Chapter 3

Human Development and Science & Technology: A Two Way Street

We cannot survive the ruthless competitive world of today without harvesting science and technology. Only science led development will give us a chance to become serious players in the international market place

- Quett Masire, President of Botswana, 1995

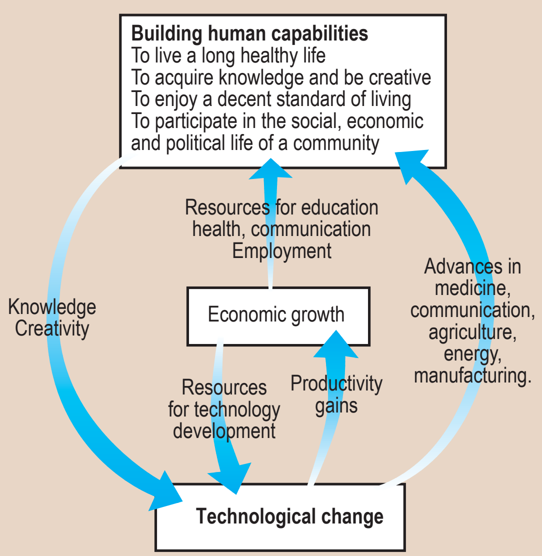
A Complex Relationship

Science, technology and human development share a close, though often complex, relationship. Progress in S&T has supported human development for as long as humankind has existed. Yet, many of mankind's problems are traceable to technology. The incredible power of death and destruction - nuclear, biological and chemical weapons – that man now yields is a result of progress in S&T. And so is the extensive damage to environmental resources through pollution and unsustainable exploitation, for instance through overgrazing, excessive sand mining and annexation of more virgin land for arable use. Overall though, progress in S&T aids development.

Science and Technology: A Key Factor Behind Progress in Human Development

Advances in S&T have driven progress in human development in industrialised countries. In the emerging Asian economies, rapid technological diffusion and to a lesser extent innovation, are playing a critical role in human development, introducing new products and services, raising product competitiveness, creating new job opportunities, expanding markets and accelerating growth. When progress in S&T serves human development purposes, it does so in two interrelated ways, as shown in Figure 3.1.

Figure 3.1: Links between technology and human development



Source: United Nations Development Programme. 2001. Human Development Report 2001. Making new technologies work for human development, NY

First, by directly strengthening essential human capabilities, for instance good health, literacy, knowledge and skills, technology extends the frontiers of human achievement and human wellbeing. New products and services, new industries and new employment opportunities are created. Second, through its impact on productivity and economic growth, technology raises the efficiency with which human beings do things and extends their achievement possibilities over time. By raising productivity and incomes, it provides opportunities for human beings to meet higher wants such as leisure and to do research, experiment and discover more knowledge.

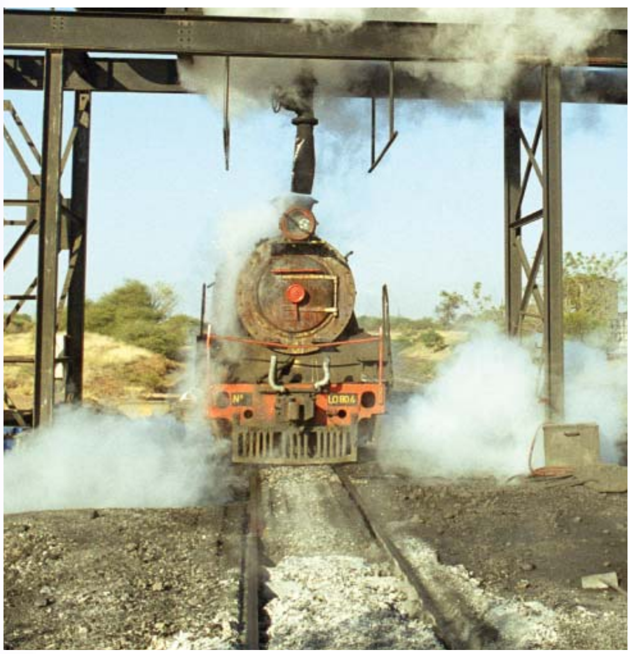
Technology, and in particular ICTs can also facilitate popular participation and promote accountability and transparency in public decision-making. It can also facilitate the delivery of essential services. For instance, e-learning, e-governance and e-commerce are emerging ICT based phenomena in service delivery and doing business in an information economy. In chapters four and five, we discuss the extent to which this potential has been realised in Botswana and propose an agenda towards an information society for Botswana. The rationale for the pursuit of an information society is simple: Technology drives the development process and ICTs are the latest in a series of breakthrough technologies that perpetuate the development gap.

In the World Development Report 2001, the World Bank emphasizes three defining attributes of the human development process – the creation of opportunity for people to earn a decent living; the empowerment of people and communities to function as viable agents for their own development; and the creation of an environment of security through the reduction of risk and vulnerability, for instance through prevention and impact mitigation measures for natural disasters. Technology has served all three functions well in the developed world and has the potential to deliver development for poor people and poor countries and help the world achieve the MDGs. The green revolution raised farm productivity and incomes in Europe, enabled farming communities to market their produce and enhanced household and national food and income security.

The telephone, the telegraph, the fax, and the steam engine before them, expanded development benefits to human kind in all three dimensions, as do modern ICTs today. Each of these developments brought down communication costs, reduced the space between buyer and seller, and created new opportunities for investment, trade, growth and development. Today's information technology revolution is a central feature of the globalisation process, and a potent source of economic growth, income, wealth and development (See Box 3.1). It is also an agent for exclusionary development.

Botswana's development needs do not require exclusively new technologies. Like the rest of the developing world, most of Botswana's development needs require access to simple and existing technologies by poor people and poor countries so that they may raise their productivity, access new markets and raise their incomes. Poor farmers need seed and fertilizer technologies that raise farm yields with less water and less damage to the soil and the ecosystem. They need low cost farm implements that save labour and preserve soil moisture. Weavers and tailors need faster and more precise machines and better fabrics. Health systems require disease prevention and curative technologies - inexpensive drugs and condoms - to overcome many of the preventable diseases of poverty: HIV/AIDS, malaria, tuberculosis, polio etc.

Many of these technologies exist but access to them is constrained (a) by patents that build exorbitant monopoly rents into the prices of otherwise inexpensive technologies, (b) state failure in developing countries for reasons of lack of fiscal capacity and bad governance, (c) the low research and innovation effort committed to solving the particular problems of poor countries and (d) the failure of developed nations to fulfil their long standing commitments to meet the development resource gaps in developing countries (only a few members of the Organisation for Economic Cooperation and Development (OECD) honour their commitment to spend 0.7% of their GDP on Official Development Assistance (ODA)). Therefore the challenge in the technological development process is to build diffusion capacities for innovations in the developing world.



One mode through which development benefits expanded to human kind

Box 3.1:

The Development Promise of a Special Class of Technologies

According to a recent study on the impact of ICTs on the global economy:

- The worldwide ICT industry is worth more than $1 trillion and is expected to grow to more than $1.5 trillion by 2006. Spending on services and software will grow twice as fast as spending on hardware.
- ICT-related employment between 1995 and 2001 grew at an annual rate of seven percent, 50% faster than the average rate of employment growth in developed countries.
- Tax revenues from ICT-related activities registered a 40% increase between 1995 and 2001 and should grow another 40% by 2005.
- Asia is expected to lead in IT spending with China projected to grow the fastest at an annual growth rate of 27% to 2005.
- The value of the e-commerce marketplace is estimated at several hundreds of billions of USD. The share of GDP composed of electronic trade - mostly distribution, finance and business services - is around 30%.
- ICTs and personal computers (PCs), high speed networks and the Internet, drive this technology-facilitated trillion dollar global economy
- The internet is a technology that combines many of the most recent inventions and developments into an increasingly pervasive, open and user-friendly platform for near instantaneous access to and sharing of local and global communications, markets and resources. The internet is quickly becoming the most important platform for enabling business of all types to take place.

Human Development: A Key Factor in Both Innovation and Technological Diffusion

The relationship between human development on the one hand and S&T on the other is not unidirectional. True, progress in S&T facilitates human development but so does human development facilitate progress in S&T. The two are mutually reinforcing phenomena. Each is both an input for and an output of the other.

The relationship between human development on the one hand and technology on the other, may best be understood within the framework used by Jeffrey Sachs,[1] who identifies three groups of countries on the basis of their role in the creation, diffusion and utilisation of S&T. The first group comprises countries where technological innovation takes place on a significant scale.

They hold patents on new products and technologies that are sold both domestically and externally and give them a competitive edge in a significant range of activities. These countries are found mainly in North America and Western Europe. In this instance, technology aids development not only by creating comparative advantage but also by creating high value economic rents that are protected by patents.

1 Jeffrey Sachs, economic advisor to Kofi Annan, the Secretary General of the United Nations

The second group of countries comprises "technological diffusers," countries that adopt, adapt and use new technologies developed in the first group of countries within 5-20 years. They include China and India, much of Latin America, and some parts of Eastern Europe. Whilst these countries are not leaders in innovation themselves, they have the capacity to import and use technologies from the innovating countries to build their own competitiveness. They typically realise significant development gains from new technologies. China is on course to meet the MDG target of halving poverty by 2016 in a decade, thanks to a technology inspired productivity revolution in agriculture and manufacturing.

Human development and S&T facilitate each other

The third group comprises countries in which neither innovation nor diffusion takes place on any significant scale. This group is being marginalized from the knowledge economy. The rate and extent of technological diffusion e.g. computers per capita is too low in these countries for them to raise their competitiveness in the global economy. Thus they find themselves on the wrong side of the digital divide and are unable to capitalise on new technologies before they become obsolete. These countries include most of Sub-Saharan Africa and South Central Asia.

A number of factors explain the disparities in both innovation and technological diffusion across nations, but they all point to one thing: a country's state of development is central to its capacity to create, diffuse and use technology. These factors include:

- The quality of physical and institutional infrastructure e.g. telecommunications, electricity and knowledge creation institutions such as research institutes, universities, polytechnics and colleges;
- The state of education in terms of content and the educational attainment of the citizenry;
- The size and maturity of the market, in terms of incomes and systems of governance[2] and;
- Integration into the world economy through trade and investment.

The state of development facilitates the creation and/or diffusion of technology because of four key attributes of the processes of technological innovation and diffusion:

1. **Economies of Scale:** Knowledge creation is an "Increasing Returns to Scale process because it requires that large volumes of resources be committed to research infrastructure, equipment and the salaries and incentives of scarce and expensive research specialists. Firms in developed countries often have sufficiently large markets, domestic and foreign, to support such investments. The firms that lead the innovation process are typically large multinational corporations or state supported institutions.

2. **Public Sector Support:** Progress in S&T depends significantly on the public sector as a user, a producer, and a facilitator of the production, of scientific knowledge and technology. Whilst developed countries can afford to spend billions of dollars annually supporting cutting edge private and public research, and have the requisite physical and institutional infrastructure, poor countries spend too little, their research institutions are too few and poorly resourced, and their infrastructure is weak.

3. **Human development:** Innovation and technological diffusion require high levels of literacy, good quality higher education and adequate incomes: in other words high human development. Thus, the limited penetration of modern technology in Sub-Saharan Africa is primarily accounted for by low human development. People are either not sufficiently literate to use the technologies that come their way, e.g. the computer and the Internet, too poor to buy them and more often than not, both.

4. **Foreign Direct Investment:** Innovation and technological diffusion are functions of FDI. Trends in technological diffusion closely follow FDI trends. China, Singapore, Malaysia, South Africa and other technological diffusers are also host to billions of dollars' worth of FDI, which serves as a medium for the transfer of knowledge and skills.

Progress in S&T is important not as an end in itself but rather as a vehicle for further human development. In turn, human development facilitates progress in S&T. Quality infrastructure, a quality human resource base, a quality education system, quality incomes and quality public support for research and development through a strong and competitive business sector facilitate further innovation.

Botswana meets the main requirements for developing a strong science and technology capability. Fiscally, it is strong. It can finance at least some of the requisite initiatives. Its communications infrastructure is good, literacy levels are high and improving, the education sector is well resourced and private incomes are of the order of upper middle income countries. Furthermore, Botswana has a strong market oriented economy. It is remarkable that despite being a small economy, Botswana ranks second in Africa in terms of economic freedom, and alongside mature economies such as Japan, Norway, Sweden, South Korea and Taiwan. The country is favourably disposed to foreign trade and investment. These attributes are not, by themselves, sufficient to turn Botswana into a competent technological diffuser, let alone a leader in innovation. A deliberate strategy, purposely pursued to exploit these conditions is required to create a national S&T capability.

2 Governance in this instance refers to the statues, regulations, and institutions that facilitate and regulate the exchange of goods and services as well as the conduct of players - sellers, investors and government – in the market and define and protect their roles and rights.

Building a Science and Technology Capability

Botswana has a number of institutions tasked with researching, developing and/or adapting technologies for application in Botswana. These institutions are central to Botswana's quest for a meaningful S&T capability. In this regard, four questions require answers as Botswana gears up for the creation of a national S&T capability.

Botswana Technology Centre (BOTEC) one of the key research institutes

- Are Botswana's research and development institutions delivering value in terms of generating viable and accessible knowledge relevant to the needs of the economy?
- Is Botswana doing enough to keep abreast of developments that form the basis for establishing and maintaining comparative and competitive advantages in a knowledge driven global economy?
- What examples can Botswana draw inspiration from in her quest to meet the challenges of rapid technological innovation and/or diffusion?
- Is the limited S&T expertise in the country used in the most optimal of ways?

The general impression, borne out of lack of results on the ground, is that this research infrastructure has failed to deliver and perhaps Botswana should re-learn how to build capacity the Malaysia and Singapore ways, as per Text Box 3.2.

The Institutional Infrastructure

On paper, Botswana's research and development infrastructure includes the UB, the country's only university and several Government funded applied sciences institutes that undertake research and development work to meet the specific needs of Botswana. The UB is endowed with cutting edge equipment and instrumentation, however there is absolutely no funding infrastructure that can allow a quantum of research outputs to match the equipment potential. This has resulted in the UB failing to build a significant capability for research and development in spite of the wonderful endowment it possesses.

Botswana's key research institutes are the Botswana Technology Centre (BOTEC), the Rural Industries Promotion Company (RIPCO) and its subsidiary, the Rural Industries Innovation Centre (RIIC), the National Food Technology Research Centre (NFTRC), the Department of Agricultural Research (DAR), BIDPA as well as other government research departments. Veld Products Research and Development and Thusano Lefatsheng are non-governmental research organisations that undertake research in non-timber forest products and medicinal plants respectively.

The applied research institutions' mandate and focus is on developing and adapting technologies for the local market. These inward looking institutions on the whole do not undertake research and develop technologies that could be of interest to markets and users abroad. Similarly, collaboration with the private sector seems to be very limited to meeting the needs of local SMMEs, particularly rural enterprises and the farm sector[3] through low technology products. Thus, these institutions rarely hold patents over their innovations.

The Policy and Legislative Environment

The Science and Technology Policy: The National Assembly approved the Science and Technology Policy for Botswana in July 1998. As per the policy, S&T is critical to productivity growth, national competitiveness and the diversification of the economy. The Policy thus commits Botswana to developing a S&T capability through, amongst others, increased spending on scientific research. Whereas successful developing and emerging economies spend in the order of 2-3% of GDP on S&T related research, Botswana's research expenditure is estimated to amount to less than 1% of GDP.

The Policy assigns priorities to each of several critical sectors, including agriculture, commerce and industry, education and human resource development, energy, environment, health, meteorology, mining, population planning and human settlement, tourism, transport and communication, water and wildlife. It also gives priority to strengthening telecommunications infrastructure and the use of ICTs and attracting women to professions and careers in the field of S&T.

S&T Policy prioritises industry among other sectors

Significantly, the policy provides for the coordination of scientific research within the country and with the rest of the world. To this end, it proposes the establishment of three institutions to coordinate and promote scientific and technological research. These are, the National Commission for Science and Technology (The Commission or NCST) to deal with policy issues), the National Council on Research, Science and Technology (The Council), whose concern will be resource allocation for S&T research, and a National Centre for Scientific and Industrial Research (NCSIR) whose primary responsibility would be to undertake publicly funded applied research.

The above institutional framework has since been modified along the Incentive model as per the New Zealand Consortium's recommendations, which proposed the NCST as the policy advisory body; the Botswana Research Science and Technology Investment Agency (BRSTIA) responsible for the output-based resource allocations for research and development, and the Botswana National Association of Scientists and Technologists (BNAST) which is supposed to play the role of an umbrella

3 Milne, D., Palmer, C. and Yeabsley, J. 2000. Focusing investment in innovation. On the co-ordination and rationalization of science and technology and research and development in Botswana. New Zealand Science and Technology Consortium (Wellington).

advocacy agency for professional researchers. The constraints that have hindered the progression of the country on the S&T path, partly as a result of the fact that policy on S&T is recent, has been the lack of articulation and coordination, backed up by legislative muscle to ensure the objectives of the Science and Technology Policy are actually realised. There are moves afoot to legislate for the BRSTIA, the proposal having gone to the Attorney General's Chambers, but the fact that the legislative framework is not all encompassing, but rather piece-meal in approach might perpetuate problems such as lack of articulation.

Whereas actual research on S&T in Botswana is spread across several sectors, only a few patents have been registered since Botswana enacted the requisite legislation in 1996. There is an urgent need to increase awareness about the advantages of patenting knowledge. Knowledge is a commodity with public good elements and whilst patents often restrict access to essential technologies at great cost to society and the development process, it is equally true that patents generate great benefits for society and the development process, simply by making it worthwhile to invest in knowledge creation.

It may cost money and time to create knowledge, but it is relatively easy to replicate once created. Thus, for the nation' innovators to realise the commodity value of their innovations, to gain competitive advantage from their innovations, and to have the incentive to invest in research and development, they must patent their knowledge. Furthermore, Botswana should develop standards, including industrial and consumer standards, to ensure research excellence, assure the quality of Botswana products and promote their international competitiveness.

Intellectual Property Rights (IPR): Botswana has IPR legislation that is in accord with the World Trade Organisation (WTO) Agreement on Trade Related Aspects of Intellectual Property Rights (TRIPS). The legislation comprises the Copyright Act of March 2000, The Patent and Trademark Act, and the Industrial Property Act of 1997 and it's implementing legislation in late 1998. The IPR legislation provides internationally recognized standards of protection for both foreign and domestic holders of patents, industrial designs, and trademarks, and fully complies with the TRIPS agreement[4]. Botswana is a member of both the Bern and Paris Conventions, the international baseline IPR agreements.

Botswana is now an original Registrar of Trademarks, Patents and Designs. Previously, any trademark, patent or design originating from Botswana had to be registered in South Africa or the United Kingdom to be accorded protection in Botswana[5]. Despite this development, the documentation, and registration of intellectual property by Batswana artisans, artists and inventors is hardly taking place. According to the World Bank World Development Indicators published in 2001[6], there were seven (7) patent applications of Botswana origin recorded in the World Intellectual Property Organisation (WIPO[7]) database in 1998. WIPO further reports that only one (1) patent was granted to a citizen of Botswana in 2000 whereas the patent office of the GoB recorded 51 patents registered to foreign entities in 1999 and 5 in the year 2000[8]. Not one patent recorded by the Patent Office of the GoB over the period 1985 to date was considered of national origin.

One explanation for the foregoing may be that changes permitting registration of patents in Botswana have only recently been made. Another could be lack of capacity in the patent office. The patent office in the Office of the Registrar of Companies is, like the Registrar's Office itself, yet to computerise its record keeping. Furthermore, it is presently ill-equipped to undertake the advocacy necessary to create awareness about IPRs. Awareness about IPRs and the patent office itself is low. Some patents are registered in Harare. The third constraint on patent registration may be the cost and complexity of the process. The patent must be filed in several jurisdictions around the world in order to secure effective protection and benefit. Often, this requires the services of lawyers and/or other specialists whose services may be inaccessible to individuals and small firms.

Local and traditional knowledge, especially of natural products, is another area that requires patent protection. There are difficulties peculiar to securing patents for local and traditional knowledge. For instance, documenting such knowledge may be difficult and costly. It may be difficult to ascribe such knowledge to a beneficiary because indigenous knowledge creation and innovation is often collective, intergenerational and for the social good[9]. Seeking a way to channel the benefits to the community may require the creation of a legal entity[10] such as a Community Trust. Another approach may be to create a database of indigenous knowledge so that in the event of perceived unauthorised use, or undue restrictions on the use, of traditional knowledge resources, a legal challenge may be considered on the basis of information in the database[11].

Effective protection of intellectual property rights is the foundation for innovation and research. IPR regimes allow those who invest resources in the creation of knowledge to realise the benefit of their investment. In the absence of a credible IPR framework, research and development will be stifled because whilst new knowledge is costly to produce, it is often easy to replicate. Thus IPR legislation must strike an efficient balance between incentives for innovation and the public interest in the diffusion of new knowledge. Through Patent and Copy Rights Legislation, this balance is struck by granting innovators monopoly rights over their ideas for a period long enough for them to recoup their costs.

Levering Science and Technology for Human Development – Achievements and Possibilities

Apart from mining technologies, Botswana's achievements in S&T have occurred in the areas of livestock and crop sciences, and natural resources management, including rangeland management and water resources management. These achievements generally take the form of adaptation of existing low level technologies to Botswana's needs at the SMME level and in agriculture, or low technology innovations again aimed at the Botswana market rather than breakthrough innovations of the type that give a country a decisive gain in comparative and/or competitive advantage. In this regard, some achievements have been made in the development, adaptation and use of village level technologies such as the rough planter and in the use of natural products such as non-timber forest and rangeland products. A new and promising area is HIV/AIDS, where intense research work is now being done on HIV/AIDS and related diseases (TB) through two USA/Botswana collaborative initiatives. In discussing the potential of Botswana's initiatives, the experiences of other countries, given the title best practices (Textbox 3.2), must be considered to set the right context under which the striving for a better technology driven Botswana economy can be based. One must consider in Singapore's case, that its development is driven by the systematic development of human resources as opposed to Botswana's that is reliant on natural resources.

Livestock Sciences

Given the strategic role of beef in the Botswana economy and the sector's vulnerability to disease outbreaks, Botswana invested resources in the creation of research, development and training capabilities to service the livestock sector. For training purposes, the

4 US Commercial Service. 2001. Botswana country commercial guide FY2002. Investment climate statement. http://www.usatrade.gov/Website/CCG.nsf/CCGurl/CCG-BOTSWANA2002-CH-7:-005CDCA9
5 http://mbendi.co.za/werksmns/lexaf/busbo.htm#Intellectual
6 World Bank. 2001. World Development Indicators 2001. Science and technology, Table 5.11
7 World Intellectual Property Organisation. http://www.wipo.int/ipstats/en/
8 United Nations Development Programme. 2002. List of patents collected by Botswana Human Development Report research team
9 United Nations Development Programme and Institute of Statistical, Social and Economic Research, University of Ghana. 2001. Ghana Human Development Report 2000. Science, technology and human development. Accra.
10 Inger, D. 2002. CEO. Veld Products Research and Development, Gaborone. Personal communication.
11 Van Dijshorst, Hilde. 2002. Protecting indigenous knowledge by intellectual property rights: a suitable solution? Report for Veld Products Research and Development. Gaborone. 28 pp.

Botswana College of Agriculture (BCA), was created to train extension staff to the Certificate, Diploma and Degree levels. Whilst its primary role is to train extension workers, the college also has research specialists. The Botswana Vaccine Institute (BVI) was developed specifically to undertake research into livestock diseases and to develop vaccines and cures, and have successfully developed foot and mouth vaccines over the years.

One important outcome of this investment is for the Botswana livestock industry to have been able to meet the quality and disease control standards of the European Union. This was made possible through the development of a solid research and livestock disease management capability covering veterinary science/medicine and environmental monitoring and evaluation.

In the past, research has been focussed on the evaluation of beef breeds and their crosses to determine their potential for beef production and also the potential to use composite breeds. The composite breed that continues to be evaluated has a genetic population of 28.24, 4.44, 22.6, 26.32, 24.79, 2.8 and 1.8 % of Tswana, Tuli, Brahman, Simmental, Africander, Hereford and Shorthorn, respectively. However recently there have been indications that the European market prefers the organically bred beef, as it is supposed to have less fat. This should favour the Tswana breeds that are currently disadvantaged by the Botswana Meat Commission's prizing that is based mainly on body weight. The demand for organic beef should see such a policy reversed as it was also contributing to the marginalisation of indigenous breeds. There is already evidence that local populations in Southern Africa would have to re-import African Boran and Tuli breeds that have been improved by the Australians[12].

Water Management and Conservation

Botswana has also made significant progress in using S&T to access sub-surface water resources. In the 1950s, the installation of boreholes in the hard veld and sand veld areas enabled cattle posts to be established on a year round basis. As a result, livestock numbers increased through the 1960s and 1970s to reach a peak in 1981.

The introduction of borehole technology has enabled the country to cope better with recurring droughts and maintain the livestock industry in a relatively stable fashion because it has given the livestock industry access to good rangeland that could hitherto not be used because of lack of water. In addition, access to ground water and water supply infrastructure has allowed for more efficient use of water and rangeland resources.

The downside of the development of this technology is three fold. First, it is expensive and is therefore inaccessible to poor farmers. Second It has therefore conferred disproportionate benefits, including de facto exclusive grazing rights, on well off farmers. Worse still, because of policy weakness, such farmers retain access to the more congested areas where ground surface water is available and the user rights are neither de jure nor de facto exclusive.

By building on Botswana's capabilities in water management, this area of applied research could be further strengthened to deal with national water conservation and management issues and build up into an area of national as well as international expertise.

Natural Resources and Rangeland Management

Botswana has developed expertise in the use of non-mineral natural products such as non-timber forest products. Veld Products Research and Development, an applied science research and development institute, has a strong and internationally recognised track record of research into veld products. Its research covers medicinal plants, herbal teas, wild fruits, bee-keeping, wild birds, the Mophane worm and truffles, most of which have significant potential to enhance rural livelihoods in Botswana.

Many of these resources have traditionally been used for subsistence purposes and the viability of their commercial use is still uncertain. Research by non-governmental organizations, the UB and Ministry of Agriculture (MoA) into the development of efficient and sustainable cultivation and harvesting technologies is ongoing. Combined with existing scientific and research expertise, this work could provide a basis for structured ethno-botanical and pharmaceutical research.

Health care and HIV/AIDS

The research collaboration on HIV/AIDS that Botswana has secured in partnership with the international community is an example of the kind of North South partnership for development envisaged under the eighth MDG – developing a global partnership for development. Two North South partnerships are worthy of consideration. The first is the collaboration between Botswana and the US Centre for Disease Control (CDC) and is known as the BOTUSA Project.

The BOTUSA Project: The BOTUSA Project is part of the Global AIDS Programme (GAP) of the CDC. The principal goal of the project is to investigate the relationship between the parallel epidemics of TB and HIV/AIDS in order to develop prevention strategies to control the spread of both. The specific objectives of the programme are as follows:

- Improve access to voluntary HIV/AIDS counselling and testing (VCT);
- Increase the coverage of the national programme to prevent mother-to-child transmission (MTCT) of HIV;
- Improve youth access to youth-oriented HIV/AIDS prevention services;
- Develop media and community strategies to deliver more effective information and education about HIV/AIDS and TB;
- Improve treatment and care services for People Living with HIV/AIDS (PLWA), especially through TB preventive therapy;
- Strengthen HIV surveillance to include young males and measurement of behavioural risk factors and;
- Conduct research on the epidemiology of TB and HIV, and on TB prevention, diagnosis and treatment. BOTUSA is also preparing to conduct research on the Carraguard HIV vaginal microbicide.

12 Rege, J.E.O. and Gibson, J.P. 2003. Animal genetic resources and economic development: issues in relation to economic valuation. Ecological Economics 45: 319-330

Box 3.2: **Some Best Practices to Consider**

Singapore

Singapore is a world-class leader in science and technology and research and development. Its priority development goal is to attain an unrivalled living standard and surpass the U.S. standard of living by 2010 based on S&T led growth and development. To become a world-class technology leader, Singapore, along with South Korea, Malaysia, China, China Taiwan and China Hong Kong, went through three stages of economic development, viz., industrial development through low-cost labour; upgrading technology and other infrastructure; and developing globally competitive businesses.

Singapore's success in digital transformation was built on three main pillars. First, the development of electronic engineering and an ICT base as the key gateways to Singapore's global competitiveness. When Singapore lost wage competitiveness, it shifted focus to building a national S&T capability. It upgraded its industrial and research infrastructure and committed resources to advanced science and technology research and incentives to attract global technology leaders. It encouraged offshore manufacturing while retaining the headquarters and Research and Development (R&D) facilities of offshore enterprises in Singapore. In the 1991–96 five-year plan, Singapore allocated over US$3 billion to upgrade and transform infrastructure from that of a manufacturing centre to that of an innovation hub capable of creating new and better products for the region and the world. This sum included $500 million to promote private sector innovation by covering up to 70% of eligible project costs.

Second, Singapore aggressively pursued foreign direct investment through appropriate adjustments of the local environment. It paid particular attention to:

(a) The development of specialised skills for emerging industries and wafer fabrication projects required for assembling microprocessors.

(b) Upgrading infrastructure and services: To further deepen its science and technology capability, Singapore decided to build a multi-technology, ultramodern telecommunications and information infrastructure. It plans to make its port the most automated in the world. Its Tradenet system now links (in 1999) government agencies through computer networks that can process over 10,000 customs declarations daily. The system can handle complete documentation for trade, government administration, transport, banking, and insurance.

(c) Meeting the land requirements of foreign investors.

Finally, Singapore had a strategic focus on creating an electronics industry cluster, including semiconductors, communications, display, and data storage businesses. Singapore's successful electronics development strategy produced revenues of over $45 billion in 1995. The Government offers tax incentives for pioneering investments, skills training, R&D training, and special reduced taxation for specific industries and technologies. Singapore also has introduced a value added tax system to reduce overall taxation on individuals as well as on corporations.

The lesson from Singapore is that an economic transformation of the type sought by Botswana requires a deliberate strategy and a political conviction of the type that will ensure allocation of sufficient resources for transformation. This is precisely the route Botswana has taken with regard to development of an International Financial Services Centre (IFSC). The technology and knowledge initiatives have on the other hand been relatively more tentative. The R&D institutions appear under resourced and ill-equipped to attract and retain the right calibre of researchers.

Adapted from Boulton, R., Kelly, M.J., Yoshida, P.G. 1999. *Information technologies in the development strategies of Asia.* International Technology Research Institute. USA.

Malaysia

Malaysia's vision is to become a developed country by the year 2020. Part of the effort to achieve this goal has involved the creation of Government-supported research institutes (GRIs). Malaysia's GRIs include the Standards and Industrial Research Institute of Malaysia and the Malaysian Institute for Microelectronic Systems (MIMOS). MIMOS, which was started in 1985 within the prime minister's office, is now a department of the Ministry of Science, Technology, and the Environment. MIMOS is Malaysia's national center of excellence in microelectronics and information technology. MIMOS projects are product oriented and focused on boosting the competitive and innovative levels of the domestic electronics industry.

Malaysia has relied heavily on cooperation with foreign technology leaders, often by expanding on relationships begun in contract labour arrangements, to enter and compete in markets for technologically advanced components and products. Thus, like Taiwan, Singapore and South Korea, Malaysia is committed to attracting and keeping the involvement of companies that are technology leaders, recognising that once foreign corporations have a stake in the local market, they typically continue to upgrade technologies.

Malaysia is committed to the use of ICTs to achieve its development objectives. It has a vision to utilize ICTs to transform all of Malaysian society into an information society, a knowledge society and finally a values-based knowledge society in that order.

Malaysia plans to invest more than $2 billion over the next decade to become the multimedia hub of Southeast Asia. In August 1995, Prime Minister Mahathir proposed the Multimedia Super Corridor (MSC) project to foster IT industries. MSC stretches south of the capital of Kuala Lumpur to where a new international airport and new federal capital are under construction - a 9-mile by 30-mile zone about the size of Singapore. This corridor will attract a workforce of 150,000.

By creating an advanced information network, Malaysia's government hopes to lure leading R&D companies and software developers from abroad. More than 900 companies have applied to participate in the MSC program. Qualifying firms must be suppliers of multimedia and other information technology products or services and be willing to transfer technology to Malaysia. Non-manual workers such as engineers should account for at least 15% of the workforce. Companies that joined the project by the end of 1997 will be exempted from corporate taxes for up to ten years.

The Botswana-Harvard Partnership for HIV/AIDS Research and Education: Established in 1996, The Botswana-Harvard Partnership for HIV/AIDS Research and Education is a collaborative research and training initiative of the GoB and the Harvard AIDS Institute of the USA. The partnership has developed, in Botswana, a state-of-the-art laboratory and research capability on the grounds of the Princess Marina Hospital in Gaborone and collaboration with research specialists in the USA. The aim of the laboratory is to conduct cutting-edge research on HIV/AIDS in Botswana and Southern Africa.

The laboratory houses epidemiological and laboratory-based research on the prevention of mother-to-infant transmission of HIV, treatment for AIDS and vaccine design and testing. It serves as the leading facility for the processing and testing of specimens from the Partnership's HIV research studies as well as specimens from Botswana's national programs. The research initiatives focuses on the HIV-1 subtype C, the viral subtype predominant in southern Africa, and the subtype causing the highest numbers of new HIV infection worldwide.

The new facility has the capacity to run qualitative Deoxyribonucleic Acid (DNA), Polymerised Chain Reaction (PCR) tests, Enzyme Linked Immunosorbent Assay (ELISA), and Western Blot serological assays to accurately diagnose infection, together with quantitative viral load determination and CD4/CD8 counts to support the treatment and monitoring of HIV/AIDS patients. It is also possible to culture the virus, carry out DNA cloning, sequencing, immune function assays and flow cytometry within the facility. These techniques allow scientists to improve their understanding of HIV - how it functions and how the immune system responds to it - to support the development of effective and locally relevant treatment and prevention programs.

The MoH in Botswana, the Harvard AIDS Institute, the National Institutes of Health (USA), the Harvard Medical School, the HIV vaccine Trials Network, St Louis University, and Epimmune (the California company that developed the experimental vaccine), have formed a partnership that resulted in the first HIV vaccine trials in Botswana since July 2003.

Other key players in the fight against HIV/AIDS

The National Aids Council (NAC), chaired by the President, is the policy forming and directing agency on HIV/AIDS matters. Its implementing arm, the National Aids Coordinating Agency (NACA) which operates from the office of the President, was formed in 1999 by a cabinet directive and is charged with coordinating and facilitating the nation’s response to the HIV/AIDS epidemic. The coordination involves identifying the key strategic priorities in the war on HIV/AIDS, development and support of programs and policies that can deliver on the priorities and the development of tools and mechanisms to monitor and evaluate progress in the war on HIV/AIDS.

ACHAP is a collaboration between the Government of Botswana, the Bill & Melinda Gates Foundation and the Merck Company Foundation to prevent and treat HIV/AIDS in Botswana. ACHAP was formed in 2000 and it supports GoB in its endeavour to decrease HIV incidence, significantly increase the rate of diagnosis and the treatment of the disease, by rapidly advancing prevention programmes, healthcare access, patient management and treatment of HIV/AIDS.

Knowledge, Innovation and Training Shall Overcome (KITSO) AIDS Training program is a collaborative program MoH, the Harvard AIDS Institute and the Botswana-Harvard AIDS Institute Partnership. Taking its name from the Setswana word for knowledge, KITSO combines classroom and facility based learning to provide quality, multidisciplinary and standardised training designed to meet the needs for Botswana’s health professionals.

Other initiatives include the TCB Programme, IEC Programme, Masa ARV Therapy programme, Botswana Christian AIDS Intervention Programme (BOCAIP), HIV/AIDS capacity building in the private sector in Botswana, highly mobile populations sexually transmitted infections prevention programme and Coping centres for people living with HIV/AIDS (COCEPWA). The role of the IEC programme is to manage the demand for, and promote adherence to, treatment by managing expectations, standardising messages and coordinating communications activities. Masa, derived from a Setswana word meaning ‘new dawn’, is a bold initiative by the GoB that seeks to provide ARV therapy free of charge to all Batswana who need it. COCEPWA provides a base and platform where HIV-infected people can speak and share their experiences and the challenge of living a positive life.

Many other civil society organisations and initiatives such as the Botswana network of AIDS service organisations (BONASO); Botswana network of people living with HIV/AIDS (BONEPWA); home-based care centres; and many others exist and respond to HIV/AIDS in a diversity of ways. The list of these and other corporate entities that have joined the fight against the epidemic is long and is not exhausted, but what it shows is the slow realisation in Botswana that HIV/AIDS is no longer just a health issue; it is an all encompassing social, economic and political problem that must be confronted if its negative impact is to be reversed.

Alternative Energy Sources

Botswana has had limited success in introducing alternative energy sources such as biomass and solar energy. Botswana enjoys more than 3,200 hours of sunshine per year and receives 21 MJ per square metre on average in daily solar radiation on a horizontal surface[13]. The development of technological capabilities for harnessing solar energy has been ongoing for more than two decades in Botswana but the results have to date fallen short of establishing acceptable levels of efficiency and reliability, let alone, commercial viability.

Solar energy: Botswana uses solar energy where it might not be economically viable to provide electricity through the national grid. For example, it has been used for borehole water reticulation in remote areas, providing energy to the remote installations of the railway and the Botswana Telecommunications Corporation (BTC) and for lighting in remote areas. District councils use solar power to provide electricity to clinics and schools for refrigeration and lighting purposes. The GoB National Photovoltaic Rural Electrification Programme of 1997 that is implemented by the RIIC in Kanye (which is ending in 2004) has made 300 photovoltaic energy installations throughout the country, predominantly in households.

Despite its potential, solar energy is not widely used because of high initial investment costs and deficiencies in backup service owing to lack of appropriately skilled personnel.

Fuel wood: This is an important source of energy for cooking and lighting purposes, especially in rural areas. It is an overexploited resource whose use, though declining in favour of low-pressure gas and electricity, has serious environmental consequences. In the neighbourhood of major population centres, where a market for fuel wood exists, sellers frequently chop down live trees for fuel wood instead of dead ones, thus accelerating desertification.

Precisely because fuel wood is an extensively used energy source, the absence of fuel wood plantations, community woodlots, fast growing fuel wood species, and limited research in this direction, appears anomalous.

13 Mogotsi and Kumar. 2001

The ascent of low-pressure gas as the fastest growing source of energy for cooking may however explain the situation[14].

Other sources of energy: Two other sources of energy in Botswana have attracted both research and application interest. One is biomass, from which methane gas may be extracted. The other is wind energy, which may be used to power boreholes. Both have to date proved lacking in viability. The utilisation of biomass is constrained by low concentration of biomass and large distances between prospective production centres and consumption centres. The use of wind technology on the other hand is constrained by a combination of low wind speeds, product failure and lack of technical support.

Crop Research

There have been efforts by crop scientists at the Department of Agricultural research to develop sorghum hybrids in Botswana. Sorghum (Sorghum bicolor L. Moench) was domesticated in Africa and has emerged to be an important cereal crop for Botswana. In Botswana, sorghum ranks first in the total tonnage of grain produced and the total area planted and thus makes it the most important cereal and forage crop. Generally small-scale farmers grow open pollinated varieties and the large-scale farmers grow mainly hybrids. The first Botswana sorghum hybrid, developed in conjunction with the sorghum and millet improvement program, Southern African Development Community and the International Crops Research Institute for the Semi-Arid Tropics (ICRIST) was introduced in 1995. Although many other hybrids have since been available, most are well suited to brewing and thus further tests are essential to identify those that are adapted to specific agro zones. According to Stimela and Lekgari, significant increases in sorghum production in Botswana will require improved agronomic practises in addition to improved hybrids.

A Change in the Focus on Research and Development may be in Order

The point has been made in this section that by design, Botswana's publicly funded research programme is largely focused on low value technologies of the type that does not transform an industry or an economy through quantum gains in productivity and/or competitiveness. The New Zealand Science and Technology Consortium[15] picks this as a fundamental flaw and observes in a 2000 report that the emphasis on rural technologies in research activities and funding is a problem for the following reasons:

- It has a low technology content and is focussed on rural development based on mild improvements through mechanisation. Thus, the programme is not seeking breakthrough innovations.
- Because of the above flaw, the programme will not close the gap between Botswana and technology leaders i.e. it will not produce the quantum leap required to make a discernible impact on the economy.

Beyond these, there are questions regarding incentives for research. Whilst facilities may have been developed, Botswana's research institutions do not reward researchers sufficiently to attract and retain thinkers. The field of knowledge creation requires the brightest of a nation's educated people. Unless they offer better pay packages than the civil service and employ strict selection criteria, research institutions will not accumulate experience and expertise and will in the main be no better than extensions of the civil service.

14 Afrane-Okese (2001). Energy in Botswana: Trends and use of fuel wood, gas, electricity coal and paraffin. Energy and Development Research Centre. University of Cape Town, http://www.eldis.org/static/DOC11189.htm

15 Milne, D., Palmer, C. and Yeabsley, J. 2000. Focusing investment in innovation. On the co-ordination and rationalization of science and technology and research and development in Botswana. New Zealand Science and Technology Consortium. 182 pp. Wellington.