in Tanzania are partly historical and partly due to socio-economic development problems facing the country. The major contributing factors are the uses of inappropriate and deleterious technologies, lack of awareness on cleaner production technologies, lack of local technological capability and lack of a coherent policy and strategies for replacing existing absolute and deleterious technologies. Lack of investment capability in acquiring and diffusing newer and cleaner technologies and lack of capability to introduce minor changes to the existing technologies are also a major hindrance.

Environmentally Sound Technologies

Environmentally sound technologies are technologies aimed at sustaining development through producing better while at the same time polluting less.

They are essentially clean in the sense that due consideration is taken of environmental concerns⁵. A clean technology is a process of fabrication allowing the reduction of an effluent polluting the environment, more rational use of raw materials and energy at a reasonable and economic price. According to Bizri,⁶ three main categories of environmentally sound technologies can be identified:

First, processes and materials that are developed for neutralizing the environmentally harmful effects of a given operation without necessarily introducing fundamental modifications in the original process. These are the so called "end-of-pipe" remedies. They include treatment plants for liquid wastes, filters and scrubbing units for gas emissions, treatment and recuperative methods for solid wastes, etc. Technologies in this category are more rapidly developed and assimilated and often represent incremental changes or additions to the existing plant structure.

Second, process modifications e.g. the introduction of monitoring and control techniques to existing processes, changes in raw or intermediate materials which may be incorporated in existing technologies to minimize adverse environmental impacts of the process. Examples include the introduction of control and computerised optimization technologies in conventional industries to reduce undesirable by-products. Technologies in this category are less rapidly developed and assimilated than those in the first category despite the fact that minimizing the generation of polluting substances targeted by environmentally sound technologies in this category is often more effective.

Third, novel and traditional technologies that are inherently sound from an environmental point of view e.g. solar and wind energy technologies, membrane separation and other novel industrial transformations based on biotechnology. Technologies in this category have become less widespread than those in the second and first categories probably because they involve more radical transformations which require prohibitive investment outlays.

Among the contributing factors to environmental pollution is that in most cases, environmental protection, water treatment and energy consumption were not taken into consideration during project initiation and design phases. Furthermore, the type of technologies currently in use in various Tanzania industries are certainly outdated, highly polluting and water and energy intensive. Although consciousness on environmental impacts is growing among the general public, the national environmental policy will need future technology transfer arrangements and environmental protection.

Constraints on cleaner technology transfer to developing countries are closely related to known obstacles to technology transfer in general, some of which are enumerated below.

Lack of Policy and Strategies

Tanzania does not, at the moment, have a coherent policy and strategies for dealing with (and replacing) inappropriate and deleterious technologies. It is

only fairly recently that Tanzania launched the National Conservation Strategy in an attempt to have environmental conservation incorporated in planning at all levels of the Tanzanian society.

Lack of Awareness of Environmentally Sound Technologies

The concept of cleaner technologies is new to local industrialists and policy makers. Awareness of environmental concerns in general is still low, as is the awareness of cleaner production and environmentally sound technologies.

Lack of Environmental Research and Technology Innovation

Cleaner technologies or environmentally sound technologies refer to technologies designed specifically to prevent waste emissions at the source of generation, as opposed to treating them at the end of the production process. Cleaner technologies include recycling processes and product reformulations, substitution with less hazardous feed-stocks and installation of more efficient equipment. Cleaner technologies are not common in this country and are not well known because the majority of industries in Tanzania were not conceived with cleaner production in mind.

A survey carried out by the National Environmental Management Council (NEMC), in conjunction with the Ministry of Water, Energy and Minerals and the University of Dar es Salaam has revealed that most of the textile industries in Tanzania use much more water than they should because water recycling is hardly practised.^{7,8} Furthermore, all the tanneries use continuous rinsing method in their production processes, a method which requires the use of a lot of water. Introduction of sequential washing methods could have reduced water usage by 50%. One of the contributing factors to the above mentioned problems is that there is hardly any research being done in the country. Furthermore, lack of awareness on the part of management personnel on environmentally sound technologies for both economic competitiveness and pollution control aggravates this problem.

Financial Constraints and Economic Incentives

The cost of a clean technology may pose a stumbling block to technology acquisition in developing countries. The added lack of economic incentives for industries in developing countries amplifies this cost factor. The cost differential between conventional and cleaner technology is further aggravated by the lack of legislative framework promoting cleaner technologies. If legislation or regulations do not penalise polluting technologies by obliging manufacturers to use add-on technology for pollution control, then it is clear that cleaner technologies will be more expensive than conventional technologies especially if economic incentives are not available. These incentives could include subsidies for those choosing to introduce cleaner technologies.

Legislation

Lack of, or limited enforcement of, legislation creates uncertainty for

prospective investors and discourages foreign or national investment in cleaner technologies. In cases where regulatory mechanisms are already in place, they should be enforced.

Absorptive Capacity

A given technology must work under conditions conducive enough to sustaining the desired optimum functional level of that technology. Appropriate technical personnel, sufficient funds for adequate maintenance in the recipient country are among the important factors for the absorption and maintenance required for the optimal functioning of the imported technology.

Constraints to Environmentally Sound Technologies: Solutions

The substitution of deleterious technologies by environmentally friendly technologies involves huge capital investments. As a result most operators in industry have opted for add-on technologies, optimising existing processes or developing novel technologies which may in future take the lead.

Chemical Industry

The chemical industry has been concentrating on identifying and reducing pollutants by adding effluent treatment and scrubbing units to existing processes. A few operators have succeeded in optimising operations in order to reduce fugitive emissions and waste generations. An example is the introduction of membrane separation to replace mercury-based techniques in the calor-alkali industry. Some firms have been able to substitute dangerous organic chemicals and trichloroethylene with less hazardous alternatives.

Energy Sector

Rising energy consumption has resulted in deforestation, especially in the Third World. Use of fossil fuel can be avoided through exploiting renewable energy sources. Energy conservation and efficiency enhancing technologies are environmentally sound technologies in the energy sector. The introduction of "Dodoma cookstove" and of the "Jiko Bora" in Tanzania represent some of the efforts made in indigenous technology innovation.

Agricultural Sector

Intensive methods of agriculture greatly contribute to environmental problems. Mechanization requires treeless areas and a widespread use of chemical fertilizers and pesticides. Large scale mechanization can be moderated if advanced technologies are used such as pest eradication and breeding more suitable varieties of plants and animals for higher productivity. Integrated pest management, suitable diversified cropping patterns and the use of more environmentally sound fertilizers should be encouraged.

Transport Sector

Environmentally sound technologies in the transport sector fall into three main categories.⁶

- (a) catalytic converters that render pollutants from gasoline and diesel engines harmless;
- (b) technologies that reduce fuel consumption and, therefore, minimize quantities of pollutants emitted; and
- (c) more advanced technologies based on non-polluting fuels such as hydrogen and solar power.

Another area that requires attention is the improvement of transportation networks through redesigning of roads, terminals and traffic patterns to ease congestion and energy consumption.

Establishment of Data Bases

Information on the sources and choice of environmentally sound technologies plays a crucial role in identifying, selecting and acquiring the right technology. Databases should be developed that will enable local enterprises secure relevant information on these technologies. Currently, the Centre for the Development and Transfer of Technology (COSTCH) at the Tanzania Commission for Science and Technology (CDTT) is establishing a database on sources of foreign and local technologies. It also provides advisory services on technology selection, sourcing, technology contracts, drafting and negotiation.

Endogenous Capacity Building in Process and Engineering Design

Environmentally sound technologies are relatively new. There is, therefore, little or no cumulative experience on their operation in the developing countries. As a matter of strategy, developing countries should evolve local technological capabilities in process and engineering design in order to be able to modify and introduce minor changes into the existing technologies taking into consideration the peculiarities of each country.

Improving Research Capability

There is a need for the government to put priority on research on technology development in general, and environmentally sound technologies in particular. The government should also provide support to institutions engaged in environmental management and research and to industries in order to arrest industrial pollution. Research on environmentally sound technologies should be given a high priority. Furthermore, technologies which allow the use of closed loop water cycles should be used to the extent that the production processes allow. Wherever possible, recycling of residues as well as the use of by-products of one industry by another should be encouraged.

Establishment of Institutional Framework to Assess Cleaner Technologies

When discussing environmentally sound technologies in Tanzania, the reference is naturally to imported technologies. Considering its technological level of development, Tanzania will for a long time depend on imported technology. This, therefore, calls for selectivity in importing and using foreign

technologies through devising an elaborate and coherent mechanism of technology choice and transfer, taking into account the link between the social carriers of the techniques and the local technological capability. These capabilities should be oriented towards creation, absorption, adaptation and diffusion of specific technologies that are in line with the country's development goals.

Thus, application of environmentally sound technologies should go hand in hand with the establishment of an institutional framework to assess and monitor these technologies. The Tanzania Industrial Research Development Organisation (TIRDO) has recently been nominated to host a Cleaner Production Centre with the assistance of UNIDO. Also fairly recently, TIRDO and the Institute of Marine Science (IMS) of the University of Dar es Salaam have been chosen to be among 10 Third World Centres of Excellence and will together be upgraded to what will be known as the International Centre of Industrial Technology and Marine Science (ICITEMS). Support for the establishment of such centres of excellence has been provided by the Third World Academy of Sciences (TWAS). Moreover, the recently established Centre for the Development and Transfer of Technology will help to streamline the choice for cleaner technologies and eliminate the use of deleterious technologies in the country.

One problem experienced so far is the lack of both the capacity and capability to assess and evaluate imported technologies, and to carry out environmental impact assessments. There is a need to innovate or even adapt existing technologies to contain undesired environmental effects. Of prime importance, at least in the short term, is the need to generate endogenous technological capability for assessment, negotiation and internalisation of environmentally sound technologies. Of crucial importance also is the ability to identify environmentally sound technologies through deliberate technology prospecting and making rational choices of such technologies. So far, most of the technologies being used in the country have been donor-funded with little or/no choice by the recipients.

Institutional Framework for Standards and Quality Control

Strengthening and upgrading the existing institutions(s) through capacity and capability building is a prerequisite if technology and product standards and quality assurance are to be maintained.

Making Use of Local Resources

Comparative advantage does exist in the country in cheap labour force to engage in recycling of materials which is essentially labour intensive.

Promotion of Awareness on Environmentally Sound Technologies

There is an urgent need to promote awareness of environmentally sound technologies to industrialists, decision and policy makers in the country. This, it is hoped, will facilitate easy adoption of these technologies which have the potential of stimulating indigenous industries due to their inherent advantages in lowering the cost of production.

Summary and Conclusion

The growing industrial sector in Tanzania is creating industrial pollution problems similar to those experienced in the advanced industrialised countries. The underlying causes of industrial pollution problems in Tanzania are partly historical in that pollution prevention and control has not evolved as part and parcel of industrialization. Other contributing factors include use of inappropriate and deleterious technologies, lack of policy and strategies for replacing inappropriate and deleterious technologies, lack of awareness among the local industrialists, policy and decision makers on cleaner production as well as lack of environmental research on cleaner technologies.

There are a number of obstacles in respect of applying cleaner technologies in Tanzania in a bid to control industrial pollution problems. These include the inability to make proper choices of technology to be acquired, lack of investment capability to acquire such technologies and, above all, the problem of donor-driven technology supply syndrome. Awareness creation on cleaner technologies, especially to policy and decision makers and industrialists, could perhaps assist towards charting out better strategies and policies to counteract the prevailing situation.

From studies conducted elsewhere, it is evident that developing economies in general, and Tanzania in particular, with galloping population pressures experience ever increasing demands for industrialisation and maximum exploitation of natural resources in order to accelerate and sustain development. Environmental pollution associated with industrial activities is a major cause for concern in these economies. Therefore, deliberate measures have to be taken to arrest this situation. One of these measures and efforts include the utilisation of environmentally sound technologies. This will remain an important element for abating industrial pollution in these countries and, therefore, calls for a need to incorporate environmental impact assessment in the complete process of technology planning. This, however, necessitates the creation of a mechanism for technology, assessment, choice and monitoring which is a prerequisite for developing endogenous technological capability for carrying out the above tasks.

Through the recently established Centre for the Development and Transfer of Technology at COSTECH, the Centre for Cleaner Production at TIRDO, the International Centre for Industrial Technology and Marine Sciences also at TIRDO, the National Environmental Management Council (NEMC), the Ministry of Tourism National Resources and Environment and other allied bodies, it should be possible to deal with the general and specific aspects of environmental concerns due to importation, development and use of environmentally unsound technologies through incentive based regulatory and promotional measures.

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