Duplicate

Baseline Information on Technology-Oriented Initiatives in Rural Areas to Promote Economic Development

Final Draft

by

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1 Introduction

Just less than half of the South African population resides in rural areas, however it is widely recognised that a disproportionate share of rural people are poor, and a disproportionate share of the poor are rural. It is also generally recognised that the fight against rural poverty must be multi-pronged. The Department of Science and Technology (DST) is perpetually seeking to define and refine its contribution to this collective effort. Among other things, as the custodian of the national system of innovation, DST is seeking to ensure that technology is harnessed towards the objective of rural development.

One particular initiative of DST in this respect is the creation of a South African chapter of the African Institute for Capacity Development, i.e. 'AICAD-SA'. Broadly speaking, AICAD seeks to achieve poverty reduction by means of promoting the utilisation of existing and new knowledge and technologies, including local and indigenous technologies, in part by facilitating the sharing of information. Up to now, AICAD has involved the participation of only three countries in East Africa. Although in the first instance AICAD-SA is focussed on South Africa, in effect it sows a seed of AICAD in Southern Africa as well.

One of the first steps DST has identified towards making AICAD-SA a reality is to establish what is presently happening by way of technologically-oriented poverty reduction initiatives in South Africa. Having a clear picture of the status quo will assist DST to figure out how it should position itself to make the greatest possible difference in the fight against poverty. What are the gaps? What is relatively well covered? What is the scope for information sharing? What difference is presently being made?

The present report seeks to provide some answers – albeit partial – to these questions, with a particular focus on rural areas. The report assembles various pieces of information and analysis regarding contemporary, programmatic attempts to promote rural development in South Africa by means of technology. The emphasis of the exercise was specifically on the development and/or transfer of technologies that seek to address poverty by means of supporting productive activities.

The report is built upon two main exercises, namely a literature review and an audit of technology-oriented initiatives aimed at economic development and poverty reduction in rural areas.

The literature review sought to identify recent trends, current debates, and 'state-of-the-art' in respect of selected sectors. It drew on both South African literature as well as literature related to experiences elsewhere in Africa and the world. In principle, it was also meant to make use of local grey literature, e.g. unpublished evaluation reports, but in practice few of these were found.

The audit consisted of an attempt to identify as many initiatives as possible within rural South Africa that fit the description of "technology-oriented" initiatives, and then to populate a database on such initiatives in such a manner as to build a comprehensive idea of the scope of such activities. Meanwhile, in the course of sourcing this information – mainly from those institutions responsible for their implementation – semi-structured interviews were conducted in order to elicit views from practitioners as to what is working well and what is not working so well.

The sectors that were the focus of both the literature review and the audit were:

- Agriculture
- Small-scale mining
- Manufacturing
- Information and Communication Technologies
- Energy, and
- Environment.

The findings are fairly uneven. This is due to methodological problems experienced. It was not always possible to secure interviews with the relevant representatives. Also, the interviewees in different provinces were not always of the equivalent status, with the result that very different types of views were expressed. Sometimes the 'responsible person' proved to have little knowledge about what happens in their department or organisation in terms of technology transfer.

The balance of this report consists of four sections:

- Section 2 provides a broad perspective on technology for rural development, including debates regarding the efficacy of using technology as tool for development.

- Section 3 presents a statistical profile of the programmes identified through the audit.

- Section 4 presents analyses the issues in respect of each of the selected sectors, drawing on the literature review, example programmes encountered in the course of conducting the audit, and perspectives from interviewees.

- Section 5 concludes by means of reflecting on a number of key themes that emerged in the course of conducting the study.

2 Broad perspectives on technology for rural development

2.1 Introduction

Although South Africa's economic growth has been growing consistently since at least 1996, this growth has not been able to make significant impact on reducing poverty and unemployment. Rural poverty and unemployment in particular continue to grow and spill into the towns and cities of the country. To this effect, technology is seen as an economic impetus to reduce poverty and unemployment in the rural areas. In line with the rest of the world, South Africa is committed to the Millennium Development Goals (MDGs) of the United Nations as adopted in the 2000 Summit to have extreme poverty eradicated by the year 2015. The Millennium Development Goals require that countries develop their own strategies, with coherent policy support, to direct more resources towards the creation of a level field for rural development initiatives to improve livelihoods. All the Millennium Development Goals are essentially underpinned by technology and innovation. The improvement in human welfare as for example seen in the developed world is principally a result of developments in technological innovations. The innovations have led to better healthcare, nutrition, agriculture, lower mortality rates and longer life expectancy among other things. Innovations have led also to the growth of business. To sustain these achievements, the developed world has placed great emphasis on developing indigenous expertise as a base without which the industries cannot grow and the economy cannot benefit from technology (Juma et al. 2005).

In this part of the report we look broadly at few areas in relation to technology transfer. Firstly we address the policy environment as this is a very critical area. Without positive supportive national policy it is almost impractical to achieve anything. Secondly the importance of technology in stimulating and sustaining economic growth and poverty reduction is brought to the fore. Thirdly, South Africa is compared with other countries in the SDAC region. We point out here that the comparison may be unfair as South Africa is considered an economic powerhouse not only in the region but continentally. To close this section, we point out that technology is not without criticism. That technology transfer should not be taken at face-value as it has some serious underpinnings for the developing countries in particular.

2.2 Policy environment

The concept of policy environment covers a wide area of policy or governance. It refers to constitutions, legislative, regulatory and administrative norms and procedures. For the purposes of this study, we would like to look at those institutions that are created to make technological advancement possible. Institutional involvement is demanded by the fact that economic development generally is not easy to achieve because of political interests. In the first place, economic development happens with the support of governments using public funds sometimes to assist individual businesses. This attracts a lot of criticism from opposition parties and interests groups. Governments are accused of either corporate welfarism, i.e. protecting the industry or of interfering with the economy. Having said that, intervention by governments is important. Harrison (1998) explains this importance thus:

> *As much as innovation and creativity are at the root of social progress, governments bear primary responsibility for progress in specific economic sectors. To this end, creativity and skill on the part of government policy makers play a crucial role in economic development.*

In Tanzania, The Tanzania Commission for Science and Technology Act, 1986 was passed to manage technological advancement. Under this Act, a number of governance structures were created (or those that were in existence were brought under this Act), such as the (UNCTAD 2003):

- Centre for the Development and Transfer of Technology
- National Fund for the Advancement of Science and Technology
- Tanzania Award for Science and Technological Achievement
- Tanzania Bureau of Standards

Kenya is another country that is working hard to introduce technology in her life. But unlike Tanzania, Kenya has does not have institutional mechanism to drive science and technology. However, she does have policy-making structures like the (UNCTAD 2003):

- Ministry of Education, Science and Technology
- Ministry of Tourism, Trade and Industry
- Ministry of Labour and Human Resource Development

Botswana has also been working hard in her attempt s to prioritise technological capabilities in rural areas. The Botswana Science and Technology Policy was approved by that country's parliament in 1998. The Policy covers thirteen key sectors of the economy, namely: Agriculture, Forestry and Fisheries, Commerce and Industry, Education and Human Development, Energy, Environment, Health, Meteorology, Mining, Tourism, Population Planning and Human Settlement, Transport and Communication, Water, and Wildlife.

Outside Africa, Japan represents one of those countries that became industrialised because of the realisation of what technology can do for a country. Fransman (1997) indicates that the Japanese government took a conscious decision to play an important role in building the country's science and technology base. The Japanese government got involved for two major reasons, namely:

- Market failure – Firstly private companies are not willing to undertake research where the risks are high, and they may have impact on the profits, and secondly the size of investment required is too large, it may deter private companies from investing;

- Basic research – The government feels it is crucial that it strengthens its capabilities in basic research. The Science and Technology Agency as well as the Ministry of Education, Science and Culture are entrusted with the task of ensuring that this objective is achieved.

It is easy to understand this objective. The Japanese government lags behind in terms of its contribution to science and technology expenditure at 18.6% compared to her major competitors like Germany (33.2%), USA (46.1 % and France (49.3%) (Fransman 1997).

Similarly, faced with the growing problems of poverty and unemployment, the South African government is very clear about the roles it requires and expects of technology to achieve. Some of these are (FRD 1998):

- Improving the productivity of the economy
- Promoting national development
- Employment creation
- Creation of a society that embodies technology
- Ensuring competitiveness globally
- Capacity development

The South African National Research and Development Strategy (2002) recognises technology as paramount in the creation of wealth and economic growth. The Strategy document explains that currently technology contributes about 10% to economic growth and by 2012 this contribution could be between 25% and 30%. These figures confirm what Fedderke (2001) (see HSRC 2004) found that technological change is uncontested as a driver for macro-economic growth in South Africa. Fedderke estimates that in the 1990s, the contribution of technological change to growth was about 2.5 times as great as that of capital. In South Africa various bodies are involved in transferring technology to the rural areas. These are government (various departments), public bodies (e.g. CSIR, Mintek), universities, NGOs and the private sector. There is therefore a need to find out what these organisations have to tell us in order to understand the extent of technology transfer in rural areas.

To this end South Africa, through the Department of Science and Technology, has in place legislation that aims to provide policy directions in terms of what needs to be achieved. Some of these policy documents are:

- National Research and Development Strategy
- Academy of Science of South Africa Act
- Science and Technology White Paper
- Natural Scientific Professions Act
- National Advisory Council on Innovation Act
- National Research Foundation Act

To ensure technological innovation is successful, DST is also leading other government departments to implement technology through the following programmes:

- **Science and Technology for Economic Impact** supports science and technology interventions that require interdepartmental and government-industry cooperation. These interventions aim at achieving economic growth and government's development objectives.

- **Science and Technology for Social Impact** supports science and technology interventions that require interdepartmental cooperation for addressing identified priorities in sectors such as health, agriculture, and the Millennium Development Goals.

- **The Sector Research and Development Planning** supports sector-based departments and institutions to develop five-year R&D plans. This Sub-Programme annually prepares a National Science and Technology Expenditure Plan that provides a holistic view of science and technology spending by government.

To conclude this section, it is crucial to note that the diffusion of technology to poor rural areas requires concerted efforts on the part of the policy makers to ensure that it reaches the poor. It would be meaningless for example to expect small farmers to adopt a particular technology when extension services are poor or even not available. It would also be a futile exercise to persuade the private banking sector to grant credit to people that have no secure land tenure, or poorly defined property rights simply because the aim is to introduce some advanced irrigation schemes. The same applies to the fact that governments wish for universal literacy which could help people for example to access many forms of information and communication technologies, but the same governments show little commitment to fighting illiteracy.

Rural productivity is the key objective to introducing technology in those areas. But technological transfer alone cannot make a dent on poverty if the infrastructure and markets are not developed. It helps very little for example to ask farmers to produce more when they have no where to sell the produce, or the means to get there. It is the responsibility of governments to ensure that the relevant infrastructure is in place to support and encourage productivity.

2.3 The importance of technology for poverty reduction

Our investigation looks specifically at productive technology that is used either by individuals or small, micro and medium enterprises (SMMEs) and or a combination of both. But how do we understand the term 'technology'?

Wallender (1979) defines technology as

> *"...any tool or technique, product or process, physical equipment or method of doing or making, by which human capability is extended" and in "simplistic terms technology is knowledge".*

To this end, this author categorises technology into specific types as: 1) general knowledge which is freely available to everyone as in books; 2) industry-specific knowledge that all firms in an industry use; 3) system-specific knowledge required in order to produce a specific product. This kind of technology may be possessed by a single firm but could be adopted by others; 4) firm-specific knowledge which a particular firm may use but not used by others in production of a product, and 5) on-going problem-solving capability which is representative of unique experiences in solving production and process problems on on-going basis. As such, a *new* technology can relate to innovations in respect of product, process, services, support technology, or institutional strategy, because one or more of these innovations could contribute to sustenance and comfort, or the 'objects' that produce them. In other words, both 'hard' and 'soft' technologies and innovations are recognised, or more accurately the fact that most technologies encompass a range of hard and soft aspects (HSRC 2004).

In this regard, technology can be categorised in the following ways:

- *Process* technology which leads to higher productivity or improved quality of a product;
- *Product* technology which creates new products, and
- *Transaction* technology that facilitates co-ordination, information sharing and exchanging among market participants.

Concerns about the use of technology in rural areas indicates that South Africa has entered what is termed the fourth generation of technology. Briefly, Galbraith (2005) describes these phases in the following way. The first generation of technology took place in the 1960s and was characterised by the broad commercialisation of the integrated circuit. This was followed by massive productions in for example digital watches, electronic calculators, minicomputers. In the 1980s a new generation appeared. This period also represents the time of maturity for the first generation technology. At the same time new technology appeared in the form of biotechnology, medical technology and information technology. This kind of technology was mainly in the cities where sophisticated social and economic infrastructure and progressive governments were in place. These places managed to attract the brilliant young university graduates, engineers and technical workers. The third generation appeared in the 1990s. It consisted in those firms that got driven by a very few successful individuals who located their business in mid-sized areas of the USA among their own communities. The fourth generation of technology takes place in rural and small community areas. This process allows rural communities the opportunities to take part in economic development that is technology-driven.

Generally, technology is regarded as critical to economic development. In the context of Africa, the Organisation of African Unity (OAU) was unequivocal in its insistence on expanding technology into the remote rural parts of member-countries. The Organisation was very alive to the achievements of the developed world in terms of science and technology. In its Lagos Plan, the OAU stated that:

> (a) Member states should direct their efforts to spelling out a strategy for development which should guide their thinking, planning and action on bringing about socio-economic changes necessary for improving the quality of life of the majority of the people. This objective requires them to invest in science and technology resources for raising African standards of living and for relieving misery in the rural areas.
>
> (b) Attention should therefore be paid to the role of science and technology in integrated rural development. This would require, among other things, the generation of financial resources and political will and courage on the part of policy and decision-makers of the continent to induce a profound change with far-reaching effects on the use of science and technology as the basis of socio-economic development as a matter of the utmost importance and urgency at this fateful juncture of history.
>
> (c) Member States should, therefore, adopt measures to ensure the development of an adequate science and technology base and the appropriate application of science and technology in spear-heading development in agriculture; transport and communications; industry, including agro-allied industries; health and sanitation; energy, education and manpower development, housing, urban development and environment.

At the level of the UN, the 1992 Rio de Janeiro Summit through Agenda 21 as well as the Johannesburg 2002 World Summit on Sustainable Development (WSSD), technology is seen as a critical means to implement sustainable development. The WSSD in particular was very specific in calling upon governments to take decisive steps towards the implementation of Agenda 21. These conventions recognise the fact that even the Millennium Development Goals, particularly the first one on eradication of extreme poverty; depend a great deal on countries becoming knowledge-based (Juma et al. 2005).

The other point to consider is the manner in which technology is transferred. Specific methods have been used particularly in technology transfer that involves countries. The methods are (Mowery & Oxley 1997):

- Direct foreign investments (DFIs)
- Joint ventures
- Strategic alliances
- Technology licencing
- Embodied technology transfer.

The multiplier effects of technology are wide: the development of new products and processes are realised faster than otherwise, this leads to new businesses being established and the improvement of the quality of life of the people as job opportunities are created. Sustainability is ensured because the economy becomes competitive in the global arena. It changes the ways in which business is conducted. At local level, technology provides people with easy access not only to private but also to the provision of public services. In essence, a knowledge-based society is in an advantageous position. Harrison (1998) sums this attitude as follows:

> *If the society's world view encourages the belief that humans have the capacity to know and understand the world around them, that the universe operates according to a largely decipherable pattern of laws, and that the scientific method can unlock many secrets of the unknown, it is clearly imparting a set of attitudes tightly linked to the ideas of progress and change…*

Technology transfer has proved to be an engine for economic growth particularly in the newly industrialising countries (NICs). In the table below, we show how economic growth has occurred in the countries listed as a result of technology transfer.

Table 2.1: Growth in output and total factor productivity in nine Asian economies, 1970 – 1980

Country	Annual growth rate %	Total factor productivity %
Hong Kong	9.6	21.3
Indonesia	7.7	31.5
South Korea	8.5	41.2
Malaysia	7.8	21.7
Philippines	6.2	20.6
Singapore	9.1	19.7
Taiwan	8.5	50.0
Thailand	6.9	19.7
India	3.0	0.2

Adapted: Mowery & Oxley, 1997.

Expanding technology to rural areas also has many advantages. Among these, Juma et al. (2005), mention:

- Increased rural incomes
- Meeting market demands
- Better living rural environment
- Capacity building
- Further spread and promotion of appropriate technologies
- Facilitation of social stability
- Improved conditions of women

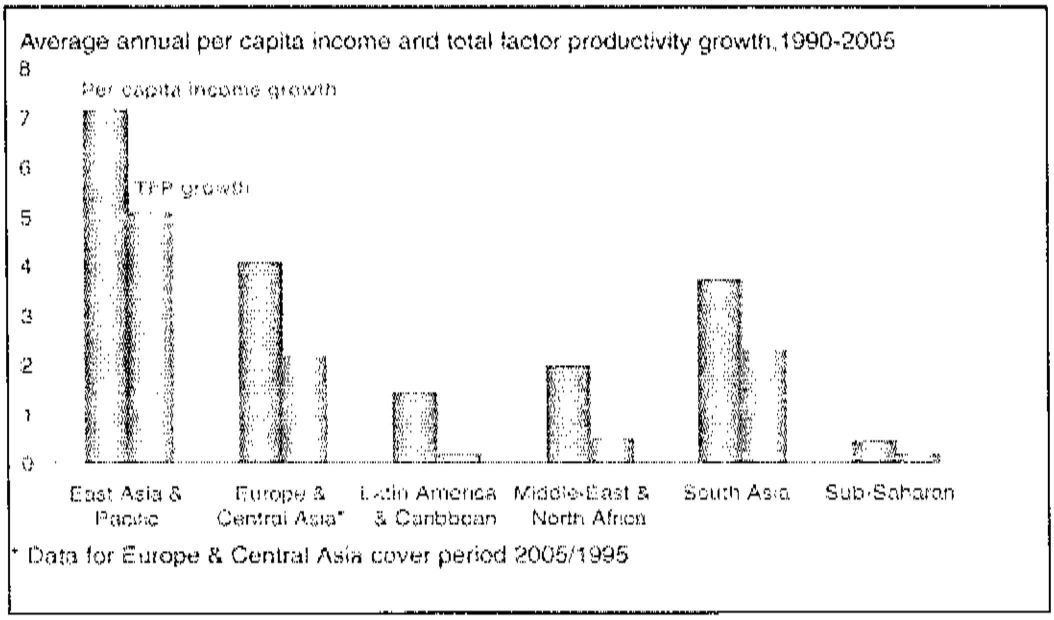
Notwithstanding this, there are other challenges with regards to rural areas. Chiefly, there is concern that rural areas are slow in adopting even the available technology for a number of reasons. Among these challenges is the question of financing. South Africa's ambition for a knowledge-based society depends more than anything on the ability to finance that ambition. The country has a large rural based community. This base consists of both the few rich commercial and mostly poor subsistent farmers. According to Karekezi (1992) poverty is the key obstacle on the successful introduction of technology in rural areas. These rural people are not able to raise the required money to invest in the technology that is being introduced. Through the land reform policies many previously disadvantaged people have entered the field of commercial farming. Recent studies relating to land reform that we have conducted indicate, however, that these emerging farmers in partcular struggle to secure loans with commercial banks. The conclusion is that without finance, these farmers will never be able to rise to the technological level required to be productive and therefore promote growth. To this end, Juma et al. (2005) suggest various ways which governments can adopt to assist farmers with financing. The first is public funding itself. Governments will remain the key funders for a foreseeable future because the private sector is reluctant to invest in areas they are not certain about. The second is government-guaranteed loans with the commercial banks and thirdly is the concept of rural banks as used in Australia (www.eldersruralbank.com). Having said this, the governments on their own can never achieve the goals of the MDG. The private sector has a tremendous role to play in the diffusion of technology because in the first place they are the custodians of such technology.

Other challenges can be summarised as follows (HSRC 2007, Pagura and Kirsten 2006 and Jedlicka 1977):

- Lack of leadership and policy direction by government particularly municipalities
- High poverty rates
- Lack of interests by universities
- Personal circumstances of individuals
- Appropriateness of technology
- Insecured land tenure
- Managerial
- Competition
- Infrastructure

The figure below shows a portrayal of the effects of technology on income growth and poverty reduction:

Figure 2.1: Contribution of technology to income growth and poverty reduction



Source: World Bank, 2008

Having said that about rural areas, the impression may be created that people in these areas are resistant to technological progress, or something like that. In fact, people in rural areas are very much open to technological development as much as everybody else. They accept or may even reject a technology based on rational grounds. It may also be that their technology has been given a particular status as 'one of a kind technology' commonly referred to as indigenous knowledge (IK). But these people have a history and still practice some of the following technologies (Hoppers 2006):

- Medicine
- Food security
- Mining and metallurgy
- Tool-making
- Building construction
- Manufacturing
- Handicrafts
- Geology, and
- Water conservation

Hoppers (2006) indicate for example that 80% of the people in the developing world rely on traditional medicines for their health care needs and many more still depend on old age forms of food production to meet their nutritional needs. The problem with these conditions is that the poor have been dealt with unfairly as their technologies have in many instances been stolen and used without proper patenting as there are no intellectual property right to protect their interests. A point in case would be the development of the hoodia as a slimming remedy (www.ageless.co.za).

2.4 South Africa within the Southern African Development Community

According to the SADC Review (2007) the South African economy is the most advanced on the African continent, with a sophisticated financial system that includes one of the top 10 stock exchanges in the world and well-developed physical, telecommunications, and energy infrastructures. As an emerging market in the global economy, South Africa is a leader and a competitive producer of both raw commodity exports and value-added goods, such as motor vehicles.

Even so, the relative position of South Africa is largely a function of its large size, and of the dynamism of its 'modern' ('first economy') sector. In other respects, South Africa is fairly average among SADC member states. The selection of indicators in Table 2.2 gives some indication of this. For 2004, the most rapidly growing economies in the region were among those starting from the lowest base (not least those emerging from years of civil conflict), e.g. Angola, DRC, Mozambique and Tanzania. Other countries performing well were those reaping the benefits of sustained attention to macroeconomic management and sector development strategies, e.g. Botswana and Mauritius. In terms of access to technologies, the picture is equally mixed, and surprisingly uncorrelated to the near-contemporaneous growth figures.

Table 2.2: GDP growth and selected technology access indicators for SADC countries

	Real GDP Growth Rate, 2004 Estimate	Landline and cellphone subscribers, 2003 (per 1000 people)	Internet users, 2003 (per 1000 people)	Personal computers in use, 2003 (per 1000 people)
Angola	12.2%	15.4	2.9	1.9
Botswana	5.4%	371.9	34.9	40.7
Comoros	1.6%	19.1	6.3	5.8
DRC	5.7%	10.8	na	na
Lesotho	4.4%	55.7	9.7	na
Madagascar	4.7%	21.0	4.3	4.9
Malawi	3.6%	21.0	3.4	1.5
Mauritius	4.1%	552.2	122.9	116.5
Mozambique	7.3%	18.6	2.8	4.5
Namibia	4.4%	182.5	33.8	99.3
Seychelles	-2.0%	850.7	140.2	160.8
South Africa	3.7%	410.5	68.2	72.6
Swaziland	2.1%	128.5	25.9	28.7
Tanzania	5.7%	29.5	7.1	5.7
Zambia	4.6%	29.4	6.1	8.5
Zimbabwe	-4.3%	57.8	43.0	52.7

Sources: Global Insight and DBSA 2005

While it is unfortunate that we could not find total factor productivity growth figures for these economies – which probably would have revealed a closer correlation to the growth figures – the suggestion is that the link between technology and economic development may be strong but far from deterministic. Where the link is especially weak is in situations like South Africa, where massive inequalities militate against the poor sharing equally in the benefits of economic growth. In these situations, technology can function in various ways, and does: technology can be deployed to improve the quality of life of the poor, notwithstanding ongoing economic deprivation; it can be used to support and diversify the livelihoods of the poor, in some instances by providing them a structural link to the formal economy that was previously lacking; or – as is very much the case presently in South Africa – it can exacerbate the divide between those who benefit from economic growth because they possess the skills suited to its dynamic sectors, and those who do not.

2.5 Critiquing technology

The development and use of technology in developing countries has had some criticism leveled against it in a number of ways. This is not to say that the critics are against technology being transferred and or used in developing countries but that technology should be adopted and used with circumspection.

Kay (2000) points out that technology is usually owned and controlled by multinational corporations (MNCs) with the aim of earning profits out of it. This profit motive is above the development interests of poor countries. In many instances technology transfer blunts the contradiction between the developed and the developing world in a globalising situation. Globalisation ignores the interests of the poor countries and therefore technology is presented as a "*goodie goodie*" for all.

Castells (1989), Veak (2000) and Vernengo (2004) argue that technological designs are political in nature. The rich countries impose their views on the poor countries in terms of mono-economism, i.e. there is one path of development; namely to follow the rich. To this end, technology creates dependency by the poor on the rich. While technology has increased the capacity of the developed world, the poor are marginalised. The poor have to pay royalties and license fees on top of the debts that they owe to the developed world.

Furthermore, Castells (1989) argues that the developing countries lack what he calls "endogenous capacity" to sustain the use of technology. Since technology has the in-built problem of obsolescence, for example computer software which are appropriate for no longer than two years in many cases, the developing world has to consistently import these expensive software, machinery and parts with no matching exports because they want to be seen as being technologically relevant.

Technology may lead to over-production and surpluses as in agriculture pushing prices down for the farmers (Castells 1989). Farm unemployment increases in spite of the fact that developing countries still depend on agriculture for the employment of much of their labour force. With the introduction of genetically modified organisms (GMOs) in agriculture for example, developing countries have seen increased farm production, but decreasing rural employment as the technology requires less labour. Added to this burden of unemployment is the problem of royalties for the seeds the small farmers have to pay or face prosecution. Above all this is the fact that GMOs pose the threat of destroying the soil such that more and more expensive fertilisers need to be used making the technology unsustainable in the long run for the small farmer. In the final analysis, the poor countries' chances of importing food increase. As the poor become more dependent on technology, the more the international dominance reproduces itself.

Technology makes life easier than otherwise. Machines relieve people from the drudgery of farm work and lead to increase production. On the other hand, for example in agriculture, there is danger of chemicals used in fertilising fields draining into water resources. Rivers and ground water are polluted by these chemicals to the detriment of communities. There is no monitoring of the farming communities that they could only use so much fertilisers in crop production. Mechanisation of agriculture itself increases the emission of carbon dioxide contributing to climate change. Coupled with the acid rain effects, technology in farming can lead to disastrous effects in the longer term.

In the box below, is an extraction from one of the HSRC's report (2007) on technology transfer and observed difficulties.

Box 2.1

By and large the technologies that have been installed on the projects surveyed are well designed, appropriate, and well managed. It must be stated clearly that the team performing this evaluation is not competent to appreciate the finer points of boilers, pots, tunnels, cooling towers, fish cages, etc., but what is quite evident is that the technologies introduced are within the means of the target beneficiaries to use and to some degree maintain (one would not expect them to be able to maintain their facilities fully, any more than most of us are self-sufficient in car maintenance), they are kept tidy and generally secure, and they do the jobs for which they were intended. At least as importantly, one can trace improvements in technology design over very brief periods of time, for example from immobile to trailer-based pots for the distilleries, more durable fish cages, etc. Moreover, an enormous advantage of the distillery system developed by CSIR is its ability to handle any number of different plant species, which has provided crucial flexibility (for example when the Driekoppies project switched from geranium to BP1 on account of the susceptibility of the former to termites), and enhances the projects' viability as they seek to diversify and use the plants to fuller capacity. The beauty of the University of Stellenbosch's fish cages, apart from their relatively low-cost construction (for example, by using standard plastic canisters for buoyancy), is that they tap into a resource that is already there in large numbers, namely farm dams. The Beaufort West hydroponics project, while not necessarily novel, has been built and operated expertly, while adapting to the temperature extremes of the Karoo.

What must be stated emphatically is that South Africa enjoys a tremendous amount of creative scientific talent which, thanks in part to DST, is being usefully channelled to the goal of poverty reduction.

Interestingly, in respect of the essential oils projects, the key technological concerns are not on the processing side but on the agriculture side. Questions about the appropriateness of agricultural technology are by no means specific to DST and CSIR-supported projects, rather this is a theme of relevance to many of government's agriculture-related initiatives. A finding of the earlier DST-commissioned study on technology transfer for poverty reduction was that many land reform projects adopt technological packages that are out of sync with the comparative advantages of beneficiaries as well as the social objectives of the interventions – i.e. they are capital rather than labour intensive.

An illustration of this tension is that of weed control. Three of the essential oils projects visited have serious if not project-threatening weed problems. How did things get so out of hand? There appear to be two factors. First, CSIR as implementing agent does not appear to be certain what is the most efficacious approach for controlling weeds *in the present circumstances*. Up to very recently, it has favoured bringing in local contractors (i.e. white commercial farmers from the vicinity of the project) to apply chemicals through boom sprayers, or failing that, to purchase chemicals that project employees will administer via backpack sprayers. Each of these might be potentially efficacious, but both have run into problems. First, it turns out that on-site project managers have encountered difficulty in negotiating the services of contractors, either because of the cultural chasm that separates them, or because of reluctance of contractors to give priority to doing business with blacks, new landowners, etc., presumably aggravated by the fact that typically the amount of work requested would be quite modest. Depending on the time of year, a delay in getting the contractor in can be very problematic. Second, the careless application of herbicides via backpack sprayers was such that a fair number of geranium plants were killed. Even applied more carefully, spraying does not eliminate the need for manual weeding, though it might reduce it somewhat.

Thus the solution would appear to be a more aggressive application of labour to keep the weeds under control in the first place. Why was this not possible? The answer is not altogether clear. From the perspective of on-site managers, they did not have the discretion to hire the additional casual workers needed to do the work. It may be nothing more than a communication glitch between CSIR and the projects it supports. It is not so much our purpose to recommend that chemicals fall away entirely in favour of manual weeding (nor is it to imply that a particular party is at fault), as to suggest that better communication and flexibility between implementing agents and the on-site project managers would probably assist in sorting out the relatively pedestrian but nonetheless critical technology issues.

Source: HSRC 2007.

2.6 Conclusion

What we have done here is to show that technology is irreplaceable for economic development. While it can be argued whether technology is a panacea for economic development or not, it cannot be argued that it has become fundamental for such development in modern times. Evidence of the fact that the developed world has managed to conquer nature because of technology is beyond imagination.

At the same time, we highlight the fact that although technology has enabled humankind to conquer nature, it has not been able to resolve human relations. Technology has the potential and in fact does lead to conflict between labour and capital as machines replace and displace labour leading to unemployment and underemployment, and at times leading to mis-employment of labour.

In the final analysis therefore, technology should be approached with circumspection. The political leadership should be prepared and able to face the consequences as much as it should be able to take the lead. Within the development context, the question of whether the state should take the lead or not is redundant to the level of irrelevancy. The problems of rural poverty in particular cannot be left to the forces of private capital.

3 Statistical profile of technology-oriented poverty reduction initiatives

3.1 Introduction

The audit yielded a database comprising a total of 245 records. The objective was to make this a database of 'programmes', by which we mean well-defined initiatives related to a particular technology, irrespective of how many projects they subsume.[1] In practice it was not possible to ensure a uniform and precise understanding of 'programme'. The most common example where this presented a difficulty was where a particular technology was being promoted in different parts of the country; most implementers regarded this as a single programme with multiple, geographically distinct projects, while some others felt that these geographically distinct initiatives constituted distinct programmes on the grounds that the technical adaptation process is unique to each. Since technical adaptation is a significant feature of the overall process of promoting the use of technologies for poverty reduction, which after all is the focus of this study, then it was recognised that this ambiguity comes with the terrain. The view of the team was that, at the risk of some inconsistency, it was best to define a 'programme' as per the preference of the institutions furnishing the information.

As mentioned in the introduction, the conduct of the audit was beset with serious problems of getting access to information. The nature of the problem tended to be that the team would learn of a relevant programme or set of programmes, but fail to convince implementers or other partners to share sufficiently detailed information about it. Thus it is a certainty that the 245 records indicated is an undercount of relevant initiatives. While it is impossible to place a figure on the seriousness of our undercount, the impressionistic estimate of the team is that the database contains between 75% and 90% of the actual relevant initiatives out there. Areas where we feel we have most seriously fallen short are agriculture (notwithstanding the fact that as a sector it dominates the database anyway), and ICTs. Moreover, although the bulk of the information captured in the database comes from programmes implemented by government, it is likely that of that which is missing in the database, most are government-implemented programmes.

The team was open to the possibility of capturing information on programmes that have already ceased, and indeed asked respondents about any such programmes, in practice only 29 (12%) out of the 245 records refer to programmes that have terminated, and most of these seemingly within the past few years (the year in which the programme was terminated was not indicated for about a third of these 29). Very likely this is a significant under-count of terminated programmes (not least because to the extent we depended on

[1] This was informed by an earlier attempt by the HSRC to produce a list of technology transfer *'projects'* (HSRC, 2004), the problem being that it congested the database with too many fundamentally identical initiatives, e.g. essential oils projects implemented by the CSIR on behalf of DST.

accessing existing databases or lists, it is not surprising that many of these contained only current initiatives); however, it is also evident that developing, adapting, and transferring technologies for purposes of reducing rural poverty and promoting rural development takes a long time. This will be discussed below, but in the meantime it is necessary to point out that the descriptive tables that follow include rather than exclude the terminated programmes.

3.2 Findings

This section presents a series of descriptive tables that seek to present a profile of technology-oriented, poverty-reduction programmes in rural areas, based on the not-quite-complete audit. The tables do not exhaust the information that is captured in the audit; indeed, some fields captured relatively qualitative information (such as in response to questions about 'achievements' and 'constraints') that is not presented below but in part informs the analysis of the following section.

To begin with, the audit confirms what one might have expected, namely that programmes in the agricultural sector greatly dominate those of other sectors (see Table 3.1). This was to be expected partly on the basis of other studies, but also simply because the audit focused on rural areas, for which agriculture is a common focus for poverty reduction initiatives whether or not there is a salient technological dimension. Whether this suggests that agriculture is over-subscribed is difficult to say; certainly the imbalance of the figures is not enough to conclude that this is the case, though it might well suggest that interventions in other sectors are too few.

Table 3.1: Sector in which programmes undertaken

	Number	Share
Agriculture	209	85.3%
Energy	12	4.9%
Energy and agriculture	1	0.4%
Environment	6	2.4%
ICT	4	1.6%
Manufacturing	11	4.5%
Mining	2	0.8%
All	245	100.0%

Although by definition all of the programmes captured in the audit aim at reducing rural poverty, their more proximate objectives are diverse. Table 3.2 indicates that promoting income generation is the most common objective, followed by enhancing household-level food security. Because many of the programmes have multiple objectives (for example, 100 programmes indicated that they seek to promote income generation as well as food security), the sum is greater than the number of programmes. (The percentages are calculated as the ratio of the number of programmes that address a particular objective relative to the total number of programmes in the dataset, i.e. 245.) The relatively small number of programmes which seek to support service delivery owes to the fact that few programmes in the energy sector were captured; it is worth reminding the reader that the audit did not seek however to cover service delivery issues comprehensively, thus it does not pick up on technologically-oriented initiatives in the housing or water sectors. As for conservation, from the interviews conducted it was generally clear that the conservation programmes captured are not seeking to promote conservation for its own sake, at least not entirely so; conservation is seen as one means of assisting people to improve their food security or incomes, e.g. through better fodder for livestock. This is why there is an apparent discrepancy between the number of projects which identify conservation as at least one of their objectives (26), and the much small number for which the sector was identified as 'environment' (six; see Table 3.1). The majority of programmes which identify conservation as an objective are undertaken by agriculture departments, have the ultimate objective of protecting agricultural resources, and as such are identified as within the agricultural sector; most of the others are the six programmes identified with the environment sector, by a variety of institutions other than departments of agriculture.

Table 3.2: Programme objectives

	Number	Share
Conservation	26	10.6%
Food security	122	49.8%
Income	203	82.9%
Services	8	3.3%

It is difficult to capture the complex nature of work on technology in a database format, but an attempt was made to distinguish different types of initiatives related technology promotion, and the source or origins of the technology being promoted. The former, for which a summary is presented in Table 3.3, refers to different links in the chain between technology development and adoption. The results must be interpreted with some caution, however, because in practice the concepts are not always crisply distinct or understood the same way. Even so, the results are interesting: of the programmes captured in the audit, about half focus exclusively on transferring technologies that are already developed and seemingly adapted; about one quarter of programmes involve actual technology development, whether on its own or in conjunction with adaptive research and transfer activities; and the other quarter of programmes start with technology adaptation. Part of the distinction between these categories is merely one of time and packaging, in the sense that some programmes are able to provide for development, adaptation and transfer from the beginning, while others focus on the first phase (e.g. development), concluding which the next phase may be contemplated.

Table 3.3: Type of technology promotion

	Share
Development	10.6%
Development and adaptation	2.9%
Development and transfer	8.6%
Development, adaptation and transfer	1.2%
Adaptation	3.3%
Adaptation and transfer	19.6%
Transfer	51.4%
Missing	2.4%
All	100.0%

Just under one quarter of the technologies in the database involve a technology that was developed for the particular use and general target group for which it is presently being promoted. This does not necessarily mean that it was specifically designed by the particular programme that is now promoting it, i.e. in some many instances, programmes seek to transfer technologies that were specifically designed at another time and/or by someone else. An example of a spillover technology project is one that takes genetically modified crop varieties that have largely been developed for large-scale commercial farmers, and adapting either them or the associated farming practices such that they can be used by small-scale or emerging farmers. A scaled-down technology could be the development of ore processing methods that are appropriate to small-scale operations, but based on the same technological principles applied in industry at large. However, in practice 'spillover' and 'scaled-down' technologies are difficult to distinguish and often mean much the same thing, as is even evident from the examples provided.

Table 3.4: 'Origins' of technology

	Share
Specifically designed	23.7%
Indigenous	0.8%
Scaled-down	13.5%
Scaled-down and indigenous	0.4%
Scaled-down and spillover	5.3%
Spillover	36.3%
Unclear	9.4%
Missing	10.6%
All	100.0%

Moving on now to institutional aspects of the programmes captured in the database, we start by summarising the types of organisations that were cited as the implementers (see Table 3.5). Almost half of the programmes are implemented by provincial government departments. This is not surprising given the predominance of agricultural projects. The second largest category is sciences councils and other parastatals, followed as a significant but distant third by private companies. Tertiary institutions, national government, and civil society account for the rest of the programmes. Having said that, 65% of all programmes in the database involve some kind of partnership with other institutions (not shown), whether these be funders or other institutions that assist in some manner with the implementation. (This is apart from partnerships with local communities, which were also often cited.) Most of these partner institutions are themselves government departments and local government structures, but a significant number are also parastatals, private companies (sometimes but not always through their corporate social investment structures), donors, and tertiary institutions.

Table 3.5: Types of implementing organisations

	Share
Government, national	3.3%
Government, provincial	49.8%
NPO/CBO/NGO	4.5%
Private company	10.6%
Science council/parastatal	24.9%
Tertiary institution	7.8%

Table 3.6 takes the theme a bit further and relates the question of implementing organisation back to the sector. Bearing in mind that some sectors are represented by few or very few programmes (in which case the percentages must be interpreted with caution), it conveys a good idea as to the strong identification of provincial government with agriculture, the private sector with energy, ICTs and mining, and of science councils and other parastatals with manufacturing.

Table 3.6: Types of implementing organisations by sector

	Agric	Energy	Enviro	ICT	Manuf	Mining
Government, national	2%	17%	17%	0%	8%	0%
Government, provincial	57%	0%	0%	0%	0%	50%
NPO/CBO/NGO	3%	0%	33%	0%	17%	0%
Private company	6%	67%	17%	75%	8%	0%
Science council/parastatal	25%	0%	17%	25%	58%	50%
Tertiary institution	7%	17%	17%	0%	8%	0%
All	100%	100%	100%	100%	100%	100%

As for funding institutions, the picture is of course somewhat different. The table below summarises, where the percentages represent the share of all programmes for which we have information (201) that receive or received funding from the types of institutions indicated. The South African government is by far the most common funder, while the private sector is a distant second. (Since the audit did not capture information on the amounts of funding, these ratios are in terms of programme numbers and not money spent or committed. Moreover, some programmes have more than one funder, which accounts for the fact that the total figure in the table exceeds the number of programmes.) What this probably implies is that, on balance, the private sector tends to be more involved in these programmes as a service provider and technology source than as funder.

Table 3.7: Type of funding institution

	Share receiving
Development finance institution	1.5%
Government	89.1%
Private sector	11.4%
Donor	6.5%
NPO/CBO/NGO	3.5%
Tertiary	1.0%
Other	2.5%

Table 3.8 expands on the previous table by showing the percentage of programmes per sector that receive(d) funding from each of the types of funding institutions. Again stressing that for some sectors these percentages are calculated relative to small base (especially since there is a fair amount of missing information in respect of funding institutions, as indicated by the 'n' at the bottom of each column), it again suggests certain predominant associations, yet the overall picture is that government is dominant for most of the sectors, while the involvement of donors is concentrated in energy and mining, and that of the private sector in environment, ICTs (very tentatively) and mining. Looking more

closely at the relatively dominant number of programmes in the agricultural sector, it appears that the private sector involvement is split between companies that are seeking to introduce new (e.g. genetically modified) seed varieties – in other words which the programme most likely is an effort to expand business opportunities in South Africa – and companies whose involvement in agriculture is a form of corporate social involvement, generally unrelated to the companies' own sphere of business activities. A small number (three) of programmes in the agricultural sector involve loan finance, presumably production loans to farmers participating in seed trials.

Table 3.8: Type of funding institution by sector

	Agric	Energy	Enviro	ICT	Manuf	Mining
DFI	1%	10%	0%	0%	0%	0%
Government	93%	80%	33%	25%	100%	100%
Private sector	9%	20%	33%	75%	18%	50%
Donor	5%	40%	0%	0%	0%	50%
NPO/CBO/NGO	2%	0%	33%	0%	0%	0%
Tertiary	1%	0%	0%	0%	0%	0%
Other	1%	0%	0%	0%	0%	0%
n	168	10	6	1	11	3

As noted above, all but 29 of the programmes captured in the database are active. About 9% were begun in 1994 or before, and a surprisingly large 20% were begun between 1995 and 1999, meaning that almost one third of these programmes have been active for 10 years or more. In the years 2000 to present, there is an unevenness in the numbers of programmes begun each year, the reason for which is not clear. The decline from 2000 to 2002 may reflect the ending of the Treasury's Poverty Reduction Programme, while the upsurge from 2003 may signal a reinvigoration in the fight against poverty, particularly by DST and partner institutions. However, it might also be that a large fraction of the cohort of programmes begun in the early 2000s have since ended and were simply not captured in the audit.

Table 3.9: Year in which programme began

	Share
1980s or before	3.1%
1990 to 1994	5.7%
1995 to 1999	19.5%
2000	8.8%
2001	6.9%
2002	5.0%
2003	13.2%
2004	7.5%
2005	11.3%
2006	11.9%
2007	6.9%
All	100.0%

As for the 29 programmes that have been terminated, as a group they reveal little as to the common attributes of such programmes. Most (79%) were within the agricultural sector, but this is in keeping with the overall proportion represented by agriculture among active programmes. Arguably the most significant commonality is the fact that each of these programmes – which lasted from two to nine years – appear to have been closed as scheduled, rather than, say, prematurely due to problems encountered. Some of these ended when the technology had been transferred, while others when the technology had been developed. It is difficult from the dataset to determine how many of the latter subsequently served as the basis for a technology development and/or technology transfer initiative, though it is clear from the commentary associated with some of the non-terminated programmes that this is a common scenario.

Finally, we touch on the geographical distribution of the programmes. More than half of all programmes are active in Limpopo and/or North West, while KwaZulu-Natal and Mpumalanga together account for another quarter.

Table 3.10: Provinces where programmes implemented

	Number	Share
Eastern Cape	17	7.9%
Free State	9	4.2%
Gauteng	8	3.7%
KwaZulu-Natal	37	17.3%
Limpopo	63	29.4%
Mpumalanga	32	15.0%
North West	55	25.7%
Northern Cape	4	1.9%
Western Cape	15	7.0%

These figures include the fact that many programmes are undertaken in two or more provinces, but it does not fully capture the fact that there are a number of programmes for which the actual provinces were not identified: all in all, 30 programmes (or 12%) are involved in five or more provinces, about half which were described as 'national' in scope. The table below summarises. About 20% of all programmes involve two or more provinces.

Table 3.11: Number of provinces in which programmes

Number of provinces	Number	Share
1	194	79.2%
2	11	4.5%
3	5	2.0%
4	2	0.8%
5	7	2.9%
6	3	1.2%
7	2	0.8%
'National'	17	6.9%
Missing or unclear	4	1.6%
All	245	100.0%

4 Sector analysis

4.1 Introduction

This section of the report seeks to bring together – in both a descriptive and analytical fashion – information from the literature and audit, and including from the somewhat subjective perspectives of those interviewed in the course of conducting the audit. The section is organised according to the six main sectors that were identified from the beginning as the focus of the study. Although each sector-specific sub-section is organised in the same manner (i.e. introduction, literature review, analysis and conclusion), there is a very large unevenness in the length of the sub-sections. In particular, the sub-section on agriculture is far longer than those for the other sectors. This is simply because there is so much more information about the use of agricultural technologies for rural poverty reduction, whether in South Africa or elsewhere. It also reflects the predominance of programmes in the agricultural sector as shown in the statistical profile above. The concern is not particularly that the sub-section on agriculture is so long, but that those for the other sub-sectors are so relatively brief, owing to a dearth of useful information.

4.2 Environment sector

4.2.1 Introduction

The environment sector is very broad and for the purposes of this study it will be instructing to define it clearly. It is very broad because it cuts across many other sectors such as agriculture, conservation and tourism (See box below). In this regard, it may prove difficult to pin down exactly that which we set out to achieve. For the purpose of this study, the environment sector refers to those economic activities that use natural environment related materials to generate incomes using one or other form of technology.

This section of the study provides a discussion of the sectors that were identified. Each of those six identified sectors is presented in three sub-headings, namely

- Introduction,
- Literature review
- Analysis, and
- Conclusion.

Box 4.1

The environmental sector of EPWP is focused on creating work opportunities in public environmental programmes. The objectives of the sector are summarised in the sector's Plan (DEAT, 2004) as:

- Creating jobs and providing training through these jobs to facilitate long-term employment.
- Linking people in the marginalised "second economy" with opportunities and resources to enable their participation in the developed "first economy".
- Integrating sustainable rural development and urban renewal
- Creating land-based livelihoods
- Promoting community-based natural resource management
- Developing the natural resources and cultural heritage
- Rehabilitation of natural resources and protection of biodiversity
- Promoting tourism

The environmental sector's approach mainly involves the expansion of pre-existing programmes such as Agriculture's Land Care programme; the Department of Environmental Affairs and Tourism (DEAT)'s People and Parks, Coastal Care, Sustainable Land-based Livelihoods, Cleaning up SA, and Growing a Tourism Economy programmes; the Department of Water Affairs and Forestry (DWAF)'s Working for Water, Wetlands, and Fire programmes; and the Department of Arts and Culture (DAC)'s programmes. DEAT is the sector lead department for the environmental sector, and DWAF, DoA and DAC are the other key sector partners.

Source: HSRC 2007

4.2.2 Literature review

The industrialisation process has not only brought economic benefits to humankind but it has also brought with it negative effects upon the natural environment. The effects come in the form of air pollution, water pollution, and land pollution. These are all by-products of industrial activities which has not only affected the cities but also the countryside of countires. As a result, these effects are not only having negative results on people's health and biological diversity but they are also having tremendous effects on the climate.

But it would be too simplistic to merely state that it is the industry alone that generates pollutants. Agriculture has become a great polluter as well. Fay and Golomb (2002) state that "... industrial agriculture has expanded the predominance of monocultured crops and intensified production by copious application of pesticides, herbicides, and inorganic fertilizers..." Herein lie the opportunities for rural enterprises. The waste from pigs and fowls cages provide good opportunities to turn these into profitable businesses for organic fertilisers.

As concerns about these effects grow, governments worldwide have embