Technology Transfer in a Globalizing World: Many Promises, Lack of Responsibility, and Challenges for Africa

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List of Abbreviations and Acronyms

AIJ	Activities implemented jointly
BHL	
BZD	Beijing Heavy Electrical Machinery Works
CBD	Convention on Biological Diversity
CDM	Clean Development Mechanism
CFCs	chlorofluorocarbons
CNTIC	China National Technical Import Corporation
COP	Conference of the Parties
CWE	China International Water and Electric Corporation
DAEs	Dynamic Asian Economies
DCs	Developing countries
DFI	Direct foreign investment
FCCC	Framework Convention on Climate Change
GATT	General Agreement on Tariffs and Trade
GHG	Greenhouse gases
HCFCs	hydrochlorofluorocarbons
HFCs	hydrofluorocarbons
HPEA	DAEs Dynamic Asian Economies
ICOLP	Industry Cooperative for Ozone Layer Protection
ICs	Industrialized countries
ICTs	Information and communication technologies
IMF	International Monetary Fund
ISI	Import substitution industrialization
ITCC	
ITDC	Independent technology development capacity
ITLC	Independent technology learning capacity
JI	
JICA	
KEPCO	Korea electric power company
KNE	Koprea Nuclear Engineering Company
KOPEC	
KOSAMI	Korea Society for the Advancement of Machine Industry
MCI	Ministry of Commerce and Industry

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1. Introduction

In numerous international fora and global gatherings, Africa has often been promised a wide range of technologies from the rich industrialized countries of the North. Such pledges are made in the context of global concerns to pull Africa out of grinding poverty and, in the process, propel her on a path of sustainable economic change. Vast commitments have studded the pages of global conventions and protocols, the latter being agreements reached in international conferences that in effect, epitomize global efforts at international cooperation. For example, the post-Rio (Earth Summit, 1992) products such as the Convention on Biological Diversity (CBD) and the Framework Convention on Climate Change (FCCC), among others, are dotted by sterling technological commitments. Clearly, such formal assurances foster the impression that Africa's circumscribed access to vital technologies has remained a critical constraint in her efforts to catalyze the process of sustainable development.

Yet, in both principle and purpose, the imperative to technologize Africa has largely remained lip service. One view is that the rich industrialized countries have neither been keen nor enthusiastic in keeping their promises on the grounds that significant technology transfer to Africa would jeopardize their competitive advantages in the foreseeable future. There is another perception that Africa is guilty of not doing enough. Not only have Africa's efforts been shallow, inchoate, flawed, and poorly conceived, but she has also demonstrated technical negligence by failing to learn from robust technology acquisition experiences in Asia and elsewhere. This lack of dynamic protectiveness has profoundly hampered Africa's unenviable endeavours at technologization.

This paper attempts to analyze the two views cited above. The discourse is structured as follows: First, the paper describes the controversies surrounding the technology transfer issue, and then proceeds to discuss the various established modes employed in that transfer. Second, the paper not only examines the technology transfer commitments made by the industrialized countries as embodied in a selected number of international agreements and conventions, but also seeks to understand why the powerful signatories have largely failed to fulfil their side of the bargain. Third, the discourse reflects on several insightful international experiences on this score, and in this context, proceeds to distil the main determinants of a successful technology transfer process. Finally, the paper dissects some African cases in a bid to reveal both problems and prospects of technological change. In conclusion, strategies are proposed, including the potentials offered by the information and communication technologies (ICTs) in enhancing the robust technologization of the region.

2. The Technology Transfer Process: Concerns, Contentions and Controversies

Early technology studies focussed considerable attention on the issue of technological transfer and how it generated dependence. Within that purview, several observers raised concerns about the wide range of constraints that governed the flow of technology from the North to the South. Technology transfer relations came to be seen in commodity terms, though the tool of cost-benefit analysis shifted emphasis from sterile analysis to a more critical assessment of the phenomenon.

In the 1970s, UNCTAD initiated a series of steps on regulations of technology transfer. A code came into being in 1977 to govern techno-global intercourse, one that sought a more equitable conduct in the technology trade. Unfortunately, this model continued to perceive developing countries as passive receivers of technological innovations. Yet forces were at work, at both the domestic and global levels, that affected the evolution of technological capabilities in developing countries.

2.1 Technological Capabilities and the Transfer Process

In 1974, in the wake of sharp international disparities in economic power, industrialization and material welfare between the North and the South, developing countries began to voice major concerns about the injustices in the global economic system. They argued that the global structures and institutions of trade and exchange were lopsided, and stacked against the development of the so-called Third World countries. In solidarity, the developing countries called for a *New International Economic Order* - a series of demands and proposals meant to restructure global economic relations for greater equity among nations.

Developing countries suggested fundamental reforms in the global order and asked for major concessions from the North. Apart from the broader issues of trade, aid and the international financial system, an area of central concern to developing countries was access to foreign technology. Connected to this vital question was the role of Transnational Corporations (TNCs) in the transfer of technology. To assist in this process, developing countries demanded the preparation of a *Code of Conduct on Transfer of Technology* and also the formulation of the *Draft Code of Conduct for Transnational Corporations*.

Both these documents illustrate the importance attached to technology issues by developing countries in the economic process, and how the central agents of technology production, ownership, and control — the TNCs —— could be regulated to maximize benefits in the South.

However, despite the growing recognition of the importance of technology to developing countries (DCs) and the intensifying internationalization of communication between states, the transfer of technology from the industrialized countries has been insignificant.

Two issues are said to be at the heart of this paltry flow.[1] First, is the concern that developing countries have found it difficult to *secure access* of ICTs because of the *severe terms and conditions tied to the technologies*. The nature of the international patent system, the limited access by DCs to patented and non-patented technology, the massive restrictions imposed on transferred technologies, and the overwhelming control by TNCs over technology flows, are all prohibitive to developing countries.

Following the apparent success of OPEC, in the immediate aftermath of the 1973 energy crisis, many developing countries began to forge new alliances in their bid to secure benefits from an international system which in their perception perpetuated sound and economic injustice. To a large extent, the new status of OPEC created the circle to confront the system through organized compromise. The huge inflows of petrodollars for oil-producers dramatized the vulnerability of the external factor, and how organized responses to it could generate benefits of the OPEC-kind, and minimize both dependence and widespread malaise in developing countries.

Disillusionment with the prevailing global economic system could be traced to the development failures which marked the first UN Development Decade. Economic strategies designed to reduce poverty, foster industrialization and enhance standards of living failed to fulfil the rising tide of expectations. Above all, the promise of sustained benefits expected from freer international trade and based on neoclassical market notions did not generate the predicted changes. The global economic system policy-makers in the Third World continued to reflect upon the structural rigidities of the global economic system, which they blamed for much of the slow progress and pace of transformation.

The urgings for a New International Economic Order (NIEO) in 1974 were seen against this background of mounting disenchantment. The new demands clearly identified the world environment as the villain, and sought to restructure that environment for any meaningful development to take place. Contents of the NIEO agenda illustrated the central "environmental" concerns in international relations, which included a renegotiation agenda on debts, terms of trade, market access, International Monetary Fund (IMF) reforms, and development assistance. All these facets are strongly external in orientation, and point to the concern that prevailing conditions in developing countries are externally induced.

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[1]See Singer, H.W. (1988) "Transfer of Technology. A One-way street" in H.W. Singer, N. Hatti, and R. Tandon (eds.) Technology Transfer by Multinationals, Ashishi Publishing House, New Delhi, p.4.

Formal endorsement of aspirations by the UN General assembly in 1974 was followed by a new wave of technological demands that cited a critical imbalance between developing and industrialized countries in the transfer process.

There was an argument, widely shared, that the world system perpetuated technological dependence of developing countries on industrialized states even though the achievements of science and technology were regarded as the "common heritage of mankind" a public- good image that became increasingly untenable under the intellectual priority system. A spate of emerging studies provided an abundance of riveting data that gave the challenge an aura of statistical and moral justification. In the 1950s and 1900s, the dependence theorist and ECLA studies had stirred controversy and generated consciousness in many developing countries. New research findings gave extra visibility to the stark differences in income, trade, financial flows and balance of payment. The most conspicuous agent in international trade was the Multinational Corporation (MNC), characterized by a world-wide network of operations and global control of technology and its benefits.

It is against the background of international disparities in technological control and in the disparities in the distribution of economic benefits that developing countries launched a major drive in 1974 to secure advantages from a lop-sided global system. In May that year, negotiations began for the formulation of a code of conduct on the transfer of technology under the auspices of *the United Nations Conference on Trade and Development* (UNCTAD).

Vaitsios' study (1974) demonstrated that industrial investment activities in developing countries were largely characterized by MNC involvement. Direct Foreign Investment (DFI) was the predominant form of technology transfer though other mechanisms like licensing or management existed. The study argued that existing modes of the technology transfer process were costly and overpriced; and the technology transfer process was owned by multinational subsidies dominating the local market. At the same time, technology transfer was restricted from involvement in defined areas and markets. Vaitsios (1974) also stated that transnational transactions were characterized by significant capital repatriations through transfer pricing.

The issue of inappropriate technology with respect to developing countries was given prominence by Stewart (1973) when linking the choice of product and the technique available to produce it. In other words, the choice of technique and its characteristics is a mere fall-out from the choice of the product.

Second, the transfer process has also posed problems to developing countries in view of the*perceived disjunction* and dysfunctional anomalies of the ICT in a Third World environment. It has been argued that given the specific factor endowments, the technology developed in ICTs has *limited relevance*, *suitability* or even *appropriateness* in a recipient developing country.

These explored themes brought to the fore two critical interrelated concerns. First, a number of policy studies addressed the issue of relevance of MNCs in the industrialisation and technology transfer context of developing countries. Farell (1979) asks whether MNCs transfer technology at all, drawing distinctions between state and dynamic technology on the one hand, and consumption and production technology on the other. Vaitsios (1974) even questions the appropriateness of the word 'transfer' used in technology transactions, and observes that the knowledge transferred in most cases covers routine operations. This issue of relevance also highlighted the appropriateness of the techniques of production employed in the light of resource endowments of developing countries. Neo-classical economics assumed the existence of an infinite range of techniques available with varying combinations of capital and labour, but the capital intensive technologies introduced in developing countries conflicted with the labour abundant requirements for appropriate technologies. Stewart (1973) argues that the neo-classical framework is empirically misleading, in that all techniques are available that would guarantee, for any relative and absolute factor endowments, full employment. She observes that:

> "Historical analysis of the development of techniques suggests a far more limited range of efficient techniques than that suggested by the neo-classical approach" (1973:117)

Sen (1979), operating within the neo-classical assumption, argues that there exists a single optimum technique of production that maximises output, employment and savings per unit of investment. The question of choice is therefore illusory on account of this view of technological determinism.

Appropriate technology became the new catchword in the lexicon of technology transactions for Third Word countries. The concept came to refer to labour-intensive, low-cost, small scale, basic needs-oriented technology, a kind of "….technology mix contributing most to economic, social and environmental objectives in relation to resource endowments and conditions of application in each country… An important overall objective of appropriate technological choice would be the achievement of greater self-reliance and increased domestic technological capability, together with the fulfilment of other development goals."[2]

Schumacher (1973) employed the term *intermediate technology*, which he defined as:

> "…Equipment cost per workplace … (which) would fit much more smoothly into the relatively unsophisticated environment in which it is to be utilised. The equipment would be fairly simple and therefore understandable, suitable for maintenance and repair on the spot. Simple equipment is normally far less dependent on raw materials of great purity or exact specifications and much more adaptable to market fluctuations than highly sophisticated equipment. Men are more easily trained, supervision, control and organisation are simpler; and there is far less vulnerability to unforeseen difficulties."[3]

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[2] UNIDO (1978), International Forum on Appropriate Technology, Vienna, p.23.
[3] Schumacher (1973) Small is Beautiful, Bloud and Buggs, London, p.151.

The earliest concerns over appropriate technology, therefore, focussed on choice of technique in relation to resource endowments and unemployment. According to Kaplinsky (1978), this scope has a limited vision, and analysis of appropriateness should encompass technological self-reliance, indigenous participation and economic restructuring to reduce income inequalities. Muller (1980), however, is critical of the concept in general, and argues that it reflects a way of thinking rather than defining a specific set of technologies. Despite this objection, the concept enhanced understanding of technological search processes, and contributed a theoretical angle to the perspective of technological development at large. But more important, it sensitised some aid and UN-agencies about basic need demands of developing countries. New regulations and mechanisms were instituted to influence the conduct and behaviour of MNCs and to ensure the extraction of maximum advantages in the distribution of costs and benefits. The formulation of the *Code of Conduct for Transnational Corporations* and the *Code of Transfer of Technology* are aspects of response to policy studies that highlighted the link between MNCs, choice of technique, and appropriate technology.

According to Alam and Langrish (1981), developing countries should establish stronger links with non-multinational firms as alternatives to MNCs in the transfer of technology. Advantages include lower rates of royalty, less equity participation and the tendency to use less elusive and more diffused technology.

2.2 Technology, Technology Policy, and Technological Change

To understand how the forces conditioned and shaped the technology transfer process, it would be instructive to first appreciate technology's real meaning, on the one hand, and its strategic significance in the context of development, on the other.

Technology is knowledge related to production, distribution, products, processes, repair, maintenance, and so on. Bell (1984) views technology from three levels: first, technology is embodied in the capital goods, engineering and managerial services, product and process capacity, or creates new production facilities. Second, it includes knowledge and skills related to operation, maintenance, and the repair of production facilities. This category is further broken down into paper-embodied and people-embodied technology, the former referring to knowledge codified in manuals, blueprints, books, operating procedures, flow charts and so on, while the latter consists of knowledge, skills, experience, and expertise embodied in people involved with the production capacities in all their diversity. Third, it consists of knowledge, skills, expertise, and experience used in generating and managing technical change. This last category is distinguished from the previous two in that it focuses on either incremental or radical innovations, or both. Pavitt (1985) observes that technology can also be tacit, uncodified, and cumulative within firms.

As regards the ambition to achieve technological advancement, Basalla (1988) has advanced six major assumptions. Technological progress has:[4]

[4]See Basalla, G. (1988) ***The Evolution of Technology***, Cambridge University Press, London, p.211.

(i) accelerated the growth of civilization by bettering our material, social, cultural, and spiritual existence;
(ii) led to decisive improvements in the products we use;
(iii) succeeded in giving man mastery over nature, thereby serving human interests and aspirations more broadly;
(iv) made it possible to undertake activities with greater speed and efficiency by exploiting new sources of power;
(v) brought within human control the origin, direction, and influence of technological change; and
(vi) received credence from the evidence that western industrialized countries have reached the highest stage of civilization from technology.

If, as discussed above, technology is that strategic and a decisively significant variable, then economies wishing to promote prosperity, engender sustainable livelihoods, and enhance dynamic development would have to devise ways of coming to terms with this phenomenal imperative. This is where *technology policy* looms into relevance. Technology policy is defined here as the conscious and deliberate manipulation of budgetary and other resources to influence the rate and direction of domestic technological change. Technological change can also be spurred by *science policy*, which the author defines as the conscious and deliberate manipulation of budgetary and other resources to influence the rate and direction of inventiveness in an economy. If a system can translate scientific discoveries into tangible commercial innovations, then the frontiers of technological change would have expanded with all the attendant consequences this change would entail. But science policy, though instrumental, is not of concern here because the focus of this exploration is *technology transfer* and why Africa has generally failed in systematizing, institutionalizing, and entrenching the process of domestic technological change. Africa can cite many compelling cases of technological success, but in the grand totality of temporal and spatial technological concerns, such triumphs are too few. Therefore, it is vital to understand the causes responsible for this dismal state of technological affairs in the region.

Djeflat (1988) states that trade in technology has been analyzed according to two approaches that have offered limited insights to policymakers and decision makers. The first approach has treated technology as though it was like any other traded commodity, while the second has viewed its exchange as complex and onerous to fathom. Both these perspectives have failed to appreciate the idiosyncratic and unique features (for example investments in its production, ownership, and so on.) For this reason, these approaches have been poor in unearthing and analyzing key issues associated with technology and its transfer.[5]

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[5] Djeflat, A. (1988) "The Management of Technology Transfer: Views and Experiences of Developing Countries"

African governments have virtually never invoked crucial technological dimensions, either systematically or proactively, as *strategic targets* to guide techno-industrial change. This has been all the more disappointing considering that most African states have Science and Technology Policy frameworks which appear as Acts enacted by national parliaments.

The role of a technology policy framework is to systematize and institutionalize the process of technologization, i.e., to steer, direct, and guide economic investments in ways that ensure the operationalization and conscious integration of technological imperatives in the development process. But to do this, policymakers would need to be fully aware of the broad manifestations of these imperatives, and what they should regard as strategic targets when engaged in a technology transfer transaction. The targeted variables referred to as *technological targets* and *technological dimensions* interchangeably.

Some Key Technological Dimensions

- Packaging, fragmentation and constituent elements
- The level of the acquirers' consciousness with respect to this diverse discreteness
- The prospects for introducing local inputs and enhancing domestic content
- The kinds of unpacking which an acquirer can potentially exploit during the pre-investment, project execution and project implementation phases; and experience and knowledge in adapting technology
- The degree of interaction between the acquirer and supplier of technology, the competence of negotiating parties; and the nature of the contractual agreement
- Packaged or unpackaged contracts
- The nature of the importing entity (private or public)
- The party or parties responsible for putting the project together
- The supplier's and acquirer's freedom to determine and make choices
- Locus of control over the implementation of the project; the right to select subcontractors and partners
- The extent of participation and involvement of local players in decision-making – peripheral role (administrative aspects) or technological decision-making; and the depth of involvement of the acquirer during the preparatory phase of a technology transfer transaction.

2.2.1 Modes of Technology Transfer

Technology transfer would refer to a process of accumulation of skills and know-how by a receiving economy in the wake of flows of investments, equipment, machinery, and requisite services. It entails the build-up of indigenous capacities from the knowledge and capabilities possessed by technology suppliers. Technology transfer can proceed via various channels, the most widely known being direct foreign investment. This could take the form of foreign–held equity (traditionally less than 50

%) or non-equity investments. Perhaps the least known mode of transfer has been technical assistance at the level of bilateral relations. But many more non-equity channels have existed such as: outright purchases of machinery, equipment, and plant facilities; licensing and know-how agreements; service and management contracts; leasing and sub-contract arrangements; and joint ventures and turn-key contracts.[6]

At least three broad levels of technological capabilities have been identified: production, investment, and innovation capabilities.[7] Production capabilities refer to the accumulation of skills and competences crucial for operating, maintaining and running production facilities. On the other hand, investment capabilities refer to the know-how that enables an economy to design and replicate production facilities domestically or abroad. Finally, innovation capabilities refer to the skills, knowledge, and ability to improve and modify production facilities in the direction of greater resource-use efficiency and higher domestic content.

It is vital to point out that technology transfer cannot be said to have taken place if a domestic economy fails to *acquire* some of these capabilities. For instance, a country can experience industrialization without effecting technologization. Foreign direct investments underpinned by equity and involving the contractual use of trademarks would involve no technology transfer. The process of technologization would entail the substantive evolution of indigenous capacities.

In the 1960s and 1970s, many developing economies witnessed significant inflow of foreign direct investments. To a large extent, these inflows entailed the establishment of manufacturing facilities manifested by movement of capital equipment and machinery to host countries. By mid-1970s, however, several keen developing country analysts began to scrutinise the contribution of numerous technology transactions to national economic development. For all practical purposes, the results showed that the flows had little development impact.

There were deep-seated anxieties regarding the patent system especially its failure to promote technological development in Third World countries.[8] In fact, the argument was that patents tended to preserve import monopolies, militated against the working out of inventions, and constrained licensing agreements.[9] At any rate, the intellectual property regime was believed to undermine the potential evolution of domestic techno-industrial capabilities."[10] In particular, the analysts expressed:

> "..concerns over the increasing burden of royalties on the balance of payments, the restrictions imposed upon recipients, and the widespread use of terms and conditions which were believed to reduce the national potential for the development of scientific and technological capabilities."[11]

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[6] See UNCTAD, Trade and Development Report, (1987), Geneva, pp.92-93.
[7] See Kim, Westphal, and Lee (1984).
[8] Ibid, UNCTAD, 1987, p.107.
[9] Ibid, UNCTAD, 1987,p. 107.
[10] Ibid, UNCTAD, 1987, p. 107.
[11] Ibid, UNCTAD, 1987, Trade and Development Report, Geneva, p.107.

As such, many developing countries:

> "are established ...screening procedures for foreign investment and /or transfer of technology …put[ting] emphasis on controlling the costs incurred by the operation of foreign firms…particularly those limiting the remittances arising from foreign direct investments and payments for royalties and those restricting payments over excessively long periods or excessive prices in general…"[12]

The mechanisms of technology transfer are many, and the institution that has played a prominent role in the process has been the TNC. The modes include: DFI, turnkey projects, product-in-hand, technology licensing, and technical and management contracts. Each one of these is examined below.

Outright Purchases

Outright purchases refer to a mode of technology transfer that involves the complete procurement of hardware (equipment and machinery) by a domestic importer. The acquirer of technology negotiates a purchase price with the overseas supplier who assists the former in executing and implementing the project. The buyer attaches local manpower to all foreign experts in a bid to absorb skills along the technology transformation chain. If this transfer of skills and knowledge is part of the contractual arrangement, the technology supplier would invariably charge a relatively high price for an outright transaction.

Technology suppliers who subscribe to this type of transfer would often be the ones not encumbered by proprietary restrictions. They would be owners of a technology whose patent has expired or is just on the verge of expiry. Owners would not generally permit outright sales for technologies associated with trade secrets - know-how that is viewed by the proprietors as confidentially strategic. Such knowledge is deliberately left unpatented for reasons of self-interest; in particular, the maximization of returns.

Outright purchases of capital and intermediate goods have been pronounced for those technologies with readily absorbable engineering-based know-how. However, overseas proprietors have been reluctant, and even unwilling, to transfer product and process technologies that are sophisticated and complex. In cases where negotiations to effect outright sales with patent transfer have even been entertained, the owners have specified prohibitively onerous terms and conditions. Consider, for instance, the situation occasioned by Japan's desire to secure a chemical technology to manufacture acetic acid. The German company imposed severe terms that included a colossal down payment for patent transfer, receipt of a royalty rate for 10 years pitched at 5 % of the production cost, and territorial restrictions on sales. Generally, this tendency has been predominant among manufacturing enterprises employing *technology-intensive* innovations. Therefore, outright sales of

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[12] ibid, UNCTAD, 1987, Trade and Development Report, p.107.

technologies have been very rare in organic chemicals; plastic materials; scientific, medical, and optical instruments; machinery for specialized industries; non-electrical machineries; and electrical power machinery and switchgear.

Direct Foreign Investment and Joint Ventures

In a new world order characterized by the deepening economic liberalization, the establishment of DFI in developing countries is expected to increase for two main reasons: one, because TNCs prefer the DFI mechanism to avoid transaction and enforcement costs invariably associated with other technology transfer modes; and two, because investments abroad have jobs-creating potential in home environments.[13] The push for DFI is likely to receive additional governmental impetus as OECD countries are plagued by high rates of unemployment. In the 1980s, DFI outflows increased significantly. Alter (1994) has observed that:

> ".... DFI outflows are frequently welcomed as promoting the national interest by helping domestic firms conquer global markets and secure increasing technically advanced, well-paying jobs for skilled workers at home".[14]

Additionally, though many writers use the term DFI to describe flows of investment resources to developing countries or elsewhere, the meaning has shifted considerably over the years. The traditional meaning of DFI refers to the establishment in a host country of a wholly-owned subsidiary of a TNC. Yet, many writers use DFI even when describing joint-ventures. Joint ventures can take many forms and may sometimes include a licensing component as well. Fukasaku (1994), for instance, employs the term without clarifying its meaning in the context of China's phenomenal growth since 1978.[15] In reality, China has demonstrated a preference for joint ventures and has completely ruled out wholly foreign-owned subsidiaries.[16] Most observers are left with an impression closely associated with the traditional meaning of the term when the acronym DFI is used.

DFI in Korea accounted for below 10% of total inflows of foreign capital as it deepened its industrialization.[17] For other mechanisms of technology transfer, the flow of investment resources was heavily characterized by *debt* and not *equity*.[18] However, it is essential to note that DFI may not in fact be accompanied by the actual flow of investment resources into a host country. Some technology may be transferred even though the largest proportion of the capital itself could be raised from the host's environment.[19] In the case of China, for instance, wholly foreign-owned subsidiaries were discouraged. The country preferred joint ventures in the acquisition of technology,[20] and in some cases, the licensing arrangement was made part of the joint venture deal.[21]

Joint ventures, which the author defines as investments established collectively by governments and participating foreign firms according to an agreed equity-holding partnership, were devised to promote the industrialization of African economies.

DFI has been a predominant mode of technology transfer for many developing countries. Under this mechanism, a foreign firm, often a multinational company, establishes a subsidiary in a host economy (in, say, an African country) to produce goods and services for a promising or captive market. The desire by African leaders to rapidly industrialize their economies lay behind the governments' orientation to embrace the strategy of import substitution industrialization (ISI).

Transnational corporations prefer the DFI channel of technology transfer, even though the technology licensing system is clearly the most crucial to developing countries as far as building domestic technological capabilities is concerned. The reasons for this behaviour are firmly located in appropriability theory. TNCs find licensing contracts very problematic to negotiate and enforce. As such, rather than contract at arms length, the TNC would prefer to establish hierarchical links with a subsidiary in another country. Since market transactions (licensing) generate enforcement costs for TNCs, economic liberalization is likely to be exploited by them to establish hierarchical links through the channel of DFI.

But the DFI channel has several deep disadvantages to a developing country.[22] First, experience has shown that this mode is associated with limited or no generation of domestic technological capabilities in host countries. Indeed, technological decision-making is entirely in the hands of the overseas partner. Second, and related to the first, the involvement of a local partner is restricted to peripheral aspects of the technology transfer process and the technology transformation process. Third, because the foreign partner ensures that all major decisions about the transfer process reside with the parent company, knowledge about the core technology is never imparted to locals. Finally, since existing domestic technological capabilities are not utilized by the TNC subsidiaries through subcontracting arrangements, linkages with the domestic economy are usually very weak. The cumulative impact of all these factors is a degree of employment creation limited to the subsidiary itself.

China's conception of DFI has taken the form of joint venture agreements with foreign firms and has been driven by a strong indigenization policy. The agreements are underpinned by an indigenization policy which exerts pressure on DFI to exhaust domestic sources of inputs first before importing equivalents from abroad. Since 1978, the country has changed the composition of its exports, specializing more broadly on labour-intensive products. In recent years, exports of footwear, travel goods, textiles, clothes, chemicals, watches, toys and a whole range of simple electrical products have constituted over 30 % of China's total merchandise exports. Considerable strides have also been made in the production of intermediate and capital goods catering for a growing internal market, namely, iron, steel, machinery and transportation equipment. Before producing exports, China studied the international market environment for various products very closely. The policy reforms that were introduced took the potential demand into account, and deliberately guided the market system to become more integrated and allocate resources more efficiently.

In Kenya, massive concessions were extended to foreign interests to set up manufacturing facilities that they physically owned. These favours, which were staggeringly licentious in both range and pervasiveness, were not underpinned by technological considerations. Because they had no technological content whatsoever, Africa's formative industrial phase was deprived of the opportunity to forge the nascent foundations for domestic technological change.

To cite an example, consider the DFI by Firestone, in particular, the concessions granted to it by the Kenyan government in 1968. They included:

- "a quota restriction of tyre imports from outside E.A. in accordance with a formulation stipulated by Firestone USA;
- a total ban on imports of tyres (that) Firestone would from time to time notify the government of its intention to produce in Kenya;
- unrestricted import licenses (including the availability of necessary foreign exchange) for construction materials, equipment, machinery, spare parts, or raw materials;
- exemptions from import and customs duties and from any other tax for items imported by the company;
- unrestricted export licenses and total exemption from export duties;
- freedom to use its own pricing formula in the sales of its protected products;
- a commitment by the government to ensure that its departments, including the armed forces, purchase tyres from Firestone (E.A.) Limited and also ensure that the firm secured monopoly rights to supply its tyre products to any enterprise established in Kenya for the assembly of motor vehicles."[23]

From a cursory glance of the concessions, it is evident that the policy to industrialize embodied no technological content. Hence, the DFI approach that was effected in the context of the ISI strategy was not instrumental in initiating a promising process of building and strengthening domestic technological capabilities. This point is made on account of the realization that the Firestone investment was a freak exception but a reflection of systematic patterns underpinning Africa's technological experience.

In many respects, the ISI-driven DFIs contributed to Africa's heavy debt servicing burden. If these arrangements had been conceived in the context of a long-term policy to develop local technological capabilities, then the severe balance of payments problems which the DFIs aggravated would have been blunted appreciably.

DFIs are also not likely to complement any local efforts to promote and deepen domestic processes of technological change. For instance, it is common knowledge that foreign subsidiaries not only tend to shy away from applying local research and development (R&D), but also brazenly appropriate whatever innovations are generated by local talent.

Admittedly, these ISI-driven direct foreign investments did build some technological capabilities, but because the overseas interests were predominantly interested in profit maximization, the DFIs could not promote domestic technological change because their activities were largely characterized by very low domestic content, limited forward and backward linkages, transfer pricing, heavy reliance on foreign experts and managerial personnel, low levels of domestic subcontracting, minimum use of resource-based inputs, and so on.

Western circles are concerned about determined opposition to certain forms of foreign investment in many developing countries as liberalization takes root. A strong nationalistic ferron runs through the arguments raised by policymakers in DCs. The purer version of DFI, where a transnational company establishes a subsidiary in a reform- implementing country with very limited shareholding by locals in the host's environment, generates anxieties among citizens that their economy is increasingly coming under the control of foreigners. These fears are real when one appraises the characteristics of DFI in all their diversity.

It is vital to note that Japanese direct investment in the Pacific Rim nations was driven by both domestic and regional factors, the former stemming from a strategic initiative to reduce production costs and maintain economic competitiveness in the world economy as the yen appreciated sharply in the 1980s[24]. The regional factors were derived from large growing markets, low wages, and the emergence of incentives-rich policy environments in South East Asian Countries. The Japanese Investments (usually joint-ventures) succeeded so well in building domestic technological capabilities in the Pacific Rim nations that Japanese companies in Japan were confident enough in sourcing components from their joint-ventures in South-East Asia. The demands of economic competitiveness, prompted by the rising yen, have induced Japanese companies to purchase more locally-manufactured components.[25]

An important distinction ought to be made between economic liberalization as a process of allowing *selective investments* to promote sustainable development, on the one hand, and*open investments* that are capable of triggering environmental deterioration, on the other. GATT's view of economic liberalization is one where regulatory conditions to foreign investments and operations of foreign companies should be eliminated especially when they serve as barriers to trade. Some observers have already expressed worries about GATT's trade rules by noting that unregulated investments may trigger environmental degradation as governments in developing countries are hampered in their efforts to control foreign companies. De Bremond (1993) has lamented that unconditional economic liberalization awards "... free rein to logging companies, toxic waste disposal companies, and mining companies, among others, who would be free to operate in a highly unrestricted setting, regardless of the environmental impact of their practices...."[26]

Africa should press for forms of DFI which maximize the benefits of local resource use including the utilization of domestic technological capabilities. Any DFI arrangement that marginalizes local competences and ignores potential domestic subcontracting possibilities is not the kind of foreign investment Africa should encourage.

Technology Transfer through Licensing

Licensing is yet another mode of technology transfer which encompasses the flow of highly specialized proprietary and non-proprietary information and knowledge from the owner of technology (licensor) to the receiver (licensee). This transaction effectively confers on the licensee rights and responsibilities to exercise control and autonomy over the use of the licensed technology. Agreements of this type have generally featured in industries and sectors characterized by complex *technology-intensive* production and processing systems. Moreover, they would normally not be struck at a time when the advanced technologies are still in the formative stages of the technology life cycle, though owners could be driven by specific circumstances to license the sophisticated innovations.

For instance, licensors may be inspired by the calculus to secure additional earnings abroad, gain footholds in potentially lucrative overseas markets hitherto shielded by tariff and non-tariff barriers, derive competitive advantages in an overseas setting promising lower production costs, or seek to test the potential efficacy and prospects of new technologies. For licensees, however, the motivations to exploit this avenue of technology transfer may rest on broader development objectives and how potentially instrumental the technologies seem to be in the national scheme of things.

Within the licensing framework, it is worth noting that the flow of the hardware component would generally amount to a waste of time unless the full range of the proprietary and non-proprietary knowledge is imparted to the licensee. Such a transfer would mean the development of domestic technological capabilities which cannot be easily realized by any other means. The licensing agreement can assume four main forms: technological assistance contracts, patent contracts, know-how contracts, and engineering services contracts.[27] On the *technical assistance agreement*, a licensor would transfer specialized technical information essential for enabling a licensee to operate and maintain the manufacturing facilities. The knowledge under this instrument has nothing in common with information embodied in know-how and patent contracts. But its worth is considerable because it enables the licensee to acquire *short-term* services that will empower him to "…establish manufacturing facilities rapidly and economically and to exploit markets effectively."[28] Moreover, it commits the licensor to offer continuing services, a long-term effort designed to help the licensee build manpower resources to ensure enhancement of manufacturing performance, marketing, and provision of customer service.

The contents of technical assistance contracts include knowledge about consulting and engineering services. The consulting services comprise the following:[29]

- assessment of markets
- definition of products
- consulting services covering the assessment of markets
- definition of products
- investment analysis
- ensuring raw materials availability

- recommendation of plant location
- choice of technology
- identification of equipment suppliers

The continuing services covered by a technical assistance agreement include:[30]

- definition of product (product design, specifications, quality, range, as applicable)
- plant capacity (and in chemical plants, operating range)
- supply of licensor's technical personnel for construction, supervision, plant start-up, and stabilization of operations
- training (local and overseas) of client personnel in production operations, maintenance, marketing, accounting, etc.
- assurances on supply of pre-processed materials, preassemblies, components over which supplier has predominant control
- preparation of literature on operation and maintenance of plant, product specifications, technical service manuals (customer), sales data sheets, etc.
- quality control procedures and in-plant inspection standards
- productivity standards and aids to product costing
- overseas testing services for raw materials, product, etc.
- assembly diagrams and drawings for mechanical or electrical products
- pricing basis for use of overseas personnel and for the supply of items
- communication of product and process improvements
- where an independent third-party engineering firm is involved in plant design and construction, express provision that supplier technical assistance will provide supervisory services
- performance warranties
- supplier's liabilities in relation to plant performance
- remuneration for services
- provision that remuneration to supplier is for technical assistance
- "linkage" to other agreements
- governing law agreement

Despite the enormous technological potential furnished by this mode, Africa has generally not used it to stimulate the development of domestic technological capabilities.

The *patent license* agreement is a binding contract between the owner of a patent and the licensee outlining the rights, responsibilities, duties, and obligations of the contracting parties (patentee and licensee) with respect to the use, sale, or manufacture of an invention by the licensee. Under such an agreement, the licensee secures legitimate access to technology, requisite technical assistance, and markets, *but this does not grant him the patent rights*. In general, the licensee derives the following advantages:[31]

(a) The licensor's explicit statement that he has registered patents in territory covered by the agreement and bearing on its subject matter
(b) The licensor's listing of the patents that have been issued, their dates of registration and unexpired life
(c) Particular listing of all the licensor's patents in countries for which the licensee has negotiated export rights
(d) Express statement by the licensor granting rights to the licensee to operate under such patents and enumeration of licensed rights (i.e. the "make, use and sell" rights) thereunder
(e) Acceptance by the licensor of the responsibility for acting to stop infringement in the licensee's national and export territories and for undertaking such efforts at his own (licensor's) expense or at an expense shared by the licensee and licensor are matters for negotiation
(f) Representation by the licensor that licensed patents do not infringe on third-party patents or rights, and if courts find to the contrary, to absolve the licensee (indemnify licensee) of any and all damages, financial or otherwise, that may arise from such infringement (these are the so-called indemnification and "hold harmless" clauses)
(g) Release of the licensee from patent-related obligations, including royalties applicable, if for any legally determined reason the patent ceases to have validity in the licensed territory
(h) Agreement by the licensor to keep all licensed patents in force throughout the life of the patents by paying applicable registration fees and meeting other legal-administrative requirements pertaining thereto
(i) Agreement by the licensor to grant the licensee the right to patents throughout their life, even after the agreement expires
(j) Agreement by the licensor to grant the licensee any more favourable rates than granted to other licensees with whom the first licensee may compete
(k) Agreement to grant rights under improvement patents with no increase in the royalty rate

Again, despite the profound technological prospects offered by this mode, Africa has had no systematic tradition of exploiting it to build domestic technological capabilities in the industrial sector.

Licensing of technology can also be effected through a *know-how agreement*. Know-how refers to a body of industrially useful, valuable and secret information which a patentee has generated and accumulated through practical experience. It includes skills and knowledge that is *tacit* and *uncodified* that the licensee evolved over time as he worked out his patent. So important is this knowledge from experience that no marketable product can sufficiently and adequately be manufactured without its invocation. Often, the information is held in secret essentially because it confers those possessing it with production and other vital advantages against competitors, real or potential.

Though very significant, know-how has been found unpatentable due to the fact that the crucial information (knowledge, skills, and experience) fails the technical test of novelty. Yet, a licensor enjoying tangible benefits, for example, a qualitatively superior product, lower production costs, reduced investment levels, and so on, would state that he possesses "novel, valuable, and useful" knowledge. If a potential licensee is able to confirm the claim, then a contract can be signed that grants the licensee the right-of-use only. In return, he will be legally bound to strictly adhere to a confidentiality clause that obliges him to keep the information under wraps for a specified period.

Unfortunately, know-how agreements have generally imposed severe restrictions on licensees. They require that:[32]

(a) The licensee does not have the exclusive right-of-use to know-how, i.e., the licensor retains all rights to license others as well as to use it himself, both in contract and non-contract territories. Exclusive rights to make, use, sell or import are separate rights, which the licensor may grant selectively
(b) The licensee can use the know-how only in the territories specified in the agreement
(c) The licensee can use the know-how only in the field set down in the license agreement, i.e., he cannot use licensed know-how for manufacturing products not defined in the agreement (unrelated products usually). The reasonableness of this restriction is sometimes tested even in the courts of developed countries
(d) The licensee can use the know-how only at the site (or sites) of manufacture identified in the agreement
(e) The licensee cannot use the know-how to produce the licensed product beyond the capacity authorized in the agreement; the licensee also cannot expand the plant, or production, through use of licensed know-how without the licensor's express authorization.
(f) The licensee does not have the right to sublicense know-how to others
(g) The licensee can provide access to know-how only to persons identified in the agreement, i.e., use by only the persons concerned (rights of access to and use of can be defined as separate rights)
(h) The licensee and others permitted access to know-how must contractually agree to maintain the designated information in confidence for the period agreed to (this secrecy period can extend beyond the period of use)
(i) The licensee's right-of-use to know-how is limited to the duration of the agreement; the right-of-use ceases thereafter; (as in item ©, this issue arises even in developed countries)
(j) The licensee cannot commercially employ any improvements he may make on the know-how without communicating them to the licensor and transferring the right-of-use to the licensor, free of cost (and other obligation)

From a brief overview of the know-how agreement, it is clear that this mode of technology transfer is technologically constraining. The constraints include exclusivity of use, territory of use, field of use, site of manufacture, volume of production, and right to sublicense.[33]

Yet the know-how mode has been used very widely by Africa. This can be explained by the fact that most local investments employing foreign technologies have had to sign know-how agreements since these were integral components of the technology transfer process itself.

Finally, technology transfer through licensing has been realized using the *engineering services agreement*. This instrument specifies the technical work to be undertaken by the supplier of engineering services. A key concern in the contract has generally centred on the need to define clearly how the responsibilities would be divided between the licensor and the client. Such a division would also specify the range of mutual obligations. Traditionally, activities under the engineering services category have included:

> "…assessing raw materials, locating and preparing the plant site, recruiting personnel, obtaining government and municipal clearances, procuring construction materials and equipment, inspecting local and foreign-made equipment, constructing buildings, installing machinery, training operators and commissioning the plant."[34]

Other critical engineering services have been identified in the technical assistance part covered earlier (see discussion on continuing services).

The centrality of these services cannot be overemphasized. African economies that are serious about building and strengthening domestic technological capabilities cannot afford to ignore these fundamental dimensions. Yet, experience has shown that most governments in the continent have granted total responsibility over the services to overseas licensors. Leaders have failed to appreciate the strategic worth of these services in promoting domestic technological change.

Conversely, Korea has been able to build domestic technological capabilities from borrowed technologies by relying significantly on the licensing system. Japan has served as Korea's principal source of technology using this mode.[35] For most of the Pacific Rim nations, Japan transferred technologies through joint-venture arrangements or outright sales of technology. Many joint-ventures had a component of licensing in them; for outright sales, licensing was almost automatic as the Japanese firms supplied pre-investment project execution and project implementation services.[36]

The licensing of technology derives wide-ranging benefits in the transaction, namely, an opportunity to avoid costs associated with technological development (product or process), avoidance of legal battles with firms whose technology could have been pirated instead, and using a technology that is already well-received, thus enhancing the licensee's image in the market place.[37] But more importantly, the fact that licensing as a transaction process can be realized without the seller participating in the recipient's production activities enhances the latter's capacity to build domestic technological capabilities. As opposed to DFI in the traditional meaning of the word, technology licensing puts the licensee in a vintage position to evolve local competences. Indeed, the licensee is compelled by circumstance to learn as much as possible about the technology. The learning process leads to the accumulation of technological capabilities.

2.2.2 Packaged and unpackaged contracts

Broadly speaking, the process of technology transfer involving foreign suppliers and domestic clients has assumed two generic configurations, namely, packaged and unpackaged contractual forms. Packaged contracts refer to agreements that facilitate the flow of completely integrated technological entities. The various components are all wrapped up together in one combined unit and received by the client as a compact whole. Two types of packaged systems have been identified, *turnkey* and *product-in-hand*. In a turnkey arrangement, the entire investment project (from pre-investment activities to commissioning) is undertaken by a foreign supplier. He is solely responsible for putting up the facilities from start to finish and in all their diversity. Once through, he would conduct test runs to establish whether everything conforms to the set standards and performance criteria. Only then will he proceed to hand over the keys to the client for production to commence.

On the other hand, the product-in-hand contract, while sharing all the attributes of a turnkey arrangement, also includes preliminary involvement by the foreign supplier at the management and operational levels. This is designed to develop local production capability.

In contrast, unpackaged transactions refer to technology transfer practices that decompose a technology into its basic constituents and then permit individual flows to the client to proceed at this disaggregated level. The prospects for accelerating technological change are significantly heightened by this contract type.

Now, transfer modes that wish to maximize domestic technological change would need to do the following:

- Clear identification and selection of the technology in terms of type, size, appropriateness, and so on.
- Selection of experts with appropriate and relevant skills to serve as consultants to undertake pre-investment, project execution, and project implementation services
- Selection of contractor(s)
- Formation of a competent local team to manage and understudy overseas experts
- Procurement of hardware and other requisite technological components
- Designing and operationalizing the implementation framework, strategy and plan.

Technology exporting firm or economy Technology receiving firm or economy

Technological capacity

Flow A Hardware and services for installation and start-up

Flow B Operation and maintenance of production system

Flow C Technology capacity including design and reverse engineering

Figure 1: Differences and Diverse Variations in Technology Transfers
Source: *Technology Policy Formulation and Planning* (1986) by Nawaz Sharif (Ed.), Asian and Pacific Centre for Transfer of Technology, India.

3. Appraising Africa's Technological Patterns: Domestic Shortcomings and Exogenous Constraints

The various technology transfer modes described in figure 1 served as critical dimensions of analysis in research efforts that attempted to fathom the phenomenon of technology transfer from the 1960s. Since independence, the development thrust of African countries was largely informed by the strategy of import substitution industrialization. This phase witnessed the evolution of domestic technological capabilities through two broad means: one through direct foreign investments (DFI) by multinational corporations, and two, through the establishment of state enterprises (for example, in textiles, meat processing, sugar refining, milk packaging, and so on).

On techno-industrial capacities occasioned by the DFI mechanism, most governments in Africa offered extraordinary concessions to overseas investors.

Undoubtedly, the establishment of factories and industrial facilities (as subsidiaries of MNCs) during this phase of import substitution industrialization occasioned the build-up of some notable technological capacities. However, the nature of the concessions granted to foreign investors implied that most capabilities would assume the *production* type, with virtually none established in the *investment* or *innovation* categories. The requirement by governments that the DFIs comply with the indigenization policy gave training a special premium, but this insistence only built skills in general operation and maintenance activities, including competence generation at some managerial levels. But it was not conceived within a more coherent and strategic framework to build domestic technological capabilities in potentially promising areas. For instance, the issue of DFIs deliberately promoting domestic forward and backward linkages was not demanded by governments. Neither were foreign investors obliged to fulfil a set of domestic content ratios nor required to subscribe to mandatory provisions such as compulsorily granting local firms sub-contracting engagements. In short, governments in Africa had not developed an overarching technological framework to guide the process of technological change during the ISI phase. As such, apart from production capabilities, virtually all other capabilities that emerged did so by default and not by design.

But even where a basic structure of provisions existed, they hardly constituted a proactive strategy to institutionalize a process of systemic technological change. In Kenya, for instance, the New Projects Committee (NPC) had a set of quasi-technological benchmarks to guide its negotiations with potential foreign investors. At any rate, political and bureaucratic interference of NPC undermined its potential to promote the process of technological change in areas under its mandate.

The establishment of state enterprises in Africa was also an important feature of the ISI phase. Joint ventures and turnkey mechanisms were the chief means used to build domestic technological capacities. However, governments had not designed a coherent, well-coordinated, and strategic technological framework to guide the process of technological change in state enterprises. There was a superabundance of missed opportunities during this period of public sector growth.

Africa has scored some remarkable successes in a few areas but the accomplishments have, in general, happened not by design, but by default. On the whole, the process of building capabilities has often lacked a coherent *teleological* thrust; it has often not been guided by a well coordinated, decidedly proactive, and holistically consistent strategic worldview. The remarkable outcomes have largely been disparate, inchoate, ad hoc, and non-integral in nature. They also give the appearance of having been realized incidentally rather than having been sought after consciously, proactively, and premeditatedly.

The history of Africa on this score thus suggests that the evolution of technological capabilities in the continent has not been an institutionalized process. Why such a dismal record?

Several shortcomings will be discussed here, including: the absence of critical input from universities and policy research centres; the shortage of such dynamic centres; deficient and ineffective networking arrangements between such centres and national policy institutions; the existence of superficial coordination mechanisms between active policy researchers and relevant organs of government; poor conceptualization and shallow appreciation among leaders, of the strategic significance of the technological imperative in the development process; the allocation of meager resources (human, material, institutional, financial, and so on) in support of technology policy research; and the rather cavalier, if not fugitive, appreciation of the value of such research to strategic policymaking in all its diversity.

3.1 Systematic Pitfalls on the Domestic Front

The question that arises is why Africa has registered such a dismal technological record despite the existence of formal science and technology (S&T) policy regimes, on the one hand, and the articulation of strong official pronouncements affirming total support for technology, on the other hand. Why is it that African governments have not been in the vanguard of efforts to take the economic-industrial bull by the technological horns?

Several factors, both internal and external, have contributed, and continue to contribute, to this pathetic state of technological affairs. At the outset, it should be pointed out that Africa has suffered a severe shortage of skilled and appropriately trained manpower possessing the kind of strategic information and relevant know-how essential for manning, spearheading, and influencing the rate and direction of domestic technological change. And where such competence has existed, policymakers have tended to ignore it. Often, it has been a case of governments failing to appreciate the strategic worth of such human capacities in their midst.

Second, African economies have largely lacked requisite capacities to assess the merits of what is locally available and what could selectively be procured from abroad. Even when competences of this sort exist, it has of ten not been located at the strategic echelons and departments of government such as the economic and development planning departments and ministries. The limited resources are thus both marginalized and underused.

At the domestic level, the technology-importing country may be hampered by several limitations and weaknesses. For instance, the following constraints have been observed:

- absence of social carriers of technology
- lack of integration with national plan
- lack of participation by all relevant institutions and stakeholders (from the private sector, civil society, and government) in technology policy-making processes
- Absence of a technologically-skilled and informed community that is sufficiently knowledgeable about the various aspects of the technology transformation chain
- absence of a social system that duly recognizes and rewards innovators in high profile ways
- lack of gatekeepers to monitor trends in the vast global domain of innovations
- R&D systems plagued by inadequate funds, sparsely equipped facilities, and poorly rewarded manpower
- The prevalence of extremely weak linkages between R&D and production systems
- Weak capacities to bargain effectively with respect to assessment, adaptation, absorption, and acquisition of technologies
- Lack of tools and capacities for analysis
- The ministries and departments of technology are not accorded a premium and deserving status by the political leadership
- Technology policy measures to promote the evolution of domestic technological capabilities are often subverted by vested interests
- Collusion between a predatory political elite and foreign technology suppliers. The whole transfer process is hijacked and mismanaged under a cloak of secrecy. The under-the-counter deals are often fraudulent, tend to marginalize or underuse domestic capacities and promote technological rip-offs and rent-seeking behaviour among the colluding parties.
- The buyer of technology may lack capacity to undertake pre-investment work
- The buyer of technology may be oblivious to the dynamic significance of pre-investment activities in domestic technological capacity building
- The domestic economy may be presided over by leaders steeped in ignorance about the true and real worth of technological change

- The domestic economy may be presided over by leaders who pay lip-service to official declarations and policy pronouncements they make about technology
- The domestic economy may be presided over by leaders who fail to recognize and appreciate the true worth of valuable technological capacities in their midst
- Lack or shortage of local capital resources may compel governments to secure finances from technology suppliers or from sources close to, or under their potential influence. This often works to the disadvantage of the buyer.
- The buyer may be poorly informed about the existence of alternative suppliers
- The government may fail to spearhead the conscious application of technology policy
- The domestic economy may lack or suffer shortage of certain categories of indispensable manpower resources and, therefore, certain forms of managerial skills
- The buyer may be poorly informed about how to acquire vital inputs.

But, has the west's reluctance to transfer technologies to sub-Saharan Africa been a blessing in disguise?

Yes, in at least two important respects. One, and in retrospect, Africa was spared a wholesale onslaught on the environment. Most technologies that Africans have wished to receive from the west have been associated with adverse environmental ramifications. The innovations have been underpinned by a *mechanistic paradigm*, i.e., a Cartesian-Newtonian conceptual framework.

The view that we could embrace environmentally destructive technologies and seek to repair the attendant ecological damage once fortunes have been built underlines the depth of influence of the mechanistic tradition.

Another example of the dominant influence of the mechanistic worldview can be drawn from our methodological approaches to measurement. Often, we gauge agricultural performance by calculating output per acre, productivity per worker, and so on. Such measures fail to consider the imperative of *total biomass* in performance calculations. Clearly, the widespread use of mechanistic frameworks in the description, analysis, and investigation of phenomena has subverted the potential invocation of the entropic worldview in fathoming the same.

The second blessing in disguise can be explained by factors occasioned by *exigent temporal* and *global* shifts. Since the publication of *Our Common Future* in 1987 and the inauguration of unprecedented international environmental events thereafter, the policymakers around the world have come to appreciate the depth of interdependence between the various components of the global system. Though the idea of interconnectedness has much deeper historical roots, it is perhaps safe to say that it acquired a more concrete expression following Kenneth Boulding's insightful article *The Economics of the Spaceship Earth* (1968). But what truly widened the discourse and heightened the consciousness about this notion was the highly controversial study by the Club of Rome, *Limits of Growth* (1972). Paradoxically, the hostile reaction it elicited from analysts and practitioners of mechanistic persuasion tended to cast the factor of interdependence into sharp relief. And yet, it was only after the milestone environmental events of the 1980s and 1990s that the agenda for international cooperation began incorporating solemn commitments on technology transfer and flows of new and additional financial resources.

Undoubtedly, the era of sustainable development had begun. This concept, which underpinned the essence of the *Agenda 21* plan, made it crystal clear that the global challenges facing humankind needed concerted international action if the race against time was to register phenomenal achievements. For Africa, the mood fostered by the exigent environmental realities implied that the commitments to promote and accelerate technology transfers would be made good in accordance with the principles of ecological sustainability. Hence the blessing in disguise occasioned by the new temporal and global order.

3.2 Technology–Subverting Tendencies at the Global Level: Why the North Has Not Delivered

Africa's desire to acquire technologies and build technological capabilities has faced severe exogenous constraints. These include:

- the imposition of restrictive clauses by technology suppliers such as provisions restricting exports and those stressing mandatory purchases
- conditions that stipulate that know-how would remain confidential during the contract period
- compulsory demands to purchase technical assistance when purchasing patents or trade marks
- contractual clauses fixing the final price of goods manufactured
- prohibitions to produce and market similar products
- contractual provisions that grant the supplier full control of the client company
- the technology supplier encourages reliance of overseas manpower resources
- encouragement of grant-based finance by technology supplier and export credit agencies
- private appropriation by technology supplier, of domestic innovations

Foreign contractors and development cooperation agencies establish offices in developing countries to win business for their firms back home, among other things. Perhaps a Japanese example will suffice here.

Japanese firms penetrate new, and widen established markets by making available grants which essentially finance their own consultants to undertake project management and other pre-feasibility activities. Their presence makes it easier for home-country firms to win contracts for subsequent projects related to, or connected with, the services they had hitherto offered. They have also been known to advance favourable recommendations for projects that are ostensibly marginal. In such cases, they send strong signals and feelers to host government authorities expressing their support and interest to undertake local projects on government's behalf. More covertly, however, has been their disposition to formulate comprehensively detailed project specifications that easily exclude nearly all others except themselves to execute and implement projects[1]. One observer even noted:

> "If Japanese consultants are employed for yen-loan projects, they often draw up specifications that only Japanese contractors can meet".[2]

The effect of this strategy in utilizing domestic technological capabilities is adverse.

In recent years, new approaches by funding countries have further undermined or even precluded the potential use of domestic capabilities where they exist. For instance, when the Japanese offer aid, grants, or other forms of finance, they draw developing country government officials into discussions that link the assistance to a country's overall development plan. In-built in these 'discussions', proposals are advanced to the government officials to allow them review and evaluate a range of projects contained in existing development plans. These reviews modify projects in ways that ensure long-term commercial relationships with their own home-country firms. Whatever the form of assistance, the aid is disbursed mainly to procure goods and services from the donor country.

The new plans become benchmarks for developing country officials, and they contain specifications that favour donor-country firms to win domestic contracts.

It is now an open secret that many foreign agencies that operate offices in DCs are staffed significantly by employees of private firms who design terms of reference that favour donor-country companies. These "technical experts" formulate proposals tailored to suit the taste of donor-country officials.

The research and development (R&D) for instance, would use a grant to hire Japanese consultants and firms to undertake pre-investment studies which end up shaping and prioritizing the development plans of a developing country. The US Congress (1993) notes that the composition of consultancy teams is overwhelmingly Japanese with all the senior positions and over half the project time filled and executed respectively by the Japanese[3].

Involvement in pre-project activities gives donor-country firms considerable advantage in bidding for the main project. Indeed:

> "...the use of Japanese firms to do feasibility studies probably tends to steer the main projects to Japanese firms"[4].

3.3 Strategic Considerations—Intellectual Property Rights and the West's Competitive Advantage

For nearly a decade, a number of industrialized countries have complained that the existing patent regimes are too weak to protect inventors from reckless imitation of their products by pirates, mostly located in developing countries. The leitmotif of patents is to confer monopoly rights to an inventor for a limited, specified period of time. The precedent of legal protection induces further investments in technological innovations. In this context, competitors would undertake investments to outdo each other under the umbrella of protective legal guarantees. Besides, an air-tight patent protection system promises *innovation* *momentum,* i.e., competitors would constantly exert efforts to modify and improve existing products or processes so as to maintain a technological lead in a market niche. To continue having a foothold in the marketplace demands incremental, and sometimes, discontinuous innovation spills. Furthermore, because some sectors of an economy are intrinsically *science-intensive*, and because science is an expensive affair, institutions doing R&D would only be induced to carry out *resource-intensive* research under the assurance of legal protection. This means that sufficient protection is necessary to enable innovative investors to recoup their expenses.

It is essential to point out that the whole idea of patents stemmed from notions of private property protection; notions that rest fundamentally on ideological and philosophical underpinnings associated with liberal economic systems. Because private property is a central institution in market economies, the pursuit of self-interest in the management of physical artefacts is a well established phenomenon. Products of the mind which can be embodied in physical structures, big or small, are manifestations of an individual's creative process. Against this background, the legal ownership of property in a market system presupposes duties, rights and obligations between the owner and society. The issue of private property protection, therefore, becomes central in a system resting on the sanctity of the individual.

An important distinction ought to be made between an *invention* and an *innovation*. An invention is a scientific discovery or a new idea; an innovation is the practical concretization of an idea, i.e., the invention. It is therefore the practical translation of a new idea into a potentially commercializable product or process.

It is also crucial to draw a sharp distinction between *relative novelty* and *absolute novelty* in technological innovation. Human evolution has been marked by introduction of new ideas (new knowledge) which have, on numerous occasions, been translated into concrete innovations. When the world experiences the introduction of a novel idea (ideas with an innovative potential) for the very first time in its history, the event is said to display absolute novelty. Such an invention or new knowledge has no precedence anywhere, and adds something radically different from any known pre-existing inventions or innovations. In an important sense, the world's stock of knowledge increases as new novelties are brought to being.

However, while absolute novelty refers to an invention coming onto the global scene for the first time, the same invention could be new in a given country even though its appearance global has been visible for some time. Its newness in a country is thus relative in a global sense. From a global point of view, the invention already enjoys precedence, is pre-existing, and does not add to the world's stock of knowledge. When a country experiences the introduction of an invention new to it but which already is pre-existing elsewhere, the event is then said to characterize relative novelty.

In the early years of patent history, protection was essentially extended to innovations, and not inventions. For almost 200 years since the first patent was issued in Venice, the legal-institutional structure was organized in ways that granted temporary monopoly rights to investments connected expressly to inventions. Basically, the strategy was meant, through entrepreneurship, to transform new ideas into productive investments. Such patenting strategies created conducive conditions for translating inventions almost as quickly to commercial ventures. Given such an atmosphere, there were strong temptations to "*work out*" inventions since rewards could only come from a tangible property.

After several decades in operation, the patent regime began to evolve away from its initial focus on innovation protection to one which conferred monopoly rights to inventions. Patents could now be issued to new ideas without the necessity of entrepreneurial translation of those ideas. Clearly, the working of the invention was delinked from the invention itself, a fact which influenced greatly, the content and direction of technological innovation. In the former regime, invention and innovation were fused into one, becoming almost inseparable in all their diversity. It was a regime that automatically instigated the inevitable conclusion of an invention, and the innovation that followed was inextricably interlinked. Consequently, then, what was granted immediate protection was the innovation, and only indirectly the innovation.[5]

Conversely, the new patent regime extends protection more expressly to inventions and only secondarily to innovations. This shift in emphasis has far reaching implications for industrial change and technological development of Third World countries.

Kingston asserts that the present emphasis on creative inventions is misplaced especially when one compares differential investment requirements for inventors vis-à-vis innovations. The latter stage consumes far more financial and other resources than the former. For this reason, he argues, protection should indeed be accorded to those who invest in the transformation of their ideas into innovations, rather than confining protection exclusively to inventions. Protection should thus be extended to inventions which are subjected to investments.

But the question that arises is whether such a proposal should not be beefed up by safeguards to inventors. If an inventor's potentially commercializable idea is not protected for lack of investment, would this situation not lead to episodes of hijacks especially when inventors fail to secure the necessary finance? Would not the already powerful rich rivals chance upon inventions produced by relatively weaker inventors? Could such possibilities make potential inventors more secretive about their work until finances are raised for investment? And more generally, what impact would such an emphasis have on inventive and innovative activities as a whole?

These aspects are a vital part of the ongoing debate on strengthening intellectual property regimes. If the industrialized countries succeed in compelling the rest of the world in adopting uniform patent standards, there is then the imminent danger of weakening property rights regimes of indigenous communities in many developing countries. The consequent erosion of their natural resource bases will not in any way be helpful in promoting eco-development in the South. At the same time, the fact that most environmentally-sound technologies will be subject to air-tight patent regimes means that Africa's capacity to participate effectively in the UNICED agenda for eco-development will be weakened substantially.

What Africa calls for under the present institutional crisis is large-scale support for eco-activities and the technologies that go with them. Africa's ecological environment is subject to further erosion unless the sustainable technologies developed in the North are provided at large *concessionary* terms. If the efforts to make uniform or strengthen property regimes are not relaxed, and if eco-technologies are not subsidized for Africa (among other things), the continent will be reduced to a sad ecological museum. The hardships will be even greater a decade from now. Africa must be allowed to catch a glimpse of its old golden past in the sustainable process. At the present historical juncture, Africa's capacity to innovate depends not only on the willingness of the world to help her look at her own past, but also support her by supplying eco-technologies in the near future.

(Footnotes)

[1]See US Congress, Office of Technology Assessment 1993)

Development Assistance, Export Promotion, and Environmental Technology

, Washington, D.C., U.S. Government Printing Press, p.44.

[2] Ibid, p.44.

[3]Ibid, p.43.

[4]Ibid, p.43.

[5]See Kingston, W. (1992) "Patents and Endogenous Capacity-building" in

ATAS Bulletin

, Issue No. 7, United Nations, New York, Spring, pp. 176-177.

4. Why Was Africa Not Stood on the Shoulders of Giants? Lessons from Experience

Japan's technological development as in other newly industrializing countries (NICs), has often been flaunted as a possible model of imitation for developing countries aspiring to acquire industrial capabilities. However, many sceptics around the world have advanced the view that the Japanese experience has been too unique to be replicated elsewhere. Cultural, historical, and international factors have been cited emphatically to drive home the perceived "irrelevance" of Japan's technological evolution to Africa's development. Yet, after almost three decades of strategic imitation, a significant number of South East Asian countries have managed to acquire and build domestic technological capabilities along lines reminiscent of Japan's own selective approach to industrial change. The consequent success of the NICs germinated the view that despite Japan's unique attributes as a society, certain broad fundamentals exist as universals to guide "catching up" countries. If Britain's industrial experience was regarded as unique in the sense in which the Japanese case has been vaunted, then many European countries in the 19th century would not have attempted to copy certain underlying patterns of technology acquisition. While appreciating the distinctive idiosyncrasies of the British context, many European countries focused on the "strategic unities" within the broad cultural, historical, and international diversities of the technology assimilation process.

3.1 Africa's Urge to Industrialize

The mystique about industrialization evolved in the context of visible income changes, increased prosperity and far reaching structural transformations of the economic landscapes of the developed countries. It has been observed that the industrial sector not only has the potential to induce technological dynamism in many branches of an economy, but also has an infinite capacity to generate technological change within itself.[1] At the heart of these transformations is technology, whose influence as a motor and engine of change is now well recognized. The role that technology plays in economic change was empirically justified when Abramovitz (year?) furnished evidence that explained the source of the large residual (82.5%) in terms of productivity and efficiency in resource use rather than in connection with changes in factor inputs. This study, and others by Kendrick, Griliches and Solow (year?), demonstrated the significance of technology in economic change.

During the post-war period, and particularly during the 1950s and 1960s, industrialized countries experienced unprecedented increase in economic growth rates. A large chunk of the North's population enjoyed higher standards of living, rising economic prosperity, and expanding social improvements. These patterns of change made the differences in income levels, well-being and several affluences between industrialized countries (ICs) and developing countries (DCs) even starker. While ICs were characterized by affluence, the continent of Africa was largely marked by indigence, poverty, malnutrition, and general economic decline. These disparities and contrasting trends drew the attention of policy makers, academic thinkers and practical men of affairs[2] to forge arrangements that would help developing countries emerge from their predicament.

A whole range of models appeared as a consequence of policy work undertaken by development economists. Most models emphasized either internal weaknesses or external factors in explaining underdevelopment, with hardly a vision to see the world in integrated terms. These conceptions had far-reaching implications on biodiversity. The basic traditions of these models also perpetuated their economistic underpinnings, without addressing the compelling questions of model limitation.

One inevitable conclusion from the premises of such models was that developing countries should tread the path many industrialized countries had passed in their quest for modernization. It was argued that the economic fortunes of African countries depended on how faithfully they followed the footsteps of ICs in their crusade for economic development and prosperity. Only by imitating the industrialized paths of the North would Africa be assured of a prosperous future. The ICs became the paragons of emulation, and the basic assumption in such development was and still is, a view of industrialization in schematic stages. Gerschenkron puts it in the following terms:

> "... all economies were supposed regularly to pass through the same individual stages as they moved along the road of economic progress. Thus, Rostow was said to assert that the process of industrialization repeated itself from country to country lumbering through his pentametric rhythm."[3]

Gerschenkron goes further to observe that the level of a country's backwardness influenced the structure and evolution of its industrialization, here referring to discontinuity in the growth process.[4] Through 'demonstration effects', DCs emulative thrust increased in response to pent-up pressure reflected in the rising levels of consumption.[5]

Wonderstruck and enthralled by the marvels of industrialization, developing countries in their eagerness to model themselves according to ICs cultivated a belief that technology transfer from the north was an important condition of development. Access to modern technology was a crucial prerequisite for development. Gee (1981) makes the following point:

> "Foreign countries remember the miracles of technologically-based industrial innovation in the United States dating back to the Industrial Revolution and have witnessed the major role that American technology played in the economic resources of West Germany and Japan since World War Two. These industrial lessons have not been listed on them but have since found expression in their determined efforts to adapt

> imported technology to local needs. The developing countries in particular realize that, in order to reap the full benefits of an increasingly technological world, they must align their governmental infrastructure for effective utilization of technology imported mainly from the industrialized countries."[6]

Faith in technological change expressed in the policy objectives of developing countries was thus strengthened as a result of its influence on the growth patterns of industrialized countries.

The continuous creation of new science and technology, and the accumulation of knowledge in general, have been seen as positive development s largely because this accumulation is deemed to favour newcomers.[7]

The point was not lost when more than 50 % of economic growth of ICs was realized to have stemmed from technological changes, the latter being identified as a major determinant of economic development.

After this basic recognition, many developing countries expressed optimism and went about setting up institutions to obtain technology from industrialized countries. The declaration made by the United Nations proclaiming the 1960s as the first Development Decade gave greater urgency to Africa's ambition of facilitating technological, industrial and economic development. This realization also placed some responsibility on the ICs to help initiate a faster development process in the south. By the end of that decade, little progress had been made on this vital score, despite futile efforts by developing countries to secure agreement from ICs on the crucial question of the International Code of Conduct for the Transfer of Technology to the South. The technology issue was brought up in the discussions on the New International Economic Order in 1974, after developing countries felt that the global economic system was an independent development of their economies. The thrust of the challenge stemmed from the recognition that an exploitative relationship characterized economic relations between the North and the South that worked to the considerable disadvantage of the South.

International inequities, particularly those related to trade and technology transfer, were reflected in the magnitude of resource outflows from the South, mainly generated from royalty payments, transfer pricing, market control, restrictive business, monopolistic abuses, duty exemptions, capital repatriation allowances and favourable terms of trade for the North. In general terms, a large part of research and development expenditure (about 98 %) was, and continues to be invested, by industrialized countries. For the majority of African countries, interest payments for matured debts were well in excess of 50 % of export earnings, sparing only a modicum. Driven by sombre predictions of impending economic malaise, many developing countries launched a drive to redress the global economic system towards greater social and economic justice. In the wake of the OPEC oil embargo of 1973, and the new-found power of oil exporters, the developing countries put forward a series of demands that would, among other things, involve an equitable framework for questions of technology transfer, industrialization, market access of industrialized countries, debt, and aid. Despite the inauguration of two crucial environmental conferences in the early seventies, the broad issues of discussion on technology and industrialization during the decade hardly addressed the fundamental questions of ecology in the technological capabilities of the Third World.

3.2 How the Giants Did it – Distilling the Gems of Technological Success

Given the spectacular economic success of many NICs, the question that arises is whether the crucial threads of their technological experience can be used to distil basic universals for Africa's technological evolution.

4.2.1. Japan

The technological achievements and development experiences of Japan and the NICs illustrate the impact of public policy on economic transformations.

The rise of Japan to technological and industrial pre-eminence stems mainly from an ethos deeply rooted in nationalism and patriotism, a desire to develop a strong powerful economy capable of withstanding and keeping at bay colonization by imperial powers who were on the rampage, carving out the world for themselves in the 19th century. Colonialism – the actual annexation of a foreign territory by an imperial power - was severely an extension of imperialism, a phenomenon well under way in the 17th century. Sensitized by imperial adventurers of penetration and escapades of Commodore Perry in 1854, and seeing the implications for isolationist policies of the Tokugawa dynasty (whose genesis lay in European attempts at penetration in the 17th century), a revolution called the Meiji Restoration exploded in 1868, led by leaders who believed that the only way to put off imperial colonialism was to build Japan into a strong industrial power. The point was not lost when China, industrially weak and economically backward, attempted a policy of autarky but failed in the face of British might. The opium war (1839-1842) was a military clash to open up China to the west. In a sense, the Meiji rulers were saying that a militarily strong but economically weak country cannot win when confronted by an established military and industrial power. The argument was that a policy of isolationism by a weak power was bound to give way (by cutting itself off from the rest of the world) to relentless penetrative pressure emanating from an industrial giant.

With these historical facts in mind, the Meiji establishment embarked on a strategy to modernise Japan along modes of production, industrial organization, and techniques of manufacturing that succeed in making a country a dormant imperial power.[8] Of course, it is not clear whether Japan was also interested right from the beginning in being an imperial power[9]; what is evident, however, is that the desire to grow into an industrial and economic power was to keep imperial colonialism far from its shores. It was not even based on improving incomes or the profit motive.[10]

However, there were factors that helped Japan industrialize without external interference. Japan's geographical remoteness and insular position on the world map kept it almost out of reach from potential imperial invaders.

The agrarian and agricultural economies of developing countries were conditioned by the industrial imperatives of metropolitan powers. Distortions in these economies stemmed from the model of dependent or derived development, influenced overtly and covertly by external imperial forces. Colonialism and the imperial order implanted alien systems through coercion; on the other hand, Japan purchased foreign technologies and assimilated them without coercion. Japan, however, was not satellized, and therefore escaped many of the constraints associated with imperial interests.

At the same time, many early firms were established by the state but later sold off to private businesses at concessionary prices. A thriving system of domestic banking, supported and set up by the state, advanced loans, credit and capital finance to industry.

By comparison, Africa's state-sponsored, state-owned, or state-established firms are running heavy deficits and hence fail to attract potential investors and buyers.

Many government policies in Africa are guided by political patronage, nepotism, and economic favouritism. The establishment of firms is not dictated by the imperatives of the market, but by leaders' whim. Many firms doing the same business may emerge, thus building unnecessary capacities. Underutilization of facilities then follows. In contrast, Japan measured the entry of firms in particular sectors – the staggered-entry formula. Congestion was thus not allowed. It encouraged the establishment of conglomerates, and large sized firms called Zaibatsu.

Japan focussed her attention mainly on old style industries – they were capital-intensive by Japanese standards. But they could still be copied and absorbed without insurmountable difficulties.

But the biggest lesson for Africa, despite the unique advantages enjoyed by Japan and the hard realities of today's economic environment, is that Japan's *terms of reference* for industrialisation were devised and pursued by Japan herself. The search process for technology was actively pursued by several teams sent abroad for training, espionage, acquisition, absorption, assimilation and reproduction of foreign technologies.

Technological development was internalized with no ceding of control to overseas suppliers. The Japanese was a visible and active participant throughout the entire technological transformation process, from the preinvestment phase to project execution and project implementation. Some notable industries in Brazil, Argentina, India, Singapore, Malaysia, Taiwan and Hong Kong have adopted Japanese type approaches to achieving industrial and technological change. The governments were operating in a difficult environment, though less harsh than what we have now, but the multitude of technology suppliers then available made it possible to secure concessions from at least some companies. But those countries invested resources to understand alternatives and possibilities, and were fully prepared after doing their homework well.

But how did Japan organize herself? Where do we start in our efforts to understand the sources of Japan's technological achievements? Did the country have a conscious set of technological objectives? Did it have a pro-active strategy? What instrumental measures did the state enlist in pursuit of its technological goals? Above all, what were the critical factors that steered the economy along a determined technological trajectory? In short, what were the decisive circumstances, both proximate and deep-seated, that thrusted Japan onto the fateful path of technological excellence?

Efforts to fathom and explain Japan's phenomenal techno-industrial success have been staggering. The output can only be described as torrential.[11] It is interesting to distil and isolate the gems responsible for Japan's monumental technological accomplishments, but an excursion of this profundity will only enlighten if the *context* to its techno-industrial evolution is cast in sharp relief.

On the basis of the circumstances cited above, how did the leaders in Japan, arrive at the fateful conclusion that the critical *driving force* needed in realizing their overriding ambition was, first and foremost, technology? What was it that prompted the leaders to *recognize* the centrality of this factor in economic change? Why was *science* not accorded comparable recognition in Japan's development aspirations?

Perhaps the roots of Japan's early and subsequent technocentrism can be traced to the inferences drawn and conclusions reached following Commodore Perry's successful military penetration of this profoundly autarkic society. The superior technological performance of the invader's military equipment was seen as the imperative behind Japan's excruciating humiliation. Of course, there was no military defeat. Perry achieved President Fillmore's desire to have Japan establish trade relations with the US after a spectacular show of force. Before departing in 1853, Perry flexed his muscle by sailing a steamship up Tokyo Bay against the orders of the Japanese authorities. The rulers greeted this act of insubordination by a foreigner with both resentment and awe, the awe prompted by the captivating and bewildering impressions stirred by the technical innovation, i.e., the steamship, which the Japanese had never seen. It is this interplay of immiscible emotions of being both terrified and dazzled by the technological display that precipitated the act of reluctant Japanese acquiescence on Perry's return in 1854. George Mikes captures the technological temperament among the Japanese in the following vein:

"If the *gaijin* (the foreigner) can force us to do things we do not want to do, then the *gaijin* is stronger and more successful than we are. The *gaijin*, indeed, must be better. So we must learn his ways, we must learn all he can teach us. If the *gaijin* has steamships we have never seen before, then we must learn how to build steamships. And then we can face the gaijin on his own chosen ground, with his own weapons."[12]

Elsewhere, Mikes describes how success is treated as a supreme end in itself. In the Japanese tradition, success is associated with what works and that which produces tangible results. Mikes again:

"If they are told that a sense of humour is a desirable proclivity, they will form serious study-groups to discover how to acquire a really robust sense of humour."[13]

In an important sense, therefore, technocentrism among the Japanese is a cultural underpinning; it is universally embodied in the very conceptualization of success. It is a worldview that largely explains their marked propensity *to imitate what works*.

This technocentric propensity also explains why *science* (that domain of knowledge associated with fathoming *why* things work, i.e., the underlying principles and theories that necessitate phenomena) was not a prominent feature in the Japanese psyche.

> "…organized R&D played a relatively insignificant role as a policy instrument of the pre-war Government. What there was of R&D in the government enterprises, experimental stations and research institutes was mostly for *studying* foreign technology, be it a chemical process or a mechanical principle."[14]

Having explored the roots of the Japanese technological temperament, it would then be essential to examine how the leaders of this once autarkic society managed the overall programme of domestic technologization. First, the leaders were pro-active and purposefully conscious in their application of technology policy. Notably, the process of change was spearheaded and guided by a powerful modernizing and reforming elite. There was no room for lip-service since the whole ethos of success, an attribute which the Japanese worship, was defined in terms of *what works*. It is an ethos that has permeated the entire fabric of society. The initiative and impetus, however, came from above. *The vigorous application of technology policy was thus a leaders-driven endeavour*. The significance of this particular state of affairs in influencing domestic technological success cannot be overemphasized.

But Japan's quest for technological change was also favoured by conducive features then obtaining in the international environment.[15] First during the period under review, Japan was not encumbered by a restrictive and constraining intellectual property system. It could therefore build domestic techno-industrial capabilities without risking punitive trade sanctions from potentially "aggrieved" countries. Related to this situation was the way in which the international market for technology was structured and controlled. Then, governments played a prominent role in technology transfer dealings, unlike now where multinational corporations are the main and predominant suppliers of technology.

Second, Japan faced an international development context where the technological gap between early and late industrializers was narrow and therefore not so difficult to bridge. Manufacturing production, in its broadest sense, hinged on artisanal and engineering-based skills which could, in many cases, be absorbed with relative ease through apprenticeship attachments, learning-by-doing, and on-the-job training. In contrast, the present world order is characterized by vastly sophisticated and complex technologies which require considerable investments in R&D.

Finally, Japan built domestic technological capacities in an international environment that was relatively free from the militating constraints occasioned by consumption-intensive technologies. The domestic market was not overwhelmed by consumer imports. The deeply rural orientation of Japan helped catalyze the growth of the textile sector, which relied heavily on local materials. Initially, this sector of the economy, predominated by small-scale industries employed craft skills, but even when capital-intensive industries were set up using imported modern technologies, the use of resource-based inputs and local materials continued to dominate. The fungal Japanese households were thus not exposed to imported products that had the potential to drain the Meiji state of valuable foreign exchange. Accordingly, its economy was spared the adverse ramifications unleashed by such technologies. Japan's prospects for promoting and maintaining high rates of domestic savings and investments were bright under the resilience of traditional consumption lifestyles.

The contemporary absence of requisite circumstances enjoyed by pre-war Japan and which are germane to the acquisition and establishment of domestic technological capabilities suggests that Africa will have to be all the more aggressive in its technology policy initiatives. The era of soft options has long gone. This realization should not dampen the spirit of those states seeking to industrialize within the next two to three decades. By hindsight, Africa should count her blessings because the constraints posed by the contemporary international development context have spared her the grave risks that would have been unleashed by ecologically destructive technological capabilities.

Happily, in the wake of growing environmental consciousness worldwide and the heightening of sustainable concerns globally, new opportunities which African states can seize to acquire and evolve domestic technological capacities have presented themselves. At the same time, such states would stand to gain if they wisely invoke relevant environmental provisions that prohibit flows of ecologically-harmful technologies.

The conduciveness of the international environment notwithstanding, the success behind Japan's technological experience was also determined by several other imperatives. These were: how the leaders planned their strategies; the nature and composition of the technology policy framework; the timing, phasing, and sequencing of technological investments; and so on. In succinct terms, Japan's technology policy framework rested on five main pillars, namely:[16]

- Introducing advanced western technologies
- Facilitating technological adaptation and generation of domestic technologies
- Promoting and giving incentives to technological innovations and diffusion in the wider economy
- Developing skilled human resources and relevant manpower needs

- Creating appropriate institutional and legal structures

The introduction of western technologies was a carefully planned process. Throughout the pre-war period, the Japanese leaders remained focussed and determined as they sought technologies from abroad. For instance, they consciously avoided those modes of technology transfer which had the potential to undermine Japan's long-term prospects for strengthening locally available capacities. In this regard, direct foreign investment (DFI) was not a particularly favoured option. This explains the marginal contribution of the DFI component in the overall composition of total annual investments in Japan. Instead, the government borrowed from external sources to finance infrastructural projects, state utility investments, and industrial manufacturing facilities. This direct involvement took the form of hiring foreign engineers from whom local Japanese workers would acquire skills and experience through learning by doing. The government would import machinery directly, the actual purchase being effected by technology-search missions which it expressly sent abroad. This way, the government was able to establish several public enterprises in ship-building, textiles, cement, machinery, iron works, glass, railways, telecommunications, mining, and sugar refining.

These modern facilities also played another very useful technological function, namely, the role of model factories where foreign products, processes, and production techniques would be demonstrated to stimulate their diffusion in the wider economy. In addition, they would serve as experimental work stations to run improved and locally adapted innovations. In these technical experimental stations, the domestically manufactured industrial machinery (which the government actively promoted) would be subjected to test-runs to establish whether they were good imitations of the imported equivalents. In the process, the following technological changes are achieved:

- the working of the imitated models are better understood
- the growth of locally trained domestic manpower results in an expanded base of experienced and skilled manpower
- the evolution of domestic technological capabilities in the manufacture of industrial machinery
- the evolution of domestic technological capabilities in design and engineering with respect to the manufacture of machinery

Soon after the initial phase (1868 – 1880s) of parastatal investments, the government sold off the enterprises to local private investors. But it still continued to play a very active role in influencing the rate and direction of domestic technological change. In this new functional form, it financed private sector investments, supplied vital information, and subsequently relinquished the responsibility of technology importation to the private entrepreneurs themselves.

Yet, this functional transition by government culminating in subsequent private sector domination in cotton spinning, iron and steel, automobiles, electrical machinery, shipbuilding, aircraft, paper and pulp, and chemicals can easily mask the fact that it was the dominant role of government, through its public enterprises programme, that sustained the whole process of technological development .

Although the establishment of public enterprises was the chief mechanism used by government to finance (through international borrowing) the evolution of domestic technological capabilities, other modes were also employed to stimulate technology transfer. The use ***of technical licensing agreements*** was widespread, most of which have been applied to cover specific lines of manufacturing production in the highly sophisticated sectors such as chemicals and electrical machinery. However, the terms and conditions specified by foreign firms were often prohibitively exploitative, suggesting that the overseas owners were not willing to license their technologies. Yet, the leaders recognized the huge extent of technological content these agreements embodied such as designs, know-how, patents, and so on. While so much knowledge could be gained through this mode, the downside may include excessive demands such as exorbitant fees, exclusivity of use, territorial restrictions, etc. In Japan, foreign firms with huge captive markets or monopoly control appeared to be most reluctant to agree to such deals. Yet, this mode of technology transfer became more widely practiced after 1905.

The final form of technology transfer, which pre-war Japan employed, was the joint-venture agreement. Arrangements of this sort were few and most were characterized by foreign equity ratios below 50 %. Joint ventures tend to operate in lines of manufacture where the technological gulf between a foreign firm and a domestic enterprise is massive. In Japan, the sectors under this arrangement include automobiles and electricity-generating equipment.

A critical component of Japan's technology framework is the commitment to enlarge the human resource base. Educational programmes were designed to meet technological manpower needs, namely, to produce skilled human resources capable of promoting and enhancing the evolution of domestic technological capabilities. The educational strategy was two-pronged. The first consisted of making primary education universal and compulsory, while the second involved the training of leaders at university institutions. Later, vocational training and apprenticeship programmes were introduced. These tended to foster skills and experience, a blend that subsequently helped to strengthen domestic technological capacities. It is worth noting that Japan enjoyed high levels of literacy even before the Restoration. This feature, together with the momentous expansion in formal primary education, and teaching and training institutions, facilitated the process of learning of modern technologies, their assimilation, and, eventually, their successful diffusion domestically.

While the institutionalization of the educational process generally helped produce minds susceptible to ideas, it also enhanced the active application of curiosity-oriented minds . Not only did this socialization promote a temperament to fathom and analyze foreign models in all their diversity, but it also nurtured an outlook ready and willing to learn from foreign experts and technicians. Crucial to point out, however, is that the socialization experience tended to inculcate values not only of learning but also of innovating, i.e., modifying and improving borrowed technologies where necessary. In this regard, the Japanese were participant observers rather than mechanical imitators.

Despite significant strides made by the government in the spheres of education and training, the modernizing elite had to initially grapple with the problem of incompetence and low quality labour among bureaucrats. This weakness tended to have an adverse impact on policy implementation on the one hand, and attempts to import, assimilate, and build domestic technological capacities, on the other. However, as the years wore on following the Restoration, this situation changed for the better. Due to attractive and relatively superior salary scales for government officials as opposed to those enjoyed by private sector employees, the state was able to attract highly educated and better calibre manpower resources in comparison. This development led to decisive improvements in the way in which policy was formulated and implemented. The guiding, directing, and influencing role of government bureaucrats became effective. The principle **"The first machine of import, the second by domestic production"** became a realistic proposition following dramatic improvements in the calibre of educated manpower and their absorption by the state's administrative machinery.

Training for manpower needs also involved overseas studies. The government-financed scheme was tailor-made to meet the technological requirements of given industries. Comprehensive and detailed planning about who would study what, where, when, and for how long proceeded under its direction to fulfil three main demands, namely, creating and developing relevant human resources; searching and compiling appropriate technological information; and purchasing requisite machinery. Students and missions abroad were required to participate in international exhibitions, with the aim of gathering valuable technological information, and updating profiles of foreign technologies by keeping an eye on various aspects of technological changes taking place abroad.

The Japanese government also organized competitive domestic technology exhibitions, the aim of which was to promote diffusion of innovations, give incentives to technological innovations, and institutionalize the process of building profiles of domestic technological capacities.

The Legal-Institutional Environment for Technological Change

During the pre-war period, the Japanese government made conscious efforts to forge a legal and institutional framework conducive to formulating and implementing technology policy. This framework had first to grapple with several unequal treaties signed during the Tokugawa reign which, in effect, amounted to capitulation because the treaties conferred significant privileges to foreigners. From the legal standpoint, Japan was freed from the encumbrances of an alien intellectual property system imposed on it and succeeded in establishing a national patent regime in 1885. By 1905, the government had enacted legislation called the *Utility Model Law* to stimulate petty innovations. Yet, prior to this legal event, Japan became a member of the *Paris Union for the Protection of Industrial Property* in 1899. However, its own national legislation introduced provisions that excluded pharmaceutical products from patentability, imposed limitations on the non-working of patents, included the recognition of utility models under its property regime, and conferred the state the right to use or disregard those aspects of the Paris Agreement which infringe on Japan's military and public interest. Another decisive break came about in 1911 when the economy could independently manage, and operate an autonomous tariff regime. This particular development was equally momentous in that the government could employ protectionist measures to shield local industries from foreign competitive onslaughts.

Of the two, the utility model system appears to have had the greatest impact on influencing the pace of domestic technological change. It affected techno-industrial change in the consumer and light industry more decisively. Patents, however, do not seem to have had any significant impact on Japan's technological evolution, largely because the imported technologies' respective patents had long expired. Moreover, the country's geographical remoteness, market limitations, and a poor transport and communication network to Japan tended to militate against potential patent registration by western patent holders. Furthermore, Japan managed to circumvent the western patent system by importing machinery directly (outright purchases), then using reverse engineering techniques to build its own production, investment, and innovation capabilities. Finally, Japan could acquire technologies with impunity because the procedures, processes, and niceties of legal redress had not developed appreciably. This contributed to the low level of consciousness, and hence the low litigation potential.

The Government-Industry Alliance

At the national level, the policy-making function, including the implementation of a technology policy framework, had to be effected within administrative structures that integrated technology policy and industrial development policy. In this exercise, special policy-making organs were established to direct the trajectory of techno-industrial change.

As noted earlier, the impetus to direct, guide, and influence technological change in the Japanese economy came from the powerful governing elite. During the early years of techno-industrial change, state planning was not of the dirigiste variety but one designed to augment market processes. Apart from government investments in the defence and social services sectors (railways and postal services) public enterprises set up and financed by the state were eventually (after 1880s) sold to local entrepreneurs at concessionary, attractive terms. Often, the new owners were the **Zaibatsu**, the family-based conglomerates which assumed prominence during the government's privatization programme. These business outfits had their tentacles spread in fields as disparate as finance, trade, and industrial production. The privatization drive transformed the configuration of entrepreneurship in Japan.

The government actively supported the **Zaibatsus** in diverse ways. In the process, it used this relationship with industry to influence the implementation of technology policy, convey information embodying express technological import, and, above all, direct, guide, encourage, and advise the **Zaibatsus** to pursue courses of action compatible with the government's technology policy objectives as well as trading and financing imperatives. This approach, known as administrative guidance, was not entirely non-coercive since companies unresponsive to government direction or influence suffered somewhat. In this context, the conglomerates not only became effective importers and innovators of foreign technology, but also succeeded in initiating and establishing new, modern industries in areas hitherto not tackled by the government.

Morichima (1982) claims that:

> "…the business world has always been guided by the government and has reaped the benefits by swarming around the government. In Japan, to be deserted by the government is to be neglected to being a second rate enterprise…" (p. 189).

The government supported industry by implementing a range of policies to create an enabling environment and also through direct influence. It often exerted pressure on enterprises and expected a certain standard of results. It is largely because of the efforts of the government that technological innovation has come to play a decisive role in the economic growth of Japan (Minami, 1986).

Ozawa (1980) investigated the State's control over Japan's technological acquisition and also the entry of firms into new sectors. He claims that the Ministry of International Trade and Industry (MITI) was very active in orchestrating the process of development. The staggered entry formula which he cites was designed not only to establish efficient scale plants but also to initiate the process of technological innovation.

It is often forgotten that the state agencies in Japan were heavily involved in manufacturing as well. There followed a period of divestiture, but this has been more than compensated by the dynamism of firms under state direction, control and influence. The experience of the NICs is also valuable in assessing the impact of public policy in industrial development and technological innovation.

A key institutional mechanism designed by the modernizing elite to promote and deepen technological change in Japan was the **Shingikai** - government consultative councils. These arrangements, comprising government officials, academics, industrialists, bankers, financiers, and representatives of business associations, were platforms for regularly exchanging, sharing, and communicating ideas and concerns between government and the private sector in a bid to enhance the state's capacity to design and improve policies. In addition, the councils serve as fora for gathering private sector information about the effects of policy, and what changes and adjustments would need to be made, if at all necessary. Finally, these policy-making organs had the effect of drawing and assembling together people of different talents, specialization, expertise, and valuable competence, all addressing and grappling with the complex issues confronting the Japanese society.

4.2.2. The Case of South Korea

Korea borrowed heavily from Japan's technological and industrial experience. Many of the policies she instituted were modified only slightly, her success nudging other high-performing economies of East Asia to faithfully follow in their footsteps. These countries targeted a plethora of industries that received subsidized and concessional credit, post-shipment financing, and free information and marketing services from government agencies. Many government agencies and trading companies that received grants operated under stringent performance criteria. They also had automatic access to export financing at lower than normal commercial bank rates. Targeted firms benefited from medium and long-term loans for investment in export production, again at lower than normal commercial bank rates. Such firms also enjoyed high depreciation allowances for capital equipment used in export production. As far as importation is concerned, it was not a free-for-all regime. Import rights for specific products have been extended to specific firms, especially those that had a good export performance record.

On investments, again the regime was not open and free. Governments discouraged foreign direct investments and motivated licensing arrangements instead. Furthermore, they subsidized targeted firms by providing investment capital for development of new products at lower than normal commercial bank rates. Even venture capital had been extended at concessionary, non-market rates. All these policies made exports very competitive.

Protection of domestic industry took a variety of forms, of which the subsidy factor has been the most salient. Domestic firms producing for the export market were free to import inputs without duties. For targeted industries and sectors, inputs have been exempted from tariffs. Tariff exemptions have also covered capital goods used for export production. Other favorable policies have included exemptions of harbour and other charges for export products; even firms supplying intermediate inputs used for export production have benefited from a wide range of concessionary policies. The cumulative impact of all these measures has been to enhance trade competitiveness in world commerce.

In the sphere of technology, as in the industrial domain, bureaucracies continue to play an active influencing role in development. In the acquisition of technology and development of domestic capacity, again most governments have employed the subsidized credit policy. All designated industries received direct R&D support including funds for start-ups and capital injection for new ventures. Normally, targeted firms would enjoy tax credits, including tax deductions for manpower training and technology development. In other words, whatever a firm spent on R&D or manpower development, it would be deducted from taxable income.

A critical component of technology policy has been for the government to bargain directly with technology suppliers on behalf of individual buyers. The negotiating team was the country's advisory committee on technology matters, and it was made up of government officials, representatives from industries, and researchers from universities and state institutions. This way, the government secured better terms for the domestic firms and was able to screen licenses at the same time.

Most HPEA economies established centralized procurement systems administered by science and technology ministries. They drew representatives from industries, research institutions and government ministries. Participants of the centralized bodies focussed on about two dozen activities which they identified as priority areas. The identification exercise was a carefully worked out process; the criteria was to target those sectors which stimulate the development of leading industries. The bodies have also been responsible for planning and implementing technology policies, which include the formulation of annual, short-term, medium-term, and long-term plans. The plans identified vital technologies as well as activities that would be undertaken by domestic firms.

About a decade ago, Korea proposed a key technology plan that had been discussed for 2 years by some 500 experts divided into 8 sub-groups.[17] But Korea also organized national technology promotion conferences that were convened quarterly and chaired by the President himself.[18] There was no better way of demonstrating the importance of technology in development than this gesture by the Korean president.

To the credit of many East Asian economies, the bureaucracies that guided industrial and economic change were of high quality and relatively insulated from political interference. Problems of corruption have featured from time to time, some very serious. But the civil service structures have been of high calibre, conducted business transparently, and were governed by norms of public accountability.

The efforts made by the Korean power sector in building domestic technological capabilities are extremely significant for Africa. That experience shows how the various institutions of the government were harmonized under a central agency that specified the nature and texture of public procurement. At the very outset, technological imperatives were identified and integrated into the indigenization policy. A conscious policy of developing the power sector was adopted; it recognized the need to stimulate the wider industry through interlinkages and backward integration. The evolution of the power sector was therefore a process that gradually indigenized import substitution and industrialization, and succeeded in doing so by linking the expansion and growth of the power sector with the broader national industrial base.

For three years after 1945, South Korea relied on electricity supply from the North, but soon embarked on a programme of building an indigenous base after the embargo imposed by the North. The overriding objective during this early phase was to install facilities to meet the urgent electricity requirements. Given the exigency, public procurement did not radiate from an indigenization strategy, but relied substantially on foreign financed, turnkey installations to fulfill the supply ambitions.

Between 1964 and 1975, the rapid growth of demand was accompanied by a brisk electrification programme that placed heavy reliance on overseas companies to undertake pre investment, project execution, project implementation services and equipment supply. The high foreign content ratios reflected the link forged between equipment sourcing and financial considerations. However, despite the fact that public procurement revolved around financial considerations, some degree of technology unpackaging was realized in construction technology. Domestic construction firms became increasingly involved in subsequent power projects in the country. Public procurement in this regard had been indigenized.

A deliberate, conscious strategy to shift public procurement from its strong external orientation to heavy domestic sourcing of services and power equipment began in 1976. But this strategy was complemented by an industrial development policy that put emphasis on the stimulation of the machinery, steel, electrical, and ship building industries. Capacities were created to ensure policy implementation.

At the heart of the indigenization policy was a tripod institutional arrangement organized to acquire technologies and build domestic technological capacities. This paper suggests that the success of public procurement policy must be seen against the content of the indigenization policy which constituted a carefully balanced counteraction of measures and instruments that focussed sharply on both demand and supply. While the Ministry of Commerce and Industry (MCI) was responsible for planning and implementing the indigenization policy, the Korea electric power company (KEPCO) was responsible for planning, construction, and management of the power sector.

The third factor in the institutional equation is the Korea Society for the Advancement of Machine Industry (KOSAMI), which represents the machinery sector with policy powers to regulate and screen the flows of capital equipment. KEPCO represents the demand side of that institutional equation, while KOSAMI represents the supply side.

KOSAMI's other functions included the building of technology profiles, the stipulation of local content ratios for domestic equipment production, and the extent of local participation in sub contracting activities. In addition, it organized domestic finance for those activities where local capabilities existed, and also informed all equipment importers of local substitutes.

As part of the government market restrictions policy, KEPCO identifies eligible supply firms that can be supported to manufacture a specific range of sub components of a product. It also participates in quality control and the implementation phase of a power project. This rationalization process led to the systematization of the power plant equipment market where a subsidiary of KEPCO was solely responsible for the production of the main and some auxiliary equipment. Engineering services were also high on the indigenization agenda and KOPEC, a subsidiary of KEPCO, was formed as a reconstituted Korea Nuclear Engineering Company (KNE). According to the report:

> ". . .the principal rationale for this arrangement is that the specialization is necessary not only because of the limited size of the domestic market but in order to facilitate concentration of learning opportunities. Besides, such an arrangement enables constant communication between the client public utility and the supplies, which is generally believed to be conducive to quality assurance and technological improvements".

The development of the domestic technological capacity in engineering services and production of power plant equipment was based on the explicit effort to accumulate experience on machinery production, attach counterpart staff in all the activities, and intensify training of engineers and technicians. According to the report, the activities were initially undertaken by the expatriate personnel, but the counterpart staffing strategy coupled with the setting up of organized teams to learn at close range contributed substantially to capability development.

With regard to sub contracting work given to domestic firms, the contents of collaboration agreements included: the purchase of design documents for the production of certain equipment and their components, technical assistance, and the training of engineers and workers. The sub contracting work was a specific feature of the technology agreements, with deliberate conditions to import know how to the attached domestic firms.

The evolution of the power sector in Korea shows that public procurement can be an effective way of building technological capabilities. Clearly, the coordinated actions of the various ministries played a significant role in that process.

The rapid growth of technological capability in engineering services and power equipment production has not been uniform in other aspects, however. While the contents of collaboration agreements with main equipment producers specified the imperative of technological build up, the motives of domestic auxiliary equipment makers were not similarly geared. According to the report, they were more interested in adding "more and new products", or acquiring production capacity.

In conclusion, the Korean case shows that the acquisition and absorption of technology was a conscious ambition of the power sector. The terms of reference were designed to capture this ambition. It was bolstered by specific contractual agreements on training and attachment of counterpart staff overseas. The involvement of local personnel was maximized not only in building expertise in new areas, but also in strengthening technological capabilities through local subcontracting. It was the vision, complemented by an action oriented programme that helped forge strong capabilities in Korea's power sector.

4.2.3. China

Bilateral modes of procurement have significant potential to maximize technology acquisition if technological imperatives are integrated within the procurement framework.

Table 2: Content ratios for planned equipment production in China, 1986–1990*

Project Phase	Local content ratio (in percentage)
1st	22
2nd	40
3rd	50
4th	80
3rd Unit (Low pressure heater)	100
Condenser (1&2)	25
Condenser (3&4)	35

Source: MPS Staff Reporter, "Jiangyou Project Maximizes Technology Transfer," *Modern Power Systems*, (1991) vol. 11, Issue 1, January, p. 47.

* This period covers China's 7th national five-year plan. Note that local content ratio increases as the project moves to the 4th phase. Also note that local content ratio for condensers 3& 4 is higher than for 1& 2. The conditions for the entire contract were drawn by the Chinese Ministry of Energy. Clearly, an integrative approach was taken by the Chinese authorities that included intensive training, identification of specific technological targets, and reduction of overseas content ratios over time.

In 1986, China entered into a long term agreement[19] with GEC Alsthom of France for the manufacture of four 300 MW turbine generator units, transfer of design technology, documentation and drawings, and a gradual increase in domestic content in the co production of heavy power generating equipment. The Chinese public institutions involved in the venture were: China National Technical Import Corporation (CNTIC), China International Water and Electric Corporation (CWE) which owns the Jiangyou project, and Beijing Heavy Electrical Machinery Works (BZD). The latter has had years of experience in the manufacture of 200 MW turbo generators but given the annual power requirements in China (approximately 10 GW), larger unit capacities are to be produced locally. But significant in the bilateral agreement is the specific targeting of local content ratios, as summarized in Table2.

4.2.4. Other Examples

UNCTAD (1983) observes that in countries like India, the implementation of public procurement policy has sometimes been unsuccessful particularly for foreign funded projects.[20]

Public procurement here refers to the capacity of state agencies to obtain supplies from domestic firms rather than rely on overseas companies to market power equipment to India. The UNCTAD (1983) study highlights the gap between the declared policy of the government and the implicit preferences of some government officials to appoint overseas consultants and procure machinery and equipment for state institutions.[21] These "policy gyrations" as they are called, have weakened the capacity of Indian consultancy and engineering companies to maximize domestic technological content (p. 69).

However, although the sixties and seventies were characterized by some policy gyrations, India did eventually manage to increase its domestic content in state directed power investments. But the early years of building indigenous capability were gripped by problems of faulty designs (introduced by licensors who had limited familiarity with conditions in India, UNCTAD, 1990: 13). The country placed heavy emphasis on the creation and development of a power equipment manufacturing industry, but the first generation equipment produced in India through licensing precipitated problems of performance of the power sector.[22]

While the government was committed to developing indigenous capabilities by involving more domestic firms in the process, it also realized that procurement of knowledge and expertise would initially call for a relatively higher level of external support from established power firms overseas. In the short term, then, technology acquisition by Indian firms demanded a large level of collaboration with overseas firms.

By early 1980s, India's public sector had developed a capability to manufacture turbines, generators, boilers, transformers, condensers, switchgears, motors, pumps, heat exchangers and feed water heaters. Bharat Heavy Electricals Ltd. (BHEL) now satisfies 80 % of the major plant and equipment needed by India's power sector (UNCTAD, 1990: 12). India also exports power plant equipment; this is evidence of graduate maturity of a sector that initially depended heavily on overseas technology. Nayer (1983) observes, for instance, that India is now capable of breaking down (for a large number of projects) the technology package except for projects sponsored by the World Bank (p. 523) or those which contain co financing. In such cases, India's public procurement policies are heavily constrained from effectively utilizing domestic technological capabilities.[23]

India provides a minefield of valuable case studies on contrasting management possibilities in the broad vista of technology transfer development. Nath and Lokesh (1988) evaluated modest, though significant efforts directed by an indigenous laboratory to develop a technology for the production of chlorosilanes. This intermediate chemical feedstock has widespread use in the manufacture of resins, greases, emulsions, silicon rubbers, textiles, paper, leather and food.

The National Chemical Laboratories in India were inspired to develop a local capacity for two main reasons: one, chlorosilanes were wholly imported, and two, the technology for its production was a closely guarded secret. The NCL succeeded in developing one, established a successful pilot plant, and commenced manufacturing.

However, this momentous endeavour to achieve technological self-reliance through indigenous R&D was frustrated by lack of complementary institutional support. Within a few months after commissioning, the basic raw material price rose sharply. The firm was engulfed in a grave financial crisis, exacerbated by easy-flowing unrestricted imports of the finished product. The government continued to restructure the tax regime, and restrict government's staggering capacity for inaction, dealing a death blow to an R & D infrastructure capable of creating modest beginnings of indigenous technological capability. The authors lamented that:

> "—— Indigenous technology cannot play a useful role in the development of technological self-reliance unless backed by right policies and programmes of the government———"

While the dismal case of chlorosilanes raised genuine concerns for government intervention, the same authors explored the evolution of a successfully managed technological development that was supported institutionally. The project involved the production of monocrotophos, an organo-phosphorus pesticide that began in 1978 after a broad-based feasibility study. For a very long time, agricultural firms relied heavily on imports, spending large amounts of foreign exchange. At the government's request, three research laboratories embarked on intensive research to develop an indigenous capability for the manufacture of monocrotophos. The success of this project can be attributed to efficient management of transfer development of indigenous technology for self-reliance. Aspects of successful management include:

- A comprehensive market research that revealed existing pesticide demand and hence the need to develop an indigenous technology;
- Clear identification of the pesticide and the velocity with which the technology was developed;
- Government institutional support in restructuring tax regime and pricing policies of basic inputs.

The successful case of monocrotophos production is an exemplary illustration of independent technology development capacity (ITDC). Considerable research energy has been expended to learn and create an independent capacity for technology generation. Ronald Dore (1984), commenting on aspects of India's technological experience, emphasizes the need to focus more attention on independent technology learning capacity (ITLC). While stress was laid heavily on technological self-reliance, India has since realised an impressive measure of success but only at the expense of obscuring important complementary capacities in technology evolution. Dore cites an automobile manufacturing firm complacently clinging onto old designs without evolving improved processes and products, despite the enormous range of financial and institutional incentives at their disposal. The technostructure, to borrow the Galbrathian metaphor, was obsessed with the new import-substitution drive almost as a corporate ethos of self-actualization. The firm in the course of time absorbed the mechanics of automobile production (Adhesive-Imitative Capacity) without genuinely valuing adaptive innovation in product evolution (Cohesive-Creative Capacity).

A major drawback in Dore's analysis is gross oversimplification of the interaction between technology transfer, import-substitution, and government involvement. It is true that the firm producing the Ambassador failed to make R&D sacrifices to improve upon the model. Dore compares this failure with spectacular success achieved by TELCO, a bus and truck manufacturing firm, in independent technology creating and learning capacities. What he failed to note was the fact that successes or failures in India were random and not necessarily a function of state involvement. Selective government intervention depends to a large extent on the existence of symbiotic relationships between itself and specific technostructures. Passive or lukewarm intermediations have in some instances induced inertia and feeble responses to creating and generating learning capacities; the Ambassador production is a clear case in point. Corporate complacency unwittingly supported by state nonchalance and institutional distance can easily precipitate random results. The failure by government to intervene, despite ITCC, ITLC and ITDC in the case of chlorosilane's project, is a clear testimonial reminder that the quest for import substitution industrialisation and technological self-reliance may be a 'Will-o-Wisp' if the various capacities are not complemented by tactical and strategic state intervention.

(Footnotes)

[1] Singh, A. (1982) "Industrialization in Africa: A Structuralist View" in Fransman, M (ed)
Industry and Accumulation
, Heinemann Educational Books Ltd, London, p.27.

[2] Seers observes that "...close personal contact with the problems of backward countries instils for many reasons, a sense of urgency and some impatience", p.53. See Seers, D. (1963) "The limitations of the special case" reprinted in Meier, G. (1976).

[3] See Gerschenkron, A. (1962) "Economic Backwardness in Historical Perspective" reprinted in G. M. Meier (1976)
Leading Issues in Economic Development
, Oxford University Press, New York, p. 91.

[4] Ibid, p.90.

[5] Ibid, p.90.

[6] See Gee, S. (1981)
Technology Transfer Innovation and International Competitiveness
,
John Wiley and Sons, Inc., New York, pp.103-104.

[7] Hans Singer is not convinced that the accumulation of science and technology in the North presents any great advantages and benefits to latecomers. He condemns that "... it is because of the accumulation of science and technology, or rather the specific nature of this

accumulation, that we witness much widespread failures of real development among the latecomers, belying the unthinking optimism of earlier days". Singer raises two principle objections. One, a large part of the simple accumulation of scienc

e and technology in the North is unlikely to benefit the South mainly because the knowledge is idiosyncratic and distinctively unique to the problems, circumstances, factor endowments, and requirements of the North. Two, there is a continuous process of displacement of previous knowledge as new science and technology are created. The submergence of this knowledge when new innovative changes are introduced implies that it is displacement rather than accumulation that takes place. What also needs to be added

is that a large part of this knowledge is protected by patents and forms intellectual property rights, and is therefore not freely obtainable. The high cost of technology has slowed down the South's industrialization process. For an elaboration of Singer

's view on the transfer of technology, see Singer, H. (1975) "Science and Technology for Poor Countries" reprinted in G. Meier (1976) Ibid, p.395-397.

[8] Kemp, T. (1978)

Historical patterns of Industrialization

, Longman, England, p. 147.

[9] As the 19

th

century came to a close, Japan fought and defeated Chine in an unexpected military assault. At the turn of the new century, Japan 's military adventurism was directed at Russia and defeated the latter most resoundingly. With this success, the imperial temperament was being sharpened, and Japan, like the imperial forces of Europe, was bent on carving out spheres of influence in the Pacific region of the world.

[10]

ibid

, p. 147.

[11] Consult, for instance, to appreciate the prodigious scale of bibliographical references on Japan.

[12] Mikes, G. (1983)

The Land of the Rising Yen,

1983 Reprint, Penguin Books, p.14

[13] Ibid, p.15.

[14] See UNCTAD (1978)

Case Studies in the Transfer of Technology: Policies for the Transfer and Development of Technology in pre-war Japan (1868-1937),

UNCTAD, Geneva, TD/B/C.6/26, p.VI.

[15] Ibid, UNCTAD, 1978, pp.vi-vii.

[16] Ibid, UNCTAD, 1978, P.14.

[17]See U.S. Congress, Office of Technology Assessment (1991

), Competing Economies: America, Europe, and the Pacific Rim

, OTA-ITE-498, Washington, D.C., U.S. Government Printing Office, p.312.

[18]*Ibid*

, p. 312.

[19] .This section is a review of an article titled "Jiangyou Project Maximizes Technology Transfer", prepared by the staff of

Modern Power System

, (1991) vol. 11, Issue 1, January, pp. 39

–49.

[20] .There is evidence that suggests that financial packages organized by contractors may not necessarily constrain the utilization of domestic manpower resources and indigenous capabilities. The petrochemical industry in Korea had its finances arranged by the contractors, Dow Chemicals, but technological imperatives guided the acquisition of technology and subsequent utilization of in

house resources and domestic capabilities. See Enos, J.L. and W.H. Park (1988) *The Adoption and Diffusion of Imported Technology: the Case of Korea,* Croom Helm, London.

[21] .UNCTAD (1990) notes: ". . . too hasty import substitution of a large number of low cost items and lax quality control at sites caused additional serious problems. Inadequate testing facilities and lack of experience of technicians and engineers led to problems during commissioning and too long delays in reaching stable operating conditions and full load. . . . the upshot was that performance of the first indigenous power plants, large numbers of which were manufactured with original design faults before any field data and feedback experience had become available, was poor." (p. 13).

[22] .India's procurement strategy initially concentrated on licensing agreements with electric power firms in Czechoslovakia, United Kingdom, USSR (now Community of Independent States (CIS), France and Germany. A large number of power projects were thus initially undertaken by overseas firms. It is this early experience of heavy foreign presence, against the background of government declaration to involve domestic firms, that raised questions of policy gyrations.

[23] .The World Bank began to shift its strategy from financing a whole package of foreign costs to one that allowed bilateral donors to chip in under a new arrangement called *co financing*. Joint lending limits the capacity of a borrower to obtain favourable terms. There were attempts by the World Bank to subject India to this sort of manoeuvre. Hayter and Watson (1985) have noted that the Bank had extended to India a loan of $450 million for rural electrification. But the Bank insisted that procurement of aluminium rods be made exclusively from the Canadian market. India refused by arguing that the rods were 45 % more expensive in the Canadian market than elsewhere; the Bank called off the project as a result. This case illustrates that India's public procurement was constrained by such policies. Many weak economies in dire need of rural electrification could fall victims to such policy manoeuvres by the World Bank, but India's technological history and quest for technological independence has given her the strength to secure better terms of procurement for continued national self reliance. For an analysis of co financing and its impact on procurement, see Hayter, T. and C. Watson (1985), *Aid: Rhetoric and Reality*, Pluto Press, ch. 5.

5. Global Conventions, Protocols and Agreements: Solemn Promises and Lip-service Commitments

Since the publication of *Our Common Future* in 1987 and the inauguration of unprecedented international environmental events thereafter, policymakers around the world have come to appreciate the depth of interdependence between the various components of the global system. Though the idea of interconnectedness has much deeper historical roots, it acquired a more concrete expression following Kenneth Boulding's insightful article: *The Economics of the Spaceship Earth* (1968). But what truly widened the discourse and heightened the consciousness about this notion was the highly controversial study by the Club of Rome, *Limits of Growth* (1972). Paradoxically, the hostile reaction it elicited from analysts and practitioners of mechanistic persuasion tended to cast the factor of interdependence into sharp relief. And yet, it was only after the milestone environmental events of the 1980s and 1990s that the agenda for international cooperation began incorporating solemn commitments on technology transfer and flows of new and additional financial resources to developing countries.

Undoubtedly, the era of sustainable development had been born. This concept, which underpinned the essence of the*Agenda 21* plan, made it crystal clear that the global challenges facing humankind needed concerted international action if the race against time was to register phenomenal achievements. For Africa, the mood fostered by the exigent environmental realities implied that the commitments to promote and accelerate technology transfers would be honoured in accordance with the principles of ecological sustainability. Hence the blessing in disguise occasioned by the new temporal and global order.

5.1 Sustainable Technology Transfer as a Global Imperative

Would the western world be doing the Third World a favour by exporting to them environmentally-sound technologies at concessionary rates? Or would the flow of sustainable innovations to the South be a matter of global necessity? What would be the implications of the North holding back vital technologies needed to develop the South?

This paper argues that the North is obliged to arrive at cooperative accommodation with the South in the latter's economic aspirations if the North itself is to be spared the horrors of ecological disasters waiting to explode in the South. The disasters are likely to take two forms. One, the growth of inhabitable ecological conditions in the South, resulting from deepening environmental decay would trigger a wave of environmental refugees to Europe and elsewhere reminiscent of the Vietnamese boat crisis the world witnessed a few decades ago. However, the scale of the refugee crisis will surpass anything humanity has experienced in modern times. Two, the adoption of environmentally destructive technologies by the South will aggravate stresses to what are already strained ecological thresholds on renewable resources. The use of such technologies would exacerbate pollution, aggravate climate change, accelerate ozone depletion, and worsen biodiversity destruction. All these adverse trends would ultimately reverberate to other parts of the world now seemingly insulated from the latent crisis. These concerns are covered in the following sections:

5.1.1 Industrial ambitions, technological change and environmental decay

Despite audible declarations of intent to pursue sustainable development made by world leaders at the Earth Summit at Rio in 1992, the global environment has continued to deteriorate in the five years since the meeting. The phenomenon continues to raise concerns about the ability of ecosystems to support human livelihood and provide life-support functions in future. Anxiety is growing as to whether the carrying capacity of the environment is not already overstretched. It is also feared that human activities are inexorably driving the planet to potential disaster. The question often posed about various ecosystems is whether their potential viability to deliver environmental services is not under severe threat already. Equally worrying about the adverse trends are the effects of environmental degradation on human health, productivity and general economic welfare.

The acceleration of environmental destruction has assumed ominous proportions in view of rapid population growth, growing poverty, deforestation, effluent discharges, particulate emissions and general contamination from industrial pollution and agricultural run-off. Energy consumption has risen sharply this century. Energy inputs are an essential part of the development process. From cooking and travelling to the production and consumption of goods and services, energy is a vital ingredient. In quantitative terms, the largest users of energy are the industrialized countries both in absolute and per capita measures. By 2001, the OECD countries consumed a per capita ratio of 4500 kg per annum. In contrast, developing countries registered 500 kg per annum. While industrialized countries (ICs) rely heavily on non-renewable, fossil-based energy sources, DCs depend overwhelmingly on non-renewable biomass sources.

Over the years developing countries have tapped only a small proportion of their vast hydro potential. At any rate, the outcry stemming from the environmental implications of hydroelectric power development may present future problems for exploiting water resources in some developing countries. India, for instance, has recently experienced mounting pressure, occasionally culminating in violence, from a community residing in the neighbourhood of a hydroelectric development project. The World Bank backed away from the investment as environmental sensibilities intensified. As funding agencies become more sensitive to environmental concerns, the exploitation of hydro reserves may not be easy in future. Inevitably, environmentally-sound alternatives will have to be considered highly in energy planning for developing countries. But if the patterns of economic change in developing countries in the last decades are anything to go by, then their levels of energy consumption are set to increase. The increase has been accompanied by greater use of fossil-based fuels as manufacturing production expanded.

At least three distinct processes are expected to generate higher levels of pollution. First, the growth in industrial production will rise relative to agriculture, implying a pronounced growth in fossil-fuel consumption.

The pollution consequences of this structural change will be intensified adversely as industrial modernization broadens. Second, manufacturing processes are intensely pollution-prone, such that the wastes generated and the emissions discharged will have a detrimental effect on the environment. Third, the expansion of the manufacturing sector relative to agriculture will produce a labour force with higher incomes and a more diversified demand structure. Consequently, the emerging high-income groups will reveal a partiality for goods with a high income elasticity of demand. These are largely manufactured products whose energy requirements are invariably far greater than those needed to generate agricultural output. For this reason, the growth of the manufacturing industry is likely to induce a sustaining momentum for more energy-intensive goods and services. In general, therefore, the process of industrialization is expected to produce wastes with far-reaching pollution consequences for many a developing country.

It is evident from many development plans that developing countries (DCs) are aspiring to industrialize rapidly in the next 20 years. Efforts to achieve industrial objectives have continued to receive considerable government support. DCs hope to replicate and even leap-frog where necessary, the stages of growth and development experience of ICs during their evolutionary history. The desire to modernize takes on the characteristic content of existing industrial societies. Unfortunately, even though there is widespread appreciation that the environmental cost of western industrialization has been very heavy and that it continues to exert its ecological toll in adverse ways, many developing countries are still wedded to the ambition of replicating the industrial structures of the west.[1] How much of a model is the western pattern of industrial development to developing countries?

In retrospect, a number of ICs have conceded that the approach they used to achieve high standards of material prosperity have been environmentally destructive. Since this acknowledgement, efforts have been underway to develop environmentally-friendly technologies and engage the new innovations in industry and agriculture. A growing number of firms, responding either to government regulations, economic incentives or sharper consumer sensibilities towards greener products, have spearheaded a series of innovations to protect the environment. These developments are of enormous ecological value to developing countries. However, the innovations are expensive and may not be within the reach of nearly all DCs. The absence of a truly serious global partnership in techno-environmental matters will thus mean further deterioration in the planet's environmental health.

5.1.2 Diffusing environmentally-sound technologies

Conservative estimates from leading international organizations predict that the vast economic expansion planned by many developing countries is set to be a major source of greenhouse emissions in the next 25-100 years. It is widely recognized that industrial growth in industrialized countries has been responsible for much environmental degradation now threatening climate change and the world's biodiversity. Environmental fora worldwide have generally agreed that industrialized countries should take decisive steps to remove these threats. But equally appreciated has been the need expressed mainly in the South that the North should bear a significant part of the cost of the South's ambition to industrialize sustainably. The need, therefore, to formulate an *international environmental technology transfer programme* to minimize net releases of greenhouse gases to the atmosphere is not only essential but also vital in pursuing international sustainable development. There is every indication that assisting developing countries in addressing local environmental problems would contribute appreciably to global environmental protection. The ambition to mitigate greenhouse emissions thus requires global environmental stewardship that would facilitate the transfer of environmental technologies to developing countries. Given that energy needs in developing countries will double in the next 20 years, and in view of the challenge to curtail global ecological threats, the necessity to send cleaner production technologies to the South is overwhelming. In terms of energy efficiency, Kasman (1992) notes:

> "Efficiency can be increased—often with considerable cost saving—by improvements in the method of power generation, including better managerial, operational and maintenance practices; by increasing the use of renewable energy technologies and less-polluting fuels; by introducing new equipment or appliances; and by improving the design of buildings and manufacturing processes so as to reduce energy consumption. The elimination of price-subsidies by some countries would also lead to greater energy conservation and efficiency."[2]

Technological advances will have to cover a wide-range of sectors including energy, industry, transport, agriculture, and the management of natural resources. The urgency to facilitate technology transfer stems from the realization that the emission of greenhouse gases poses one of the most grievous risks to mankind.[3] As the body of scientific evidence grows, it becomes more critical that the issue has to be addressed in all its diversity. The catalogue of harmful effects outlined in study after study emphasizes the need for a rapid and sustainable response to the problem. In the anthropogenic sense, green house gases are a product of technology. It is a technology that has gone wrong right from its infancy. And given its dysfunctional base, new technological solutions have been sought to initially minimize and finally exterminate the problem. The search for sustainable technological options was thus a reaction to mankind's erstwhile technological achievements.

What are these gases and how is humanity affected by them? What sustainable technologies have been developed, and what experiments are currently underway? How should developing countries in general, and Africa in particular, respond in the face of the global environmental crisis? Are public domain environmentally-sound technologies available to be exploited by Africa? And how can global partnership and cooperation help the world escape the impending disaster?

