Science-Based Economic Development Eureka Factor

Stephen Chandiwana
Director, Blair Research Institute
Harare, Zimbabwe
Clive Shiff
Associate Professor, Johns Hopkins School of Public Health
Baltimore, Maryland
New York Academy of Sciences
March 1998

This paper examines the eureka factor in science based development and underscores the increasing concern that Africa lags behind in S&T due to political and social instability coupled by low investments in technologies. The paper emphasises that African science should come up with a decisive policy for investment in new style education and capacity building for S&T that is relevant to the African experience and addresses problems of real concern to the community. Science led development in Africa should reduce replication of foreign technologies and invest in social capital of its scientists and its R&D institutions for sustainable economic development. The aim of the paper is not to offer prescriptive solutions but to highlight areas which should stimulate debate in small working groups examining how Africa can learn from its own experience as well as that of other nations in developing an appropriate system of innovation for science led development.

Increasing Concern that Africa Lags Behind in Science and Technology

Rather belatedly before the dawn of the twenty first century, there are increasing concerns within Africa at the failure of the continent to harness science and technology (S & T) for socioeconomic development. Presenting a keynote address at a *Presidential Forum* on the *Management of Science and Technology for Development in Africa,* the President of Botswana, Sir Ketumile Masire observed that ..." Over the last thirty years the heads of various African scientific institutions have been stressing the importance of rapid industrialization and the role science and technology development can play in increasing the national output, and contributing to dynamic and self–reliant economies." (R&D Forum Update:Vol II, Dec, 1993). However he lamented that progress has been poor with less than 0.4 percent being allocated to S & T programmes and Africa continues to lag further behind global trends particularly those of the new industrialized economies of the Pacific Rim such as South Korea, Taiwan, Hong Kong and Malaysia which have utilized technology for rapid economic growth and increased prosperity for their people. On the other hand Africa has being plagued by civil wars, drought and desertification, political instability and the problem of refugees, deteriorating health infrastructures exacerbated by the AIDS/HIV pandemic, mounting external debt and a pervasive crisis of poverty among its people. African leadership should take blame for failure to diversify and broaden the base of the economy, the rapid rise in unemployment and the potentially dangerous fiscal and domestic debt situations. While exogenous influences are important, these economic problems are to a large extent the consequence of a combination of inappropriate policies, weak policy implementation and infrastructural and institutional decay. African countries must seek to upgrade technologically using their base of local scientists and economists and reduce reliance on advice from external consultants whose priorities in most cases is to implement macroeconomic policies initiated by Washington based Brentwood institutions.

According to Blake (1993) (AAS Whydah Newsletter Vol 3: pp 1–6), there is an imperative to readdress inequalities in north–south relations to remove the existing contradiction in S&T partnerships based on a superior/inferior model and replace it by one based on mutual responsibilities and respect. Science and technology and north–south partnerships are intractably linked and form the basis for sustainable economic development in Africa through creation of information bridges that facilitate access to needed

information and maximise indigenous cultural systems of technology and production. Accountability and transparency are primary prerequisites for effective governance and the development of human resources and science and technologies that will reduce dependency on donor aid for supporting government annual budgets. The same theme is supported by Professor Thomas Odhiambo, founder of the Nairobi based *African Academy of Sciences (AAS)* and more recently the *RANDFORUM,* a trust set up for the promotion of science led development in Africa. In the June 1993, volume 3 Whydah newsletter of the AAS he writes... "Africa now needs to desperately redesign its own self–image, invent a new science–led and Africa culture–informed future and create an enabling environment for social peace and intra–Africa stability as a first step in having a stake in world peace and prosperity." He calls for a decisive policy for investment in a different kind of education and capacity building.

What African Science Should Focus On

a. New style education that reintegrates science into Africa's own cultural endowment and ensures that economic and social development strategies are science–led.
b. Open Africa's education system to creative thinking and decision making. This is echoed by President Yoweri Museweni of Uganda who calls for the demystification of the teaching of science to young people "Science is nothing more than knowing our environment and knowing ourselves"
c. Scientific and economic–development is not a matter of literacy and numeracy, but should be viewed as a civic duty by the genuine African scientist whose ideals and motives should include social concerns and equity within the community.
d. The African scientist needs to recreate a tradition of believable successes if we are to build self confidence in tackling our own problems without a dependency syndrome which mimics or prefers western technology and science.
e. According to Professor Odhiambo, Africa should begin to construct or re–develop a culture of our own heroes and heroines in all fields:"the outstanding leader; the skilful artisan; the inspired humanist; the venturesome economic manager; the intellectual genius." There are numerous examples of such heroes in Africa's past such as the architects of the Pyramids and Great Zimbabwe Monuments, military strategists like Shaka, the Zulu warrior and the great traders of Timbuktu.

What Can We Learn From Successful S&T in Other Societies?

In considering the potential for economic development based on scientific advancement, a country in the process of becoming established in the global economy should put in place policies which will enable it to assess areas where it has some inherent advantage and concentrate on exploiting this advantage to the benefit of the community as a whole. At the official opening of the First National Forum for Science and Technology Dialogue in November 1997 held in Harare, the Minister of Higher Education and Technology for Zimbabwe noted that the Asian Tigers (South Korea, Taiwan and Singapore) started their development process at positions similar to that of most African countries. The success of the Asian tigers is attributed to intensive use of science and technology and the development of explicit policies for the importation, adaption and diffusion of S&T. As alluded to earlier many African countries acknowledge the importance of S&T in the development process and even go further and set up institutions and committees to deal with the issue but do little in putting together an implementable S&T policy.

In the United States there are numerous local examples where industry has sprung from research enterprises, such as the Silicon Valley in California and the Research Triangle Park in North Carolina, among many. Currently in Israel a major industrial complex is developing around the nuclear research facility in the Negev. In the African continent itself we should take special note of the management of S&T in countries such as South Africa which is currently reviewing its S&T system to reduce the disparities of a dual economy inherited from the apartheid era. The country is concerned with the establishment of a dynamic national system of innovation which addresses questions on the

optimisation of R&D investments through identification of core technologies linked to national goals. Unlike most African countries South Africa has got credible national institutions involved in R&D such as the Centre for Scientific and Industrial Research (CSIR) that are producers of new intellectual property or innovation. Other African countries which are serious in science–led economic development may find the experiences of South Africa appropriate in trying to build on their own past experiences in S&T to benefit economically in the world stage.

The Challenges for Science Led Development in Zimbabwe

Zimbabwe, is one of the African countries that recognizes the importance of science and technology in the development process and the need to initiate debate on S&T among stake holders.
Three key questions for the country are as follows:

a. Whether policies, organization and implementation strategies of the countries we wish to emulate allow cross country comparisons.
b. Whether such cross country comparisons supplement and enrich the information and insights generated by our own research effort.
c. The extent of transferability of strategies found to work elsewhere.

Whilst government recognises the importance of science and technology it does not have a blueprint for S&T. Thus in spite of having strong S&T institutions (ie Scientific and Industrial Research and Development Centre, National University of Science and Technology, Development Technology Centre); creative R&D programmes (such as the Blair Research Laboratory's public health technologies in the Water and Sanitation sector, The Department of Research and Specialists Services' On –farm research programme and the Regional Tsetse Control Programme); an active private sector (eg the Agricultural Research Trust); and interested policy makers (Research Council of Zimbabwe in the President's Office), there are weak linkages between these institutions and the country still needs to formulate an explicit S&T policy for implementation.

In spite of the above limitations, Zimbabwe is one of the countries in Africa that has set up research councils and institutions to undertake S&T. The Agricultural Sector is the most supported in terms of S&T activities in Zimbabwe. This has led to a fairly competitive and productive agricultural sector (at least by African standards), and the fruits of research and development have been utilised effectively by the agricultural industry making it the mainstay of the economy both in volume and value terms. However leading economists such as Professor Tony Hawkins fear that deteriorating infrastructures, declining governmental institutional capacity and the land redistribution policy will severely damage the country's competitive position. Therefore, Government must understand what is at stake and undertake remedial steps urgently to prevent further deterioration of the situation with dire consequences on the economy and the external debt crisis. By the standards of sub Saharan Africa one of Zimbabwe's strength is its large and diversified private enterprise sector with a sizeable pool of skilled managers and professionals.

Basically science and technology efforts involve responses to new talents and demands as well as changes in the needs of society. Science–led development in Africa should reduce replication of foreign technologies to avoid over–dependency on external S&T at the expense of developing domestic human and technical resources. Therefore Zimbabwe must promote an active, locally based, locally motivated scientific community supported by career opportunities and stable conditions to develop and seize these opportunities. There must also be a well developed agricultural and industrial sector which can capitalise on and exploit the benefits of research. In the first instance, agricultural production would seem to be the best option for expansion and later for industry to become involved in the processing of products of the collaboration.

Synergy in S & T

a. Focusing on Strengths: *Pareto's Law*

PHS Johnson, (1994) *Zimbabwe Science News* 28: discussed an interesting principle which he called Pareto's Law: Essentially it says that you should concentrate on what you do best. "The principle of comparative advantage provides the traditional case for unbalanced growth. By specializing in those sectors in which it has the greatest comparative advantage, a country can achieve the most rapid growth in the short run. Its potential for growth is certainly not equal in all sectors of the economy" R. Lipsey *An introduction to Positive Economics* stressed the importance of maintaining a competitive edge to start the process of economic development.

Johnson demonstrated that the law applied in Zimbabwe in the production of crops. He showed that a selected small fraction of planted areas (generally 20%) accounted for a disproportionally large (approximately 80%) share of the entire output of the total area planted. For investment of scientific input it would therefore be best to concentrate on the 20% of major producers. Johnson showed that for the years 1987 to 1992, an average of 84% of cotton production came from the top 20% of Intensive Conservation Areas (ICA's) producing cotton. When tested for 5 crops, cotton, maize, soybeans, tobacco and wheat, the top 20% of ICA's consistently produced approximately 75% of the total yield from each crop.

Pareto's Law gives government policy makers and commercial companies interested in marketing of crops the opportunity to evaluate where they should spend time, money and energies in future. Consideration should be given to channelling efforts into those areas which will yield the greatest returns. This is essentially the same policy that one sees in the collaboration between science and industry the world over.

b. Encouragement of Social Capital

For this discussion there are two important components of social capital, the innovators who are scientists and the producers who are the commercial farming community. Scientists constitute a significant portion of the nation's social capital and to be productive the individuals must feel confident in their careers and supported by the society. Branscomb (p.1 vol 798) stressed economic and political atmosphere conducive to science is necessary to reap the benefits of scientific endeavour. Government should facilitate this process. The best way to create opportunities for productive scientists is to demonstrate that career opportunities exist over the long term and by encouraging competitive grants programmes reward appropriate investigation with financial support based on output. However, the loss of these personnel drains science as a career, particularly when there is a breakdown of 'critical mass' for scientific productivity or when political expediency or “fiscal extortion” intervenes to destroy morale.

The producers, whether they be agriculturalists or manufacturers should be encouraged to invest their efforts through a secure and competitive atmosphere. People should be confident of a sound fiscal policy and minimum interference from administrators. There must also be a community of experienced farmers to put into practice the products of research. These assets must be nurtured. The role of government in this effort is crucial and should be directed to encouraging long term stability both for the scientific manpower and a supportive, unobtrusive atmosphere for those industries which can benefit from the input. There is no role for political expediency or short term inopportune upheavals in such developmental processes. Both science and industry can flee an intrusive government, and it is very difficult to cause them to return.

Government based research (Scientific Civil Service) should be goal orientated, with goals set by society needs and with local funding. However, these personnel too, should be encouraged to apply for grants through competitive applications. Previous governments of this country realised the importance of

scientific research and encouraged and supported an infrastructure of scientific research both in agriculture, veterinary science, health and in other fields.. The Zimbabwe Scientific Association established in 1899 was the first scientific body in Southern Africa and gives evidence to the early creation of a viable community of scientists from various disciplines who developed local interests. Subsequently after the World War II, agricultural research became a priority, the results of which were very encouraging and have helped the industry become a leader in agricultural productivity in Africa.

c. Setting Priorities

How can priorities be set in Zimbabwe to support S&T endeavours? For science–led development the goals should be responsive to:

- national priorities in agriculture, health delivery, medicine and other issues relating to the specific needs of the society.
- industrial and economic issues relating to the national economy. These goals should be set up and paid for by the users with additional national and international support.
- bilateral and regional opportunities for research funding. Here priorities may be set by international funding agencies, regional institutions and through exchange of ideas and funds.

Many scientists believe that it is not proper to prioritise innovation and it is more important to come up with a sound science and technology policy–making framework to guide the country in its national system of innovation. In the past the best solutions to local problems have been produced by local experts. Even colonial governments had a progressive attitude to supporting local research, particularly agricultural research which they considered on a long term basis and for which they provided stable funding and a conducive scientific environment. The products have shown the benefits of fostering country specific research in response to local problems of the country.

Some Country Specific Examples of Science Led Development

a. Agricultural Research

Firstly, a country needs the institutions for S&T if it is to foster a tradition of science led development. In 1997 there were about 31 R&D institutions in the agricultural sector with the majority being publicly funded institutions.

- The Agricultural Research Council
- The Department of Agricultural and Extension Services (Agritex)
- The Institute of Agricultural Engineering
- The Department of Veterinary Services (incorporating the Central Veterinary Research Laboratories and the Tsetse Control and Research Branch)
- The Department of Research and Specialist Services (DR&SS) that incorporates the Research Services Division, the Crop Research Division and Division of Livestock.
- The Agricultural Research Trust (a private research institution)
- The Tobacco Research Board
- The Pig Research Board
- Cotton Research Institute

Hybrid Maize: Zimbabwe pioneered the development of hybrid maize in Africa (Rattray et al 1962. Rhodesia Agricultural Journal 59: 166–168). Rattray belatedly obtained the premier presidential award for outstanding contribution to the agricultural sector in 1997. The product of hybrid maize research yielded a number of excellent varieties which did well in high rainfall areas. Further research in this area resulted in the development of specific varieties of high yielding maize (SR–14 and SR–52) described by Alvord et al. 1967. Rhodesia Agricultural Journal, 64: 135–139. This hybrid maize research not only exemplifies major advances in crop science with tremendous advantages to local agriculturalists but shows that local scientists can undertake research of international repute. The industrial sector in Zimbabwe has benefited

from this research and local companies notably the *Seed Coop (Pvt) Ltd* have successfully entered regional markets with seed products developed in the country.

Maize Production: Another example is given with focused research on maize production. This was done by optimizing fertilizer applications, improvement in varieties of maize available, including hybrid seed produced in the country, increase in plant population densities and earlier planting dates as well as improved techniques of pest and weed control. This led to a 312% increase in national average yield of maize production, from 1 146 kg/ha in 1946–50 to 4 725 kg/ha in 1976–80. (JR Tattersfield 1982: Zimbabwe Science News, 16: 6–10).

Wheat Research : The research was in response for the need to produce varieties of wheat suitable for local conditions and resistant to local pathogens and which would be suitable for bread and baking. The building of dams in the south east lowveld to open up large scale irrigation projects allowed for winter production of wheat and increased the potential of this crop. Yield of wheat in 1980 increased 358% over 1950 levels (JR Tattersfield, ibid). The release of 3 new wheat varieties was announced by Edwards et al., 1967 (Rhodesia Agric. Journal, 64:51).. These were resistant to rust, were short stemmed and not susceptible to water logging. Later work by Edwards (1971) focused on one major variety, Hunyani, for optimal yield and profitability. Development of these varieties enabled the country to reduce imports of wheat and save foreign currency a desirable situation both during the *UDI colonial era and today when the country is undergoing major economic reform programmes to improve its balance of payments position*.

Tsetse Research : Trypanosomiasis has been a major constraint on development of certain regions of the country endemic to this disease. Additionally the tsetse flies were voracious feeders and caused a considerable nuisance to the people. The work of a series of local scientists including Vale (1993) J. Medical Entomology 30: 831–842, have reduced the tsetse fly problem to very low levels in the Zambezi lowveld of north east Zimbabwe. This has had a major impact on the development of recreational eco–tourism along the reaches of Zambezi river earning the country millions of dollars every year. The reduction of trypanosomiasis in the region has also permitted the introduction of domestic livestock and human resettlement in large areas of the Zambezi basin. The programme has been so successful that the European Union has provided aid since 1990 to extend the control activities to cover Mozambique, Malawi and Zambia, other countries in the basin that are affected by the tsetse fly menace.

b. Health Research

The scientific support system in the Health Sector is well developed and there are several research and technical laboratories linked to the health delivery system. The public sector dominates in R&D in the health sector and supports the majority of key institutions in the country.

- The Ministry of Health's Blair Research Institute (which incorporates 11 research thrusts in vector borne diseases, communicable and infectious diseases and health systems and public health technologies).
- The Medical Research Council of Zimbabwe, a statutory body which coordinates all health research in the country and promotes Essential National Health Research (ENHR) and Institutional Ethical Review Committees (IERCs) as a strategy for sound research for health development.
- The University of Zimbabwe Medical School which has the major concentration of health professionals in the country and is involved in clinical work, research and education of medical personnel.
- Technical Units of the Ministry of Health which include *Epidemiology and Disease Control, Government Analyst Laboratory, Zimbabwe Regional Drugs Control Laboratory, Public Health Laboratories, the National Blood Transfusion Services and the Zimbabwe National Family Planning Council.*
- The Biotechnology Research Institute of the government supported Scientific and Industrial Research and Development Centre (SIRDC)

- The Harare based Biomedical Research and Training Institute for the Southern Africa Development Community which is a centre of excellence for biomedical sciences and training.

A few examples of successful technologies below illustrates the need to carry out R&D work in the user country if the end product is going to be of maximum benefit to the local population.

Malaria Research: The malaria eradication programme of the 1950s was based on a scientifically managed operation which virtually eliminated malaria from the south eastern lowveld, which was then opened up for irrigation. This led to the huge and profitable sugar estates and farms which developed a strong export industry. Zimbabwe is one of the few countries in Africa to run a research–led sustained and successful National Malaria Control Programme over four decades. The Blair Research Laboratory supports this programme through R&D on transmission patterns of the disease, in depth knowledge of the behaviour of the vector mosquitoes, assays of parasite drug resistance and locally developed and operated scientific control methods. The available research expertise has enabled the development of a control programme which is relevant to the local situation and is economically feasible.

Public Health Technologies: The development of the low cost and appropriate *Blair ventilated pit latrine* in the early 1970 's by Dr Peter Morgan of the Blair Laboratory promoted a massive rural sanitation and health education programme in the 1980's which allowed millions of peasants in the country to have access to safe and affordable household latrines for the first time. The *Bush Pump* was designed by the government irrigation department in 1934 and later improved by Dr. P. Morgan to make it the best and most successful means of obtaining water from deep wells and boreholes in arid communities. It has provided the basis for industrial development and a local industrialist builds and exports factory versions of the Bush Pump which go hand in hand with another locally manufactured health technology: *the Von der Rig* for manually drilled boreholes.
Basic health facilities in rural areas are essential for sustaining rural development as without these it is not feasible for the public to take advantage of the process of innovation.

Maximising the Eureka Factor

Local discoveries and their exploitation on behalf of the society cannot proceed without the dedication of local scientists. From experience in Europe and the USA, it is clear that the preceding condition is essential to promote scientific creativity. To maximise the *eureka factor* in S&T development, there should be put in place a national system of innovation that incorporates highly motivated scientists, adequately funded and functioning S&T institutions, organisations and policies which will blend together in a constructive fashion with the aim of meeting common social and economic goals.

The following issues are important in this process:

a.Government should facilitate the development of an explicit S&T policy formulation through consensus by involving all stakeholders which includes scientists, end–users of S&T, the public, policy and decision makers. The establishment of the SIRDC was in recognition of a *gap in the industrial S&T sector* where there were no coherent scientific support systems.

.b.Government should establish mechanisms for it and the private sector to utilise the existing S&T systems and R&D programmes more fully in order to strengthen and support them by providing suitable infrastructure and conditions of service to encourage scientists (especially those in the publicly funded institutions) to dedicate themselves to carry out research in their areas of expertise and appropriate to their normal activities.

c.Universities and research institutions should encourage the development of career structures and competitive remuneration scientists and thus help in the reversal of the brain drain.

d.The United Nations Development Programme (UNDP) and other development and academy agencies such as the New York Academy of Sciences should promote international fora where S&T issues are discussed in the context of north–south partnerships and where feasible facilitate the

negotiation of venture capital to enable African scientific entrepreneurs to apply themselves and benefit according to their productivity.

e.Research institutions and councils should cooperate and develop S&T databases and link these with existing ones to minimise duplication and facilitate their use. The research institutions should create electronic web pages and other information technology exchanges to highlight their core competencies, technical and manpower base to facilitate linkages with other research institutions and as a window for potential profitable transfer of intellectual property to industry. S&T should be popularized among the public, industry, scientific community and policy makers through round table discussions, seminars, science fairs, competitions, introducing television and radio programmes especially aimed at the youth and through syndicated newspaper columns.

f.Government must ensure peaceful resolution of society disputes, ensure that good relationships are maintained with international funding agencies and negotiate bilateral assistance programmes which will benefit the local science community.

Conclusions

The discovery of new and innovative material to help with economic development is based on an active, motivated scientific community base and that is committed to the country. However, most developing countries, particularly in Africa have been losing trained scientific personnel to the more developed nations primarily in search of opportunity for research in a safe and sophisticated environment, as well as better remuneration for active research. In Amin's volatile Uganda nationalisation of productive industries and farming enterprises led to a sharp decline in productivity. Since most economies of Africa are based on agriculture it is clear that without a sound base in agriculture, the products of research will fall on sterile ground.

It might be pertinent to conclude by referring to an article in the Zimbabwe Science News 27:1993. by Nesbitt; *Biodiversity, Science and the Dry Season.* As food to nurture the nestling and fledging nation of Zimbabwe, he stressed the importance of skills, environmental protection and development. For science led development Zimbabwe needs a long term policy which is orientated towards stability and development; career opportunity, funding for research and personal initiative. Support for local scientists by government in the form of public recognition and material incentives will create a conducive environment for science development which will allow the fruits of S&T work to benefit the country. The solutions to weak policies on S&T and economic development are not short term and cannot be solved by *the International Monetary Fund(IMF)'s* inspired economic reform packages. Rather the country requires refocused long term science led development and the revival of the entrepreneurial spirit of Zimbabweans who have already demonstrated through past successes that it is possible to improve the standards of living for the majority of inhabitants in this country.

Dr. Clive Shiff
Associate Professor
Department of Molecular Microbiology
and Immunology
Johns Hopkins School of Public Health
615 North Wolf Street
Baltimore, MD 21205
U.S A.
tel: 410-955-1263
fax: 410-955-0105
email: cshiff@jhsph.edu