Both carbon dioxide and chlorofluorocarbons (CFC) emissions are responsible for changes in climate, even though the latter has direct impact on ozone depletion, a factor that allows penetration of harmful ultraviolet radiation (UV-B) onto the earth's surface. This raises the incidence of skin cancers, impairs the body's immune system, and raises the spectre of more blindness cases. In the case of cancers, both non-melanoma and melanoma varieties increase and even cause deaths. The enervation of the body's immune system increases the incidence of infectious diseases such as tuberculosis, sexually transmitted diseases, fever, malaria, chest infections, colds, and meningitis. Blindness and varieties of eye infections also afflict humans and animals as UV-B finds its way down. Estimates indicate that cataract problems will rise by 0.6 % if the ozone-layer is depleted by one %.

Penetration of UV-B onto the earth's surface will also disrupt the vital ecosystem functions and life-support systems. Many microorganism and aquatic creatures are affected adversely in ways that destroy the food chain cycle. The web of interdependence is disrupted and affects fisheries (UNEP, 1992:12).

Additionally, the destruction of stratosphere ozone by CFCs alters the climate patterns adversely. Irregularities in weather patterns impact negatively on agricultural production, yield levels, and plant resistance to diseases and pests. Food security is thus threatened.

The disruption of ozone-layer by CFCs and the accumulation of carbon dioxide in the atmosphere combine to increase global warming. A good number of reports predict that the doubling of carbon dioxide concentration in the atmosphere by 2030 would increase the global temperature between 1.5 degrees centigrade and 4.5 degrees centigrade. Based on these estimates, a disturbing scenario has been advanced. The world is expected to experience a dramatic rise in sea level at a rate of 6 cm per decade. By 2030, the effects will be visibly grievious, the rise gobbling up low-lying coastal areas and islands. These adversities will set in motion a wave of environmental refugees as more productive land is salinized, as freshwater resources are contaminated, and as fishing grounds are disrupted. Moreover, estuaries and deltas will be permanently flooded, thus reducing agricultural production.

Another predicted impact of climate change is the increased precipitation globally. Early indications point to mixed results even though dangers still persist about possible adverse trends. It is surmised that precipitation will vary regionally with some areas expected to suffer water resource problems. In other cases, increased rainfall would intensify leaching, increase floods, and accelerate soil erosion. Higher sediment loads in rivers is thus expected to affect coral reef ecosystems. On the other hand, regions rich in forest cover may experience richer growth and soil conservation. Some agricultural areas are likely to witness weed proliferation, which will intensify competition and affect agricultural yields negatively.

It is now well established that global warming and high temperatures condition plant growth and effectively boost agricultural production. However, higher temperatures also create a congenial environment for rapid weed growth and pest proliferation. So while crop yields are likely to rise, weeds and pests may compromise agricultural productivity. In addition to such expectations, higher temperatures will require extra sustainable refrigeration facilities. Such temperatures are likely to accelerate decay of livestock and agricultural products unless they are cooked and stored well.

Two further effects are the high evaporative demand, and the degeneration of soils and the onset of their infertility. Both these are consequences of high temperatures accompanied by increased levels of carbon dioxide concentration. Weed growth, forest productivity and crop yields are expected to be more pronounced. This effect is likely to be temporary as soils will be overused. Danger looms of soils losing nutrient value rapidly, of pests proliferating excessively, and of diseases spreading widely.

In view of such frightening expectations and real dangers of green house gases, it is difficult for humanity to just sit back and do nothing.

5.1.3 Industrial acidification and global environmental degradation

The nature of atmospheric pollution and the adverse climatic changes that such emissions entail emphasize the risks posed by transboundary spillovers. Already evident in a number of pollution cases is the extensive effect of environmental problems beyond their immediate localities. Emissions are, in general terms, regional in their effects and global in their repercussions. Problems of sulphur precipitation and acidification are not confined to the sources of emissions, but cross boundaries and traverse through regions.

In addition to widespread damage on water quality, fisheries and aquatic life in general, acidification has also gravely affected the wholesomeness of soils through leaching. Most of the leached metals find their way into the lakes, reservoirs, rivers, canals and other water bodies, exacerbating the already precarious balance of aquatic life. In other words, acidification of wetlands has been worsened by eutrophication, a process that adds massive nutrients from agricultural run-off, industrial sources, and human settlements. Eutrophication causes microphyte overabundance, toxic algal blooms and suboptimal growth of other aquatic plants. (Eutrophication is the overloading of wetlands and water bodies with nutrients that distort ecosystem balances). Some of the most visible, and undoubtedly, poisoning aspects of eutrophication include: offensive water odours and tastes, impairments of fisheries and spawning grounds, limited sunlight penetration into the lower reaches of water bodies, oxygen depletion from microphyte and algal overgrowth, large water losses through evapo-transpiration, disease infestation in algal breeding grounds, water quality deterioration and discoloration, and artificial navigational hindrances from microphyte overabundance.[4]

Acid rain containing nitrous oxide is bound to poison wetlands and aggravate eutrophication. Acidification also affects forests adversely though the effects of sulphur dioxide and nitrous oxide emissions from automobile and vehicular sources are also harmful. At least over 55% of Europe's forests have been damaged by acid rain. The problem takes long to notice, but overwhelming evidence already suggests less vigorous growth of forests in the United States and Germany. [5]

Two further acid rain effects are: disfigurement of buildings and destruction of vegetation by acid deposition, threatening ecosystem functions and losses of biodiversity. The interlinkages between one ecosystem and another raises the spectre of spreading damage beyond the vegetation system affected by acidification. In areas where losses are already being felt, the danger of completely wiping out genes and species of known and unknown plants and animals clearly creates the possibility of denying humanity possible advancements in agriculture, medicine, and industry. As the genetic base is threatened by acidification, humanity's potential to exploit biotechnological genetic variation to increase production of energy, biological pesticides, medicines, food products, industrial chemicals, and other environmentally-sound resources will be substantially compromised. Policy initiatives should be set in motion to enable humanity benefit appropriately from the rich heritage of biodiversity. Control of emissions that lead to acid rain is thus vital.

Many buildings in Europe, United States and other countries have been disfigured by acid rain. The acidic condition of the environment has also raised costs of restoration, repair and maintenance. It is worth noting that the costs of rehabilitation are equivalent to the sums needed to erect pollution-reducing technologies in gas emitting plants.[6] Despite these extra-territorial externalities, DCs continue to meet considerable resistance when they urge ICs to support environmental programmes by supplying the relevant sustainable technologies to firms in the South. Yet, the global "commons" will continue to be damaged if only the ICs concentrate on them. To ignore the participation of DCs is to invite further ecological decay. Global efforts and collective partnership remains the only option for humanity.

5.1.4 The ozone-depleting substances and international cooperation

Nowhere is this concern more clearly defined than in the continued use of ozone-disruptive technologies. Anxieties about the impact of greenhouse gases on global climate has intensified in recent years as scientific consensus becomes more evident. Two broad categories of gases are responsible for global warming. One is heat-absorbing; the other is ozone-destroying, which allows more of the sun's radiation to penetrate the earth's atmosphere. Carbon dioxide and methane are the heat-absorbing gases; on the other hand, nitrous oxides and CFCs are the ozone-depleting emissions. Since the first industrial production in 1930, the use of CFCs has grown phenomenally in industrialized countries. For over four decades, CFCs consumption has been perceived as innocuous. Doubts about their safety began to emerge in the 1970s as more evidence indicated the harmless stereotype that came to be associated with CFCs. The earliest concerns were registered in the late 1960s following nitrogen oxide emissions from supersonic aircraft. The very hot gases were released at an altitude of about 20 km; they persisted and rose to the region of stratospheric ozone about 25 km from the earth's surface. Here, the oxides catalyzed the destruction of ozone. But much more virulent on stratospheric ozone are the CFCs. Under the influence of ultra violet radiation, a chlorine atom is set free from the CFC molecule, which then attacks the ozone layer. The disruptive effect of a released chlorine atom is multiplicatively extensive, implying that an unsustainable build-up of CFCs in the stratosphere could easily result in a gaping hole in the sky. This is already evident. In the event, harmful ultraviolet radiation (which is naturally blocked by the ozone layer) penetrates to the earth's surface. Its penetration causes a wide catalogue of damages.

This recognition set in motion a series of events geared to reaching an international control agreement on CFC production and use. Since the early 1970s, various Protocols were signed on emission targets but the process was characterized by deep controversies. The year 1980 is regarded as a baseline year for emission standards, with many countries pledging to cut emissions to the 1980 level.

The Helsinki Protocol of 1985 underlined the commitment by a few signatories to cut sulphur emissions to the 1980 level. Many more protocols have since come into being, including the 1987 convention on the reduction of sulfur emissions or their Transboundary Fluxes. The 1988 Protocol concerned the contents of emissions of nitrogen oxides or their conventions aimed at cutting back emissions by a target and/or freezing emissions altogether beginning 1993 and 1995 respectively.

On sulfur emissions, major disagreements have stemmed from the differential costs and benefits as each country is expected to adhere to the set, standard target. Given the contrasting cost curves for different countries in meeting a commonly uniform target, there are concerns that a single abatement level would not reflect equity of involvement. To be realistic, reduction targets must reflect general cost structures of each country. This means that every country will come up with its own abatement target so that the overall emission level is achieved. The system of tradeable permits is thus bound to integrate differential cost variations between countries. The concept of cost-effectiveness may not after all lead to an all-inclusive result.

Following the important uses in critical aspects of life, consumption of CFCs began to increase rapidly. CFCs found major uses in refrigeration and air conditioning systems, as cleaning solvents in the electronics industry, as propellants and solvents in aerosols sprays, and in the production of foams for insulation and food packaging. CFCs are also used in fire extinguishers. The technology of storage refrigeration has become vital in homes, industries and transportation. Refrigeration extends the longevity of biodegradable products, reduces losses of perishables, minimizes costs associated with decomposition, ensures non-deterioration of biodegradables which have to be transported over long distances, and preserves agricultural, livestock, pharmaceutical and marine goods susceptible to decay. The range of products that can be protected from putrefaction is so wide that industrial civilization will cease to function without refrigeration technology. Cooling and deep-freezing facilities have increased sharply in industrialized countries, as well as in Arab states.

Use of air conditioning systems has also become widespread, especially in the oil-rich Arab countries where the climate is baking hot and humid. Consumption has also risen remarkably in the tropics and sub-tropics. Both refrigeration and air-conditioning systems have become indispensable in industry, households and offices in many countries. And so have aerosols and plastic foam products.

Of about half a dozen CFCs known in the world today, only two are very widely used, CFC-11 and CFC-12. But these types also have the highest ozone-depletion potential. Recognition of their actual and potential menace has provoked governments, environmental lobby groups and international organizations to exert pressure on industries to develop ozone-friendly technologies. By setting emission targets, and a time-table to phase-out CFCs, the international institutions have redefined the agenda of many industries involved in the production of ozone-depleting substances.

A major watershed in international negotiations was reached in 1987 when the Montreal Protocol on substances that deplete the ozone layer was signed. It was adopted in 1989, and underlined the objective of reducing CFCs and halons production to 1986 levels. Subsequent amendments to the Protocol underscored phasing-out the production of ozone-depleting substances by the year 2000. A Multilateral Fund was set up to facilitate compliance of the Protocol and assist developing countries obtain the relevant technology from industrialized nations. Despite interest expressed by some countries the Fund has so far only received about 27% of the pledged contributions.

Even before environmental diplomacy reached its high-water mark in 1987, unilateral efforts to limit production of ozone-destroying substances had started in the late seventies when the US banned the use of non-essential aerosols. Other countries, like Sweden, Canada, Norway and then Soviet Union, followed suit. The paramount influence of UNEP in major discussions, and the cumulative impact ultimately gave birth to the Vienna Convention for the Protection of Ozone Layer in 1985.

Following the environmental breakthrough of 1987 and the amendments made thereafter, many countries spearheaded regulatory national legislation to implement provisions of the Montreal Protocol. Some multinational companies have since invented resources to develop sustainable alternatives to CFCs and halons. DuPont had said that it was phasing out CFC production by 1994. The electronics industry has several options available, from a new biodegradable solvent made from oranges to water-based cleaning systems. A significant number of firms within the developing countries use non-CFC refrigeration technology, the focus now being on two major alternatives, hydrochlorofluorocarbons (HCFCs) and hydrofluorocarbons (HFCs).[7]

A new association, the Industry Cooperative for Ozone Layer Protection (ICOLP) is made up of firms that pledge to provide non-CFC technologies to DCs and ICs. Digital Equipment Corporation, a member of ICOLP, has announced that it will provide water-based cleaning system technology freely and without restrictions. Although HCFCs contain chlorine atoms, the product is only remotely damaging to the ozone layer. Efforts are underway in the US (which accounts for over 85% of global CFC production) to introduce substitutes that will ensure world dominance in this field. CFC technologies are no longer protected under patents, but many firms have "vowed" not to transfer these technologies to non-signatories of the Montreal Protocol.

The search for alternatives has also led to increased knowledge about the existence of public-domain technologies. Many developing countries could be advised to exploit these substitutes that are cheaper and more energy efficient. The propane/butane refrigeration technology is in the public domain, but in addition to exploiting this technology anew, opportunities also exist to drain and collect CFCs in models being used currently. Refrigerators can then be refilled by the propane/butane mixture without the risk of legal penalties. Such refitting modifications are not patented and need to be used widely by developing countries.[8]

From the signed Protocol, and subsequent amendments and pledges made by various countries and companies, it is obvious that the world will still produce and consume CFCs for some time to come. It will be some time before the actual phasing-out begins. But what happens during the interregnum? As new technologies are generated, what should be done to the thousands of tons of CFCs currently being used?

While substitute technologies are being developed, huge amounts of CFCs are still in wide use. In recent months new devices have been produced to recover CFC refrigerators from existing systems. Recovery and recycling of ozone-depleting substances (ODS) realizes huge savings in ODS-plants, electronics industry, and refrigeration systems.[9] Wilkinson (1990) cites an IBM plant in Germany that recycles about 90 % of CFCs used. He further observes that nearly all CFCs used in the foam blowing industry is recoverable, as are the CFCs in discarded refrigerators.[10]

Predictions about the rapid growth and use of CFCs in developing countries, particularly in China and India, prompted a number of signatories of the Montreal Protocol to exert pressure on the relatively advanced developing countries (RADCs) to ratify the Protocol. But the RADCs, weary about the ICs' reluctance to share in ozone-friendly technologies, sought ways of accessing non-CFC innovations.

The Multilateral Fund was set up to assist developing countries participate effectively in phasing out CFCs. But in addition to the broad financial requirements, many DCs have also identified technology transfer as crucial in the debate.

Unfortunately, the technological question has largely been conceived in proprietary terms. The protection of new non-CFC technologies under patent regimes in the ICs has meant that the flow to the DCS (if the past is anything to go by) will be constrained, limited and paltry. The promotion of technology transfer to DCs is to complement the process of fostering domestic technological capacities. Now that the public domain, ozone-friendly technologies are available, the participation by DCs in the global agenda to eliminate CFCs might well bypass the technological veterans in ICs. Furthermore, ICOLP has created a database, OZONET, which is geared to facilitate information flow on non-CFC technologies. The DCs should participate in the information network and tap the critical knowledge.

Major chemical firms in ICs are likely to suffer market losses in the event of widespread diffusion of public-domain technologies. China and India are the two countries most eager to obtain non-CFC technologies. They have also depended on IC firms to obtain a range of products using CFCs. But the propane/butane technology promises to make them self reliant and substantially undercut markets of some well known transnational corporations.

While the patent/proprietary factor has been a constraint to technology transfer to DCs, other considerations have also tended to impede the flow of clean technologies. These include: dearth of relevant information, cost and economic factors, legislative and regulatory climate, and absorptive capacities in DCs.[11]

The industrialized countries are particularly worried about the potential consumption of CFCs by India and China though they feel that the rest of the developing world would also use large volumes of the ozone-depleting substances. Indeed, economic expansion of the two most populous countries in the world would lead to a sharp rise in the demand for products and processes that use CFCs. Two main technological types will need to be transferred - the innovations that replace the CFCs, and the technologies behind the goods and services to be used widely in a growing economy. The latter include air-conditioners, refrigerators, commercial and industrial coolers, foams, and cleaning processes in the production of medical and electronic devices.[12]

In some important respects, the Montreal Protocol is a milestone in international cooperation. But it will only fit this bill if the industrialized countries truly take momentous steps to transfer non-CFC technologies to developing countries. As is evident, the new ozone-friendly alternatives are expensive because of the shift that has to be made from the present destructive system. Given the costs involved, industrialized countries would be required to subsidize non-CFC technological flows through financial and technical assistance programmes under *additional, concessional* and *incremental* means.[13] On the additional factor, developing countries insist that new and additional resources should be made available to address the technologization process rather than divert funding from earmarked allocations and existing levels to invest in non-CFC technologies. On the concessional factor, developing countries are emphasizing the need for the North to supply resources at less than commercial rates. They also stress that the funding should be *grant-based*. Unfortunately, even though grant-based arrangements can go a long way in reducing debt obligations, the danger of such a system is that the long-term technological evolution of a third world economy would be substantially compromised. This is because grant-based arrangements tend to involve technological resources of the grant-giving country, marginalizing domestic technological capacities where they exist. Finally, the shift to non-CFC technologies entails significant costs not only in studies to determine country profiles and the various needs but also in building the necessary infrastructure to enable developing countries assimilate the new innovations.[14] This would include training to build the requisite manpower; institutional innovations suited to the introduction of the non-CFC technologies; and informational requirements vital for constant reference.

The World Bank had set aside a paltry sum of US$160 million in a new fund for addressing the ozone problem. But compared to aid flows, this figure is too tiny to confront the magnitude of the problem. It is difficult to see how additional, concessional, and incremental requirements can be met with such modicum funding. The pledges made by the World Bank to increase the amount in the event of China and India joining the Montreal Protocol is far too minute to deal with the problem in all its diversity. Yet, technology transfer and financial assistance are at the core of phasing out CFCs in developing countries. Both are limiting factors in phasing out CFCs. Unless these twin imperatives are embraced in their complexity, the rejection of CFCs by developing countries may not be realized. This is because the transition will be carried out in fits and starts; the adoption of alternative technologies will not be efficient and the North will also lose the opportunity to market the substitutes to developing countries. But worse, the world will have more problems arising from ozone-depletion.

According to World Bank projections, many developing countries have registered a growth of at least 6 % a year in total energy use. The increase in demand or energy use is thus set to increase substantially in the near future especially in view of the anticipated rises in population. Moreover, increases in economic growth in general would translate into large growth in emissions in developing countries. In cumulative terms, the emission volumes are likely to exceed those of the industrialized countries in a matter of decades.[15]

Indications show that these trends will continue something that portends a worsening of the global warming problem in the years to come. Since global warming is an international problem, and the emerging crisis has been precipitated by the industrial growth of the west, there is a strong moral, technological, and financial obligation on the part of the industrialized countries to assist developing countries pursue growth without exacerbating greenhouse gas emissions in the process. As in the case of ozone diplomacy covered above, technological and financial matters are at the core of the global warming problem in international cooperation. In this respect, industrialized countries should promote the use of renewable energy sources and push for the adoption of policies and practices that stimulate energy efficiency in production activities. By addressing these twin objectives, the level of emissions will be reduced dramatically as countries in the South industrialize.

But efficient use of energy through measures cited above will also reduce emissions if deforestation is reduced substantially. The rate of greenhouse emissions will be slowed down if a big switch is made to non-fossil fuel energy sources. By moving away from heavy wood fuel use, pressure on biodiversity will be alleviated. But such shifts will entail retrofitting expenditures. Where possible, a switch could be made from coal to natural gas. If leaks are minimized and distribution of gas is enhanced, major savings will be realized. The main effect would be a reduction in carbon emissions by over 15 %.

In most cases, introducing energy efficiency schemes could save considerable amounts of fuel. It is estimated that steam power plants in developing countries use between 20 % and 45 % more fuel in generating one kWh of electricity. Losses in distribution and transmission are also very high, pitched at over 30 %. Moreover, capacity utilization is low due to lack of maintenance and limited operational time. Outages are also inordinately high. Energy efficiency has been equally low because of persistent voltage fluctuations.[16]

The transfer of cost-effective technologies to developing countries would also go a long way in slowing down greenhouse gas emissions. For instance, several options exist that can do this including the acquisition of cogeneration systems in electricity generation, the use of industrial motors with variable speed drives, employing better lighting, water-pumping, heating and refrigeration systems, and reducing transmission and distribution losses through more efficient capacitors.[17]

Currently, both the North and South should tackle the technical and institutional obstacles frustrating the adoption of environmentally-friendly technologies in the field of energy. Developing countries should be: assisted with capital to purchase technology; equipped with capacities to secure access to relevant information; supported in reforming institutional structures in the energy sector; and should not be denied cleaner production technologies that have just appeared on stream.[18]

Maltezou (1992) identifies several constraints to clean technology transfer to developing countries. She notes, first, that developing country environments are characterized by lack of information on the relevant technologies and the skills to handle them. Second, come the cost and economic factors associated with possible acquisition of the technologies. Incentives to initiate procurement of such technologies are almost non-existent. The third drawback concerns the absence of a legislative and regulatory climate that would penalize polluting technologies and reduce uncertainty in investment decisions made by prospective firms. And finally, the sheer lack of adequate physical and institutional capacities, including the absence of requisite absorptive capabilities, tend to exert a limiting influence on the South's determination to secure clean technologies from the North. An additional factor is the lack of adaptive managerial and organizational structures,[19] including a heavily bloated bureaucratic mechanism underpinned by gross inefficiency, lack of accountability, and absence of transparent operational procedures.

Maltezou advances several important recommendations. They include: establishing data banks on clean production technologies; creating an effective technology design capability; building human capacities; creating an effective regulatory and institutional framework for standards and quality control; evolving capabilities for technology needs assessment; promoting clean production technologies in the industrialization process; and finally, establishing cleaner technology production centres.[20]

5.2 Global Commitments and Africa's Prospects for Building Eco-Capabilities

The conclusion of the Earth Summit in Brazil in June 1992 would be most remembered for two processes: the consensus reached by world leaders on how the global community intended to move forward in its development aspirations; and how it sought to achieve the goal of sustainable development through binding international agreements. The consensus was reflected in the initiative called *Agenda 21*, which, in simplicity, represented a Plan of Action describing the methods, processes, practices, and mechanisms that sovereign states around the world would adopt and use in their sustainable endeavours.

The international agreement process was epitomized by world leaders signing two paramount documents, namely, the *Convention on Biological Diversity* (CBD) and the *United Nations Framework Convention on Climate Change* (UNFCCC). Although national governments needed to ratify the conventions, which many did, to transform them into binding instruments of international law, the very expression of commitment by leaders to fulfil obligations through international cooperation was a decisive moral victory. It was clear that, for the wide range of critical environmental and development problems confronting humanity, the most sustainable solutions would demand concerted international action in all its diversity.

But two fundamental parameters tended to underpin all planned efforts at cooperative engagements: *finance* and *technology*. In relative terms, the rich industrialized countries of the North were not only indicted as the worst polluters globally, but were also the most technologically and financially endowed stakeholders in the global system. Naturally, the poor countries of the South looked to the North for assistance and support. Indeed, if the provisions in *Agenda 21*, CBD, and UNFCCC were anything to go by, then the expectations of the financially stricken and technologically starved developing countries were not entirely speculative.

5.2.1 Commitments under Agenda 21

Consider, for example, the international proposals specified in the various chapters of Agenda 21. This plan of action devotes chapter 34 exclusively to the issue of technology transfer through international cooperation. The objectives are:

- To help to ensure the access, in particular of developing countries, to scientific and technological information, including information on state-of-the-art technologies.
- To promote, facilitate, and finance, as appropriate, the access to and the transfer of environmentally sound technologies and corresponding know-how, in particular to developing countries, on favourable terms, including on concessional and preferential terms, as mutually agreed, taking into account the need to protect intellectual property rights as well as the special needs of developing countries for the implementation of Agenda 21
- To facilitate the maintenance and promotion of environmentally sound indigenous technologies that may have been neglected or displaced, in particular in developing countries, paying particular attention to their priority needs and taking into account the complementary roles of men and women
- To support endogenous capacity-building, in particular in developing countries, so they can assess, adopt, manage and apply environmentally sound technologies. This could be achieved through *inter alia*:
  - Human resource development
  - Strengthening of institutional capacities for research and development and programme implementation
  - Integrated sector assessments of technology needs, in accordance with countries' plans, objectives and priorities as foreseen in the implementation of Agenda 21 at the national level.
  - To promote long-term technological partnerships between holders of environmentally sound technologies and potential users.

5.2.2 Commitments under the Convention on Biological Diversity (CBD)

The Convention on Biological Diversity, like Agenda 21, also specifies the obligations binding contracting parties on the issue of access to, and transfer of, technology. Article 16 of the Convention states:

- Each Contracting Party, recognizing that technology includes biotechnology, and that both access to and transfer of technology among Contracting Parties are essential elements for the attainment of the objectives of this Convention, undertakes subject to the provisions of this Article to provide and/or facilitate access for and transfer to other Contracting Parties of technologies that are relevant to the conservation and sustainable use of biological diversity or make use of genetic resources and do not cause significant damage to the environment.
- Access to and transfer of technology referred to in paragraph 1 above to developing countries shall be provided and/or facilitated under fair and most favourable terms, including on

concessional and preferential terms where mutually agreed, and, where necessary, in accordance with the financial mechanism established by Articles 20 and 21. In the case of technology subject to patents and other intellectual property rights, such access and transfer shall be provided on terms which recognize and are consistent with the adequate and effective protection of intellectual property rights. The application of this paragraph shall be consistent with paragraphs 3, 4 and 5 below.

- Each Contracting Party shall take legislative, administrative or policy measures, as appropriate, with the aim that Contracting Parties, in particular those that are developing countries, which provide genetic resources are provided access to and transfer of technology which makes use of those resources, on mutually agreed terms, including technology protected by patents and other intellectual property rights, where necessary, through the provisions of Articles 20 and 21 and in accordance with international law and consistent with paragraphs 4 and 5 below.
- Each Contracting Party shall take legislative, administrative or policy measures, as appropriate, with the aim that the private sector facilitates access to joint development and transfer of technology referred to in paragraph 1 above for the benefit of both governmental institutions and the private sector of developing countries, and in this regard shall abide by the obligations included in paragraphs 1, 2 and 3 above.
- The Contracting Parties, recognizing that patents and other intellectual property rights may have an influence on the implementation of this Convention, shall cooperate in this regard subject to national legislation and international law in order to ensure that such rights are supportive of and do not run counter to its objectives.

The technological imperative is also stipulated in Article 18, which addresses the theme of Technical and Scientific Cooperation. Here, the Convention asserts:

- Each Contracting Party shall promote technical and scientific cooperation with other Contracting Parties, in particular developing countries, in implementing this convention, *inter alia*, through the development and implementation of national policies. In promoting such cooperation, special attention should be given to the development and strengthening of national capabilities, by means of human resources development and institution building.
- The Contracting Parties shall, in accordance with national legislation and policies, encourage and develop methods of cooperation for the development and use of technologies, including indigenous and traditional technologies, in pursuance of the objectives of this Convention. For this purpose, the Contracting Parties shall also promote cooperation in the training of personnel and exchange of experts.
- The Contracting Parties shall, subject to mutual agreement, promote the establishment of joint research programmes and joint ventures for the development of technologies relevant to the objectives of this Convention.

The above provisions of the Convention can only be made good if financial resources are availed to developing countries. The obligations are expressed in the following vein:

- The developed country Parties shall provide new and additional financial resources to enable developing country Parties to meet the agreed full incremental costs to them of implementing measures which fulfil the obligations of this Convention.
- The developed country Parties may also provide, and developing country Parties avail themselves of, financial resources related to the implementation of this Convention through bilateral, regional and other multilateral channels.
- The extent to which developing country Parties will effectively implement their commitments under this Convention will depend on the effective implementation by developed country Parties of their commitments under this Convention related to financial resources and transfer of technology and will take fully into account the fact that economic and social development and eradication of poverty are the first and overriding priorities of the developing country Parties.
- The Parties shall take full account of the specific needs and special situation of least developed countries in their actions with regard to funding and transfer of technology.

The above commitments binding the contracting parties clarify how the developed countries are obliged to promote and facilitate technology transfer to developing countries. Yet, evidence shows that such transfers have not occurred to any appreciable extent.

5.2.3 Commitments under the UNFCCC, joint implementation and techno-financial imperatives

Perhaps the most significant development in eco-diplomacy in recent years concerns the attempt by many countries to reduce greenhouse gas (GHG) emissions under the United Nations Framework Convention on Climate Change (FCCC). The efforts have been underpinned by commitments to finance emissions-reducing or sink-enhancing projects in other countries. This drive to "...stabilize GHG concentrations in the atmosphere to levels which will prevent anthropogenic interference with the climate system" led to the formulation of a device hitherto referred to as "joint implementation". The instrument is now more popularly known as "Activities Implemented Jointly" (AIJ). It is an international mechanism that has opened up economic opportunities and technological possibilities for reducing emissions between countries inclined to meet global obligations through techno-financial cooperation.

The first meeting of the Conference of the Parties (COP) agreed that bilateral transactions between countries should aim at stabilizing GHG emissions to the 1990 levels. This would be achieved through arrangements that would allow industrialized countries with high project costs (which have been responsible for historical and current emissions) to finance low cost projects in developing countries. By doing so, the developed countries would claim credit for reduction and sequestration of carbon emissions.

The transfer of finance and technology to achieve the abatement of GHG emissions in developing countries entails the evolution of national capacities in legal, administrative, financial, and technical arrangements all of which are few and far between. But these are not the only problems. One view is that joint implementation programmes are just another ploy to justify continuation of pollution by industries in developed countries.

The buck to stabilize GHG concentrations is simply passed to the developing countries. Some developing countries have already expressed their disappointment over the view that joint implementation is just another device urging the DCs to plant more trees, restrict the consumption of fuel-wood, and prevent logging. Another vital factor is the application of the cost-effectiveness principle. If countries inclined to cooperate in this scheme will reflect marked differences in production costs, a large number of countries falling in the intermediate range will not participate in carbon reduction and sequestration. Moreover, many of the joint implementation projects to be addressed between countries may not reflect national priorities for sustainable development. And there is the further prospect of costs changing over time in ways not anticipated even by the worst-case scenario. If this happens, the restructuring process may be too expensive. Abandoning the project may therefore turn out to be a very real possibility.

Clearly, the effectiveness of implementing joint implementation projects will depend on the ability of developing countries to generate national inventories of anthropogenic emissions, the extent to which targets and quotas can be assigned, and the degree of competence in developing guidelines for joint implementation targets. Also needed are capacities to determine safe carbon levels and a time-plan for carbon reduction and sequestration. And yet, without training, technology, and additional resources, many developing countries will not be in a position to generate national programmes to mitigate climate change.

Despite the huge challenges posed by the ecodiplomatic device, it is still possible to see advantages in the joint implementation mechanism. One of the greatest worries about the joint implementation is that many industrialized countries may not be so willing to transfer financial and technological resources that match the needs for effective mitigation of GHG emissions in developing countries.

The global imperative to reduce, through international cooperation, the concentration of greenhouse gases (GHGs) in the earth's atmosphere has stemmed from the grave concern that their continued anthropogenic build-up under the prevailing business-as-usual scenario would trigger and intensify catastrophic consequences on the planet. In view of the anticipated adverse prospects, most world leaders recognized the need to act in concert in a bid to drastically reduce GHG emissions to the 1990 levels. The scheme designed in 1992 to pursue this goal came to be known as the Framework Convention for Climate Change. Just as was the case with CBD, the imperatives of finance and technology were critical underpinnings for this arrangement. The commitments on these dimensions appear under Article 4 of the Convention. They state that "… All parties, taking into account their common but differentiated responsibilities and their specific national and regional development priorities, objectives and circumstances, shall:

- Promote and cooperate in the development, application and diffusion, including transfer, of technologies, practices and processes that control, reduce or prevent anthropogenic emissions of greenhouse gases not controlled by the Montreal Protocol in all relevant sectors, including the energy, transport, industry, agriculture, forestry and waste management sectors.
- The developed country Parties and other developed Parties included in Annex II shall take all practicable steps to promote, facilitate and finance, as appropriate, the transfer of, or

access to, environmentally sound technologies and know-how to other Parties, particularly developing country Parties, to enable them to implement the provisions of the Convention. In this process, the developed country Parties shall support the development and enhancement of endogenous capacities and technologies of developing country Parties. Other Parties and organizations in a position to do so may also assist in facilitating the transfer of such technologies.

- The extent to which developing country Parties will effectively implement their commitments under the Convention will depend on the effective implementation by developed country Parties of their commitments under the Convention related to financial resources and transfer of technology and will take fully into account that economic and social development and poverty eradication are the first and overriding priorities of the developing country Parties.
- In the implementation of the commitments in this Article, the Parties shall give full consideration to what actions are necessary under the Convention, including actions related to funding, insurance and the transfer of technology, to meet the specific needs and concerns of developing country Parties arising from the adverse effects of climate change and/or the impact of the implementation of response measures…

The above provisions leave no doubt that the developed economies are under binding obligations to promote technological change in developing countries. The question that arises, however, is whether the North has really made good its commitment to promote technology transfer and facilitate the evolution of domestic technological capacities in Africa. To establish the truth or falsity of this observation, it would be necessary to examine in detail what projects have taken off under the *Clean Development Mechanism* (CDM), within bilateral, multilateral, or other cooperative frameworks. Preliminary evidence suggests that in-depth technology policy studies of the type suggested have yet to be carried out in Africa.

The Clean Development Mechanism was established by Article 12 of the Kyoto Protocol that parties signed in 1997. The objective of this arrangement has been to assist developing country parties achieve sustainable development while enabling the developed country parties to realize compliance with GHG reduction commitments.

According to the Protocol, CDM projects were anticipated to begin in the year 2000. But Africa has lacked the human and institutional capacity to identify prototypes as well as design, market and implement projects. The sectors that are amenable to a CDM analytical framework include energy, transport, forest and agriculture.

5.2.4 Systemic contradictions in the regime of global conventions and agreements: the WTO as the sword of Damocles

While the global conventions discussed above have articulated specific commitments, especially those relating to finance and technology to be implemented by the industrialized countries, other international agreements such as the WTO seem to undermine the hopes and prospects raised by them. This trade body poses dangers to Africa's desire to obtain technologies from the rich industrialized countries.

WTO has concerned itself with accelerating the pace of globalization in an environment where the transnational companies have invariably taken the lead. In substance, the interests of international capital tend to supercede the development goals of governments. The WTO assumes that the development goals of governments and transnational corporations are coincidental.

WTO provisions have both *temporal* and *spatial* dimensions. The temporal aspect implies that signatories would be expected to comply with provisions now as well as in the future. Future generations and governments would not be able to withdraw unilaterally even if they wished to do so. On the spatial dimension, the WTO framework gives transnational corporations the freedom to go wherever they want (geographical license) and to invest in any sector (sectoral license). The implications on technological change are considerable.

Governments will not be allowed to strategically employ the instrument of public procurement to promote specific industries and generate domestic technological capabilities. WTO contends that governments seeking supplies shall not restrict their sourcing to favoured domestic firms. It invokes the *national treatment* provision which states that governments should treat TNCs no less favorably than local companies. The TNCs have pushed hard for this clause because they realize that the public procurement market is sizeable and is characterized by massive profit opportunities. They cite deficiencies in government procurement practices such as lack of openness and transparency in public purchases. But all this rationalization is prompted by their desire to capture this large market in developing countries.

The other area likely to affect Africa's prospects to build domestic technological capabilities is *trade and investment*. The WTO not only gives TNCs the right of entry into any African economy but also grants them the liberty to invest in any sector of their choice. For instance, TNCs can secure 100% equity in take-over bids involving local companies. They can also proceed with such investments without government approval. Other rights under WTO include:

- the right to purchase controlling interest of local firms without government approval
- the right to repatriate resources, unrestricted
- the right to put in place foreign management boards

In addition, WTO forbids signatories from imposing, enforcing, and maintaining performance requirements and conditions on foreign trade and foreign-owned affiliates. This will impact directly on questions of enhancing domestic content and institutionalizing domestic subcontracting provisions for all foreign investments. African governments will have no authority to regulate the operations of TNCs that require them to transfer environmentally-sound technologies as well as assist national economies build domestic technological capabilities.

WTO provisions prohibit governments from exerting conditionalities on TNCs such as requiring them to foster forward and backward linkages with the host economy, or from making employment specifications that favour recruitment of local people in managerial and key administrative and decision-making positions. It also absolves foreign investors from domestic environmental regulations. TNCs have the power to sue host governments for contravening WTO regulations. To illustrate, Ethyl Corporation in the US filed a suit against the Canadian government for prohibiting the imports of the company's toxic gasoline additive. The US investor crafted a compensation scheme accusing Canada of hurting its sales and damaging its reputation.

This means that the invocation of the WTO provisions would effectively and comprehensively marginalize African governments from proactively managing the technological affairs of their states.

But the adverse power of WTO has been extended to enlist the cooperation of very powerful multilateral institutions such as the IMF and the World Bank.

(Footnotes)

[1]If DCs fail to obtain environmentally-friendly technologies, they would still wish to industrialize and modernize. This ambition stems from the observation that such societies enjoy high standards of living, economic prosperity, and material well-being. Developing countries bent on achieving equivalent levels of material affluence will be forced to replicate such economic structures in their own countries at any cost', even if this means using ecologically-disruptive conventional technologies.

[2]See Kasman, M.S. (1992) "Economic and Legal Barriers to the Transfer of Environmentally-sound Technologies to Developing Countries" in

ATAS Bulletin

, Issue No. 7, p.166.

[3]See UNEP (1996)

Climate Change 1995

, IPCC, Cambridge University Press, New York, U.S.

[4]

For a lucid discussion of eutrophication and attendant problems, see UNEP (1992) (underline Chemical Pollution: A Global Overview,) EarthWatch, The United Nations Environment Programme, Nairobi, Kenya, pp.63-75.

[5]

op.cit. Wilkinson, p.93.

[6]

Ibid, Wilkinson, p.95.

[7]

Chittick, D.R. (1992) " The transfer of non-chlorofluorocarbons technologies: a case-study in industry cooperation" in ATAS No. 7, p.196.

[8]

For an elaborate discussion of the public domain technology, see Ecotec Resource b.v. (1993)

New Green Fridges- A Breakthrough for the Environment

, ER Ecotec Resource b.v., Development Consultants, The Netherlands.

[9]

See UNEP (1993)

Ozone Action

, UNEP IE/PAC Quarterly Publication, pp.1, 5.

[10]

op. cit. Wilkinson (1990), p.88.

[11] S

ee Maltezou, S.P. (1992) "Constraints to clear technology transfer to developing countries ", in

ATAS Bulletin

, No. 7, United Nations, p. 170.

[12]See Vogelsberg, F.A. (1992) "Technology Transfer and Assistance to Developing Countries for Phasing Out Chlorofluorocarbons" in

ATAS Bulletin

, Issue No.7, Spring 1992, p.199.

[13]See Chittick, D.R. (1992) "The Transfer of Non-Chlorofluorocarbon Technologies: a Case Study in Industry Cooperation" in

ATAS Bulletin

, Issue No.7, p.195.

[14]For a comprehensive overview of the types of assistance needed, see Vogelsberg, op.cit.

ATAS Bulletin,

Issue No.7, pp.201-202.

[15]See Bierbaum, R. and H. Levenson (1992) "Multiple Approaches to Limit Carbon dioxide Emissions in Less Developed Countries" in

ATAS Bulletin

, Issue No.9, p.188.

[16] ibid, Bierbaum and Levenson, 1992, p.189.

[17]See Bierbaum and Levenson, ibid, 1992, p.189.

[18]See Bierbaum and Levenson, 1992, p.190.

[19]See Maltezou, S. (1992) "Constraints to Clean Technology Transfer to Developing Countries" in

ATAS Bulletin

, Issue No.7, pp.170-171.

[20]ibid, Maltezou, 1992, pp.172-173.

6. Charting out New Technological Horizons: Africa's Strategic Challenges

In view of the forces that have affected and continue to affect Africa's dismal technological evolution, what then would be the way forward?

6.1 Learning from Past Mistakes

Any meaningful, progressive step must be made in the context of *learning from past mistakes*. Those who fail to learn from their mistakes are condemned to repeat them. The question that arises is whether African leaders would treat the mistakes revealed to them after a process of critical reappraisal, as constituting mistakes. The whole idea of trying to understand why Africa has generally performed dismally in acquiring and building domestic technological capabilities is not an exercise to apportion blame, but to unearth the mistakes committed, the flaws and misconceptualizations that clouded our vision, the shortcomings that constrained our efforts, and the failures that undermined our aims. Only by appreciating our ways would we be able to define a path of promise. Therefore, Africa's first critical step is to take stock of what has happened and why. Have we, for instance, adopted sound strategies, or have we misjudged the demands for technological change?

6.2 Leaders and Technological Change

The experiences of Japan, China, and Korea discussed earlier, demonstrate that the process of domestic technologization was a *leaders-driven endeavour*. Their governments put their money where their respective mouths were; they matched their words with their deeds. The conscious application of technology policy was a critical pillar of their development blueprints. For Africa to make significant strides in the techno-industrial domain, leaders of this genre should emerge.

6.3 Finance, Control and Dependence

From the experiences discussed, the trailblazers did not embrace strategies of convenience. They bit the bullet and made hard choices. They employed modes of technology transfer that conferred on them control over the entire gamut of the technology transformation chain. They consciously adopted financial and investment approaches that enhanced the prospects of deepening domestic technologization, rather than those means that could have compromised their main goal.

Africa should repudiate grant systems of finance while pursuing her technological ambitions. Such mechanisms are merely opportunistic devices which donors use to render employment to their own citizens while keeping the grant-funded firms in their home countries in production. Often, grant funded investments in Africa have been bereft of meaningful technological content.

African leaders should realize that overseas technology suppliers never build domestic technological capabilities. Foreign companies would not voluntarily give up and let go the rewarding sources of earnings. As such, they would devise contracts that only release the peripheral and secondary aspects of technology to clients in the hope that they continue to reap a stream of benefits well into the future.

It was earlier illustrated how Japan and other developed countries framed specifications that disqualified others, including firms in host economies from potentially winning future contracts. The moral of this analysis is that African countries should not be party to contractual schemes that are compromising. They should always leave open the possibility of exploring alternative sources for procuring technologies.

6.4 Legislation, Local Sub-Contracting and Domestic Content

African governments should make it mandatory for all domestic investments involving foreign technology suppliers to first exhaust the use of local technological capacities. Moreover, foreign firms should be made to comply with national legislation that awards subcontracting work to local firms before any overseas parties are considered.

6.5 Counterpart Staffing Model and Crucial Capacities

African policymakers should institutionalize the counterpart-staffing model to enable local manpower resources understudy the foreign technology suppliers, in particular, in areas of generic influence. Cross-cutting skills should be tapped so that a domestic economy would not be repeatedly obliged to procure the same technological services from abroad.

6.6 Exemption and Emergency Clauses

African governments should always seek to protect their domestic technological capacities whenever possible using the exemption and emergency clauses embodied in international trade and related agreements. In the recent past, African leaders have recklessly liberalized their economies following coercive pressure from industrialized countries. In Kenya, the rice and sugar sectors, including many subsectors in the manufacturing sphere, have had their domestic technological capacities damaged by brazen acts of doctrinaire policy implementation. Yet, exemption and emergency clauses could legitimately have been invoked to safeguard valuable local capabilities.

6.7 Embassies and Technological Search

Japan, Korea, Singapore, and Taiwan used their embassies abroad to maximize the flow of technologies to their economies. Specific sections were established, and continue to operate, in overseas diplomatic stations to facilitate technological flows. No such tradition exists in African embassies overseas. The idea of sending retired army officers to man diplomatic units abroad, as is the habit of ruling dictators in Africa, is reflective of the technology-bereft mindset dominating the highest echelons of power. African embassies have military attaches as substantive positions in the diplomatic hierarchy rather than *technology attaches*. Not surprisingly, the job descriptions of commercial attaches totally lack technological content. Yet, Africa could shift away from this diplomatic state of technological sterility to one of technocentric proactiveness.

6.8 Holding the West Accountable

African countries have not yet developed robust mechanisms to systematically hold industrialized countries accountable to the commitments of global conventions which they ratified. As examined earlier, the mandatory global agreements contain unambiguous provisions that oblige industrialized countries to transfer technologies and finance requisite initiatives in Africa and elsewhere in the developing world. Africa should exploit this opportunity to facilitate technologically-robust sustainable development.

6.9 Industrial Planning and Technological Capability Indicators

The development of the manufacturing sector in Africa has been characterized by very little techno-industrial planning. A fundamental ingredient of national planning systems and programmes involves the gathering of comprehensive information about the vast array of primary, secondary and tertiary problems which the nation, region or community faces. The gathering of this information is a dynamic process and should involve consultation with stakeholders. The planning authorities concretize a range of these problems.

In general terms, *techno-industrial planning* would comprise conscious and deliberate efforts by policymakers to target and promote the establishment of an integrated set of priority industries by focusing on a wide set of technological targets. The process defines clearly the respective roles of public and private sectors. Indeed, the government is expected to play a facilitating role through the creation of an enabling environment for private sector initiatives to flourish. The rationale for planning is to guide the industrial economy along a course that would stimulate multiple inter-linkages between and across industries.

The plans are formulated with specific time frames in mind, usually 10-20 or 15-30 years, during which realistic projections of goods and services are made. Production targets are differentiated according to export or domestic market requirements, including a clear statement of the relationship with local inputs and institutional human informational and technical capacities.

Planning the evolution and growth of the manufacturing sector should be guided by an explicit *industrial vision* and supported by a policy framework capable of generating the mix of goods and services within that vision and the country's national objectives. Undoubtedly, industrial planning is anticipatory in that, by providing scenarios and prioritizing goals, it steers the manufacturing sector along directions which hasten the realization of defined expectations and investments.

If industrial planning is defined as a conscious exercise to guide, promote and regulate manufacturing investments within a market framework and in ways that maximize the use of domestic human, informational, institutional and technical capacities, then it can be argued that Africa has not undertaken this activity in its development aspirations. And even if policymakers insist that some industrial planning has been taking place, they would easily acknowledge that technology plans have neither been prepared nor incorporated in the exercise. By failing to integrate technological considerations in the industrial planning process, the policymakers are ignoring a strategic variable in the development process. Reasons for this marginalization or ignorance are hard to find. First, many planners are not familiar with how the technological variable can be incorporated into an industrial plan. This is particularly true if the planners are neo-classical economists who regard technology as just a mere input captured by isoquants in a two - dimensional graph. This conceptualization of technology and the view expressed by neoclassical practitioners is a monumentally naive one. Second, national development planning has included industrial but not technological goals other than mere references and general remarks about technological imperatives. Though planners have from time to time expressed commitment to technological variables, their words have not matched their deeds. Third, planners do not know how to prepare a technology plan, and how it can be integrated in sectoral, industrial and national plans.

Because the technological factor is poorly understood by national development and industrial planners, technology-based planning is non-existent in much of Africa. The creating of Research, Science and Technology ministries does not imply that technology-based planning is taking place or even influencing sectoral, industrial and national plans. The creation of these ministries may have been prompted by a particular international trend that was in fashion some years ago. What's more, even though policymakers would accept the strategic importance of technology as an article of faith, its conception in the totality of the development process is poorly defined. The creation of separate ministries or departments to address science and technology matters tends to relegate the technology variable to being just another element in the development process. Such a unit should be located in the office of the President to oversee the overall development function.

If technology-based planning is to realize phenomenal gains, it would be essential to re-organize the decision-making machinery by relying on views expressed by members of a multi-disciplinary team rather than leave technology matters to bureaucrats and neoclassional technocrats only. As Sub-Saharan Africa aspires to become an industrialized region early in the new millennium, it should train many citizens in technology studies, among other fields. Meanwhile, it should begin to build a strong and comprehensive technology database for assessing national technological capabilities, gaps, and needs, and be able to improve and upgrade the information on a continuous basis.

Africa has given itself an incredible 15-30 years to excel as a newly industrializing region. China began the process of industrialization more earnestly only since 1978, and in 15 years, has mesmerized the whole world with its economic performance.[1] Yet, some would argue that a preliminary industrial base had been in existence for several decades. Thailand's extraordinary economic growth began more purposefully in the mid-1970s. Singapore, Malaysia, Hongkong, Taiwan and Korea knitted deliberate strategies in the late sixties to achieve industrialization. Governments of the Dynamic Asian Economies (DAEs) promoted universal education, employed fiscal and monetary policies, and developed sound relations between unions and management.[2]

The rational for acquiring environmentally-sound technologies for the industrialization process stems from two fundamental considerations, namely, the need to improve and protect the quality of human life and habitats, and secondly, the realization that trade issues are increasingly being permeated by environmental standards and related matters. Except for very general cases, it may be difficult for Africa to obtain environmentally-friendly technologies from the proprietors if they promise to pose competition in some of the dominant markets they could seize. And since environmentally-sound technologies have only recently started appearing in the markets, patentees are likely to extract extremely high rents for their innovations. However, if the innovators are unwilling to transfer their cleaner production technologies to the south to assist developing countries pursue sustainable industrialization, these economies will either have to develop their own environmentally-sound technologies or remain stuck with ecologically-disruptive ones. The former will mean that many developing countries will only be importers of cleaner industrial products and not exporters since they will have very little to offer in the short term in a trade environment increasingly being driven by stiff environmental standards. The assumption here is that the development of cleaner innovations has long gestation periods. If so, African countries would not be expected to participate equitably in an environmentally-sensitive trade environment.

Equally, developing countries are stuck with the present crop of ecologically-damaging industrial technologies. Their involvement in international trade will begin to experience a sharp decline once the grace period is over. In a few years, as the export markets start tightening their environmental regulations, and as industrial producers in African countries fail to develop or procure cleaner innovations, their trading potential will slide even further in world commerce. At the same time, their industrial structures would continue to wreak havoc not only on the quality of human life, but also on the environment in general.

Therefore, depending on whether developing countries succeed in generating cleaner innovations or triumph in acquiring such technologies from the pioneers, the most likely outcome for them in the new international environmental order is *de-industrialization.* If this fails to occur, then one can only assume that industrial production is continuing at the risk of environmental unsustainability. Moreover, this industrial continuity will tend to suggest that only domestic consumers are involved in the purchases of environmentally - damaging goods. Under these conditions of external environmental regulation, only the local market will serve as the logical outlet for such products.

(Footnotes)

[1]See Fukasaku, K. (1994) "China's Growing Presence", in

The OECD Observer

No. 189, August/September.

[2]Consult Richards, A. (1993) "Korea, Taiwan and Thailand: Trade Liberalization and Economic Growth" in ***The OECD Observer***, No. 185, December 1993/January 1994.

7. Technology Needs Assessment for Sustainable Industrialization

For countries seeking to industrialize sustainably, a major component of environmental technology policy should include the development of local capacity to assess a wide spectrum of human needs and the technologies that go with the fulfillment of those needs. This is what we refer to as *needs assessment* and *technology needs assessment* respectively. But the third leg in this tripod of interacting segments is the capacity of an economy to assess the technologies themselves, and in our case, be able to distinguish those that are environmentally-sound from those that are not. This is the phenomenon of *eco-technology assessment*. A meaningful classification of these technologies, in a kind of pecking order, will depend on their scores on a scale of environmental indicators, developed by technology planners and experts.

From a cursory analysis of societal development, the question of human needs arises in the contest of existing or emerging problems identified by individuals and/or their representative agencies through a consultative process or other means. Some of the problems a community could be facing may be associated with a particular technology precipitating adverse environmental consequences. On the other hand, a problem emerges not because of the presence of a technology or activity, but because of their absence. Problems are formulated and needs crystallized because certain technologies or activities are conspicuous by their absence.

On technology assessment itself, it is important to bear in mind that the criteria used to make choices (by adopting a scale of environmental indicators) have to be underpinned by a *preventive* approach rather than a *curative* course. The preventive approach refers to building knowledge capabilities in those institutions and people that place a special premium on waste minimization during the processing of inputs, use of inputs during the production stage, and in the disposal of wastes. In a sense, the human and institutional capacities (*humanware* and o*rgaware*) should acquire skills and knowledge (*infoware*) that focus on equipment, products and processes (*technoware)* with the greatest potential to reduce wastes in the various stages of the life-chain rather than on end-of-pipe systems. Hitherto, environmental performance of technologies was judged on the basis of waste treatment after the effluent or other pollutants were produced. This curative approach —— equivalent to locking the stable after the horse has bolted — has been inefficient and risky both financially and ecologically.

Cleaner technologies have been defined as production techniques which include:

> "... the efficient use of raw materials, water and energy, the elimination of toxic or dangerous materials and the reduction of emissions and wastes at the source. For products, the strategy focuses on reducing impacts along the entire life cycle of the products and services, from design and use to the ultimate disposal."[1]

In the context of this paper, technology assessment refers to a comprehensive evaluation of various techniques and institutional, human and informational capacities in order to determine, on the basis of LC criteria, their appropriateness for utilization, acquisition, and adaptation. The process involves an examination of production and processing methods in their entirety and diversity. The specific needs are classified and prioritised by rank. Within certain budgetary constraints, the needs are translated into objectives to be achieved within a specific time period. This definition of problems, their translation into needs and objectives, and their prioritisation and classification into primary, secondary, and tertiary scale is referred to as needs assessment. The information generated in this regard assists policymakers or other users to select environmentally-friendly technologies.

The success or failure of the technology assessment process depends on the availability or otherwise of requisite institutional and human capacities. Relevant organizational structures need to be in place to identify, appraise and select the appropriate technologies. The institutions need to be manned by people with skills and knowledge governing the requirements of the process, and their competence and activities will be enhanced by relevant documentation, procedures as well as equipment. TA is an extremely crucial component of technology planning and development.

Once a profile of needs is constructed and the priorities established, the next step in the planning process is to carry out a survey of all possible technological options and to classify and prioritize the technological areas of relevance associated with each need. The identification process involves an assessment of specific, generic and cluster of technology, both nationally and internationally. Specific technologies refer to a range of techniques that address particular needs. However, a specific need may be satisfied by a technique that has a more general application across many areas. These are referred to as generic technologies. It is also possible that a given need could be solved more efficiently by *clusters* of technology, i.e. by a group of technologies that operate effectively only when adopted together or used in concert.

The technological capacities that need to be identified across the spectrum of needs will include skills for investment analysis, for searching, for testing and maintaining equipment, for assimilation and upgrading, and for unpackaging design and production engineering if the technologies are to be imported. For imports or those locally available, the development of technology databases for specific areas will be an important part of the whole programme. In a sense, the national planning framework as an institutional mechanism for assessment and analysis must include an investment programme on facilities for storage, retrieval, analysis and upgrading of information.

A dynamic institutional mechanism for assessment and analysis should build profiles on national economic activities; demographic and health statistics; education and mass communication; science and technology personnel, their distribution and classification; expenditures on R & D activities, both current and capital, and on the basis of fields of specialization; sources of funding and indicators of R & D efforts; import and export profiles; and natural and human resources. And based on the assessment of society's needs and the requisite technological needs, the capacities in the national planning institutions will be able to determine technological gaps and levels.

To conclude, the process of national needs assessment, technology needs assessment and technology assessment is not just an exercise of inventory. It also entails efforts to analyse and evaluate a vast array of parameters and variables. In the case of technology needs assessment for sustainability, it entails carrying out a broad review, analysis and evaluation of technological options vis-a-vis their capacity to solve environmental problems. It is suggested that the LC criteria would be the most appropriate method to identify the most promising technological solutions that should be selected on the basis of their problem-solving potential and specific/general environmental merit. Clearly, a priority register of various technological options will emerge from a ranking list constructed on the basis of how effectively they solve environmental and human problems.

For the three types of assessments, it is essential to point out that they would require requisite institutional and human capacities supported by the relevant documentation and equipment. These capabilities constitute the spectrum of technological capacities associated with the various types of assessment. But for these assessments to make sense, they need to be placed in the context of a crucial complementary capacity, namely the availability of institutional (orgaware), human (humanware), information (infoware), and facilities (technoware) for resource assessment and construction of resource profiles.

As stated earlier, exclusive reliance of market forces would lead to the underdevelopment of technological capacity. To escape this problem, technology-based planning is vital. But the preparation of these plans would be meaningless unless they are integrated into industrial and national development planning.

A cursory glance of many national plans reveals that numerous statements mention the need for technological development. Unfortunately, while the statements create an impression that technology is recognized as vital for economic change, in reality there is no concrete evidence of this in the projects and programmess developed. Technological development is deemed to occur once industrial investments are made. This is what the author refers to as *techno-industrial fallacy.* To most neoclassical economists, technological development is seen either in terms of industrial investment or investment in R&D.

Without doubt the decision-making machinery will be vastly improved if the planning institutions involve people with knowledge and information on technological matters.

7.1 Technology Policy Lessons for Africa

But how can Africa improve its weak capacity to acquire technologies? What should it do to systematize this process? At the very outset, what issues should it engage with *upfront* to enhance its prospects for institutionalizing the process of evolving and strengthening domestic technological capabilities where necessary? What would be the *necessary conditions*, as fundamental basic ingredients, that African countries should have in place to catalyze domestic technological change?

As a starting point, it would be vital to drive home to policymakers the potentiality, if not the decisive centrality, of technology in dramatically improving a society's welfare. Of course, this perspective has featured very prominently in official speeches and policy documents of most African states, but it is obvious that this perspective is appreciated more for its *rhetorical value* than its profound concreteness.

African policymakers have hardly matched their words with deeds on this score. Often, one feels that leaders do not embrace this view with *conviction* and that, African policymakers have not demonstrated a "gut reaction" to this "belief".

Because statements extolling the virtues and significance of technology have yet to carve out a niche in the deep recesses of our *conscience*, it is not difficult to see why our leaders have exhibited such lackadaisical nonchalance towards it. Clearly, a perspective not rooted in moral conscience is not likely to be expressed in practice let alone be held with passionate religiosity.

Consider, for example, the hypothetical ratings or scores people generally attach to ministries of science and technology. When an African minister is moved from the Ministry of Finance to the Ministry of Science and Technology in a cabinet reshuffle, the perception is that the legislator has been demoted. In the public's scale of importance, science and technology (S&T) ministries score very low grades. Policymakers tend to share the same view. This appears to be the case even though official documents and speeches apotheosize technology in unrestrained terms. The author dubs this contradiction as the *paradox of technological valuation*. He narrates the following anecdote:

> In May, 1993, I was waiting to see the director of the Science and Technology Ministry in Accra, Ghana, when a journalist shot in to gather a news story from the government official. As he waited to interview the director, the visibly perplexed journalist asked the secretary why the Ministry of Science and Technology was left out of Jerry Rawling's *inner* cabinet. The secretary had no answer, and since I was to see the director first, I did not know what transpired between him and the journalist. Had I not been strapped for time, I would have waited to hear from the journalist. The situation remains unchanged to this day. This incident is a damning indictment of the approach some African leaders take in addressing development matters.

From the foregoing discussion, it is apparent that Africa's most immediate challenge to the technological phenomenon would involve efforts to anchor the sense of its significance in the *moral* recesses of our conscience. The perspective ought to be held with conviction and, therefore, be capable of evoking a gut reaction in the policymakers.

The next challenge from this dynamic should centre on the need to de-mystify the intimidating and awe-inspiring image posed by technology. Casting this dimension in complex and daunting terms has only succeeded in shrouding it in thicker veils of mystery and elusiveness. Clearly, conceptions of this kind have engendered a psychology that is not helpful; one that evokes fear and arouses feelings of timidity on the subject of technology. These tendencies have also nurtured a mentality driven by an *inferiority psychosis*, namely, that the field of technology requires extraordinary and gifted minds to comprehend and fathom the complex intricacies of the phenomenon. As such, the curiosity and exploratory instincts of potentially inquisitive minds are blunted.

The impregnable images fostered by such baroque conceptions have the potential to erode the values of self-esteem and self-belief. This appears to be the case among policymakers in Africa if the tendencies to cede control to overseas consultants and technology suppliers on public investments (for example, energy projects) are anything to go by.

Against this backdrop, it follows that African countries would be instrumentally disposed if the issues surrounding technology and technological change are made to appear practical and manageable. Africa needs to inculcate values that promote the culture of technological self-confidence.

But how should the demystification exercise proceed? Technology policy research institutions in Africa would need to do at least two things: to educate policymakers about the broad *conceptualization* of technology (away from the narrow conventional perspective); and to enable them *appreciate the real meaning* of technology in all its diversity.

Africa can learn from Asia's and Latin America's technological experiences to build its own capabilities. Three specific areas need to be mentioned: the need for a new cognitive orientation; attaching sufficient importance to techno-scientific and engineering services; and underlining the importance of identifying technological targets.

7.1.1 The need for a new cognitive orientation

Following the economic success of industrialized countries, faith in science and technology as instruments to lift developing countries out of their economic malaise has intensified. The correlation between modernization and commitment to science (in terms of resources spent on scientific activity) has been shown to be strong.[2]

A widespread view is that the role of science in economic change is critical, and societies that neglect investment in science are doing so at their own peril and technological underdevelopment.[3]

This scientocentrism is shared by many developing countries, and is reflected in the emergence and proliferation of scientific research institutes, in the hope that once established, science would acquire a momentum of its own and technological development, as a logical step, would be inevitable. Investment in research facilities was therefore synonymous with science.

While the scientocentric phenomenon received emphasis and policy support in a number of developing countries, about a dozen or so countries placed more faith in technology in achieving modernization and economic change. Over the last 40 years, the Newly Industrializing Countries (NICs) procured technology from the West and through reverse engineering and other methods, managed to build technological capabilities in key sectors of their economies. The evolution of technological capabilities from existing technologies sourced from elsewhere is an illustration of how technological development could be realized with limited or no investment in scientific inventiveness. This direct technology approach to modernization, which the author calls technocentrism,[4] has enabled some countries to leap frog and achieve a status of development within a relatively shorter period of time. The success achieved by them has forced some countries to focus more sharply on technology and technology institutions, and re orient their policies to cater for this new approach. [5]

In some Latin American countries and in a few in South East Asia, a new wave of technological optimism has been set in motion, as many more countries in the respective regions tend to be influenced (through demonstration effects) in technology oriented development.

Except for a limited number of sectors, particularly those directly connected with agriculture (for example, biotechnology), many developing countries will make a transition from scientocentrism to technocentrism. Those that would have achieved a strong, competitive dynamic economy from a technocentric orientation are likely to revert to some form of scientocentrism,[6] at least sectorally. The omniscient power of science may thus acquire a new status in countries that benefited from a technocentric vision, but those that are just beginning to industrialize will for a while be influenced by the omniscient power of technology.

7.1.2 Attaching sufficient importance to pre-investment capabilities

Africa should direct adequate attention to pre investment services. The strategic significance of these services stems from the fact that they influence decision making along the chain of the production process. They provide the strategic thrust in the process of building indigenous capacities in subsequent activities along the line. As critical building blocks, they need to be acquired and involved in investment activities.

7.1.3 Underlining the importance of identifying technological targets

There is need to integrate technological imperatives in the process of procuring technology. This entails the preparation of country resource profiles, assessing available technological capabilities, identifying technological needs, and identifying technological gaps. The technologies that are to be procured should be subdivided into their elements, and counterpart staff from the client firm should be attached to the supplying firm to obtain all the knowledge necessary for acquisition of capabilities.

(Footnotes)

[1]See UNIDO (1995)
Cleaner Industrial Production
Industrial Sectors and Environment Division, United Nations Industrial Development Organization, Vienna, Austria, p.20.

[2] .
See, for instance Frame, J.D. (1979) "National economic resources and the production of research in lesser developed countries", in

Social Studies of Science, 9:233–246.

3. On the contrary, it has been argued for instance, that the momentous changes of the Industrial Revolution had very little to do with specific impact of scientific knowledge on the economic process, and that the men behind inventions received little formal scientific education. For this view, see Yearly, S. (1988) *Science, Technology and Social Change*, Unwin Hyman, London.

4. Some writers have used the term technocentrism to mean excessive reliance on *technical experts* to offer advice and suggest solutions to problems affecting society. See Pepper, D. (1984), *The Roots of Modern Environmentalism*, Routledge, London, p. 59.

5. A number of countries in South East Asia, notably Malaysia, have experienced institutional adaptation with regard to this new vision towards technology.

6. In recent years, Japan has increased its R&D expenditure in the field of microelectronics. It has realized that to maintain its competitive edge in electronics, scientific commitment and R&D investments are necessary. In the past, microelectronics had exploited the *particle like* nature of electrons to generate innovations. Japan is now focussing attention on the *wave like* motions of electrons to generate innovations in microelectronics. This shift to scientocentrism is sectoral and Japan aims to reap benefits by being the first in the field.

8. Conclusion

Africa's record to build domestic technological capabilities has been unimpressive. Several factors, both domestic and external, have militated against their acquisition and development. Africa has scored some remarkable successes in a handful of areas, but these have been few and far between. In addition, the accomplishments have, in general, come to pass not by design, but by default. On the whole, the process of building capabilities has often lacked a coherent *teleological* thrust; it has often not been guided by a well coordinated, decidedly proactive, and holistically consistent strategic worldview. The remarkable outcomes have largely been disparate, inchoate, ad hoc, and non-integral in nature. They also give the appearance of having been realized incidentally rather than having been sought after consciously, proactively, and premeditatedly.

The history of Africa on this score suggests that the evolution of technological capabilities in the continent has not been an institutionalized process. This paper has argued that, despite the unique contexts, contrasting cultural orientations, and different historical conditions of Asian and Latin American countries, the models they have pursued in building technological capabilities possess certain broad fundamentals which can be regarded as universals for African countries striving to achieve technological development.

Even if exogenous forces were overwhelming, Africa did not produce the quality of leaders with the indomitable will and patriotic spirit as those produced by Japan, Singapore, Korea, and Taiwan. There, the leaders consciously applied technology policy because to them, applying knowledge with a proven track record, and over time improving on it, defined success in all its diversity. It was this leaders'-driven technological temperament, and the desire to match words with deeds, that made all the difference.

It is true that Japan, Korea, and many other NICs pursued their techno-industrial dreams at a time when the international development context was not particularly smothering. Yet, it must be said that these countries seized the opportunities that were then available. *But the propitious conditions would not have meant anything if they had not strategically prepared themselves for the task ahead.*

Without doubt, the Cold War period presented many African countries with momentous opportunities for setting in motion a process of domestic techno-economic evolution. In Asia, Taiwan capitalized on its ideological differences with China to draw techno-industrial advantages from the US. But her programme of industrialization and technologization was piloted by leaders who had strategies, who matched words with deeds, and who were imbued with a dynamic technological temperament.

What appeared to be common denominators for Japan, Korea, Singapore and Taiwan, as was the case for many African countries, were the foreign threat and the humiliating excesses it would unleash. Unfortunately, African leaders did not respond to the potential threat as their Asian counterparts did. They seemed to have other ideas, tribalism and corruption in particular.

At the global level, the conditions and forces at play appear to be mathematically arrayed against Africa's economies in their ambition to industrialize. Yet, the dramatic changes in perspectives occasioned by the imperative of sustainable development following heightened environmental consciousness since the mid-1980s have created fresh opportunities for Africa. Indeed, the global Conventions came to view the earth as a living organism where activities in one part of the globe tend to have repercussions in another part. Therefore, the need to promote and reinforce sustainable practices in production, consumption, and exchange among stakeholders around the world has assumed policy significance at the level of international cooperation. Sadly, Africa has neither prepared itself sufficiently nor developed a robust technological temperament to build eco-technological capabilities. This is a tragedy of colossal dimensions.

From a survey of some Asian and Latin American countries, it is evident that technological development can be realized through a system of complementary strategies that stress technological targets in their programmes. Technology led public procurement is one important aspect of policy that can be used to effect technological change. Absolute reliance on market led strategies marginalizes critical resources that can pave the way for economic and technological development. To view technological and economic change solely from the neoclassical paradigm is to ignore essential prerequisites for those changes to occur. The fostering of change must be deliberate, organized and planned because market forces alone will not do the trick. In fact, the creation of technological capacity cannot be left to the operation of market forces alone.

In this respect, procurement strategies must be seen in the context of ensuring broader national participation and greater use of domestic capabilities. This selective approach must, of course, not be seen in isolation. But it can provide the leading edge in the process of attempting to build and use scientific and technological capabilities.

A significant number of domestic companies in Asia and Latin America have developed technological capabilities, and are now poised to penetrate markets in the developing countries in a more significant way. Korea, China, and India have devised procurement strategies that are aimed at increasing their domestic content ratios. The case of China illustrated that building technological capabilities requires an understanding of the complex forces that shape them, and that a certain cognitive orientation was necessary to foster the change. At the same time, while the evolution of competences has been approached in a manner that intensifies interaction between the technology supplier and the recipient, institutions in China have been brought to bear directly on their acquisition and development.

Appendix

Agenda 21 devotes chapter 34 exclusively to the issue of technology transfer through international cooperation. The section "Basis for Action" reads:

- The availability of scientific and technological information and access to and transfer of environmentally sound technology are essential requirements for sustainable development. Providing adequate information on the environmental aspects of present technologies consists of two interrelated components: upgrading information on present and state-of-the-art technologies, including their environmental risks, and improving access to environmentally sound technologies.
- The primary goal of improved access to technology information is to enable informed choices, leading to access to and transfer of such technologies and the strengthening of countries' own technological capabilities.

Support of and Promotion of Access to Tran sfer of Technology

Governments and international organizations should promote, and encourage the private sector to promote, effective modalities for the access and transfer, in particular to developing countries, of environmentally sound technologies by means of activities, including the following:

- Formulation of policies and programmes for the effective transfer of environmentally sound technologies that are publicly owned or in the public domain;
- Creation of favourable conditions to encourage the private and public sectors to innovate, market and use environmentally sound technologies;
- Examination by Governments and, where appropriate, by relevant organizations of existing policies, including subsidies and tax policies, and regulations to determine whether they encourage or impede the access to, transfer of an introduction of environmentally sound technologies;
- Addressing, in a framework which fully integrates environment and development, barriers to the transfer of privately owned environmentally sound technologies and adoption of appropriate general measures to reduce such barriers while creating specific incentives, fiscal or otherwise, for the transfer of such technologies;

- In the case of privately owned technologies, the adoption of the following measures, in particular for developing countries:

  - Creation and enhancement of developed countries, as well as other countries which might be in a position to do so, of appropriate incentives, fiscal or otherwise, to stimulate the transfer of environmentally sound technology by companies, in particular to developing countries, as integral to sustainable development;
  - Enhancement of the access to and transfer of patent protected environmentally sound technologies, in particular to developing countries;
  - Purchase of patents and licences on commercial terms for their transfer to developing countries on non-commercial terms as part of development cooperation for sustainable development, taking into account the need to protect intellectual property rights;
  - In compliance with the under the specific circumstances recognized by the relevant international conventions adhered to by States, the undertaking of measures to prevent the abuse of intellectual property rights, including rules with respect to their acquisition through compulsory licensing, with the provision of equitable and adequate compensation.
  - Provision of financial resources to acquire environmentally sound technologies in order to enable in particular developing countries to implement measures to promote sustainable development that would entail a special or abnormal burden to them;

- Development of mechanisms for the access to and transfer of environmentally sound technologies, in particular to developing countries, while taking into account development in the process of negotiating an international code of conduct on transfer of technology, as decided by UNCTAD at its eighth session, held at Cartagena de Indias, Colombia, in February 1992.

Technology Assessment in support of the Management of Environmentally sound Technology

The international community, in particular United Nations agencies, international organizations, and other appropriate and private organizations should help exchange experiences and develop capacity for technology needs assessment, in particular in developing countries, to enable them to make choices based on environmentally sound technologies. They should:

- Build up technology assessment capacity for the management of environmentally sound technology, including environmental impact and risk assessment, with due regard to appropriate safeguards on the transfer of technologies subject to prohibition on environmental or health grounds;

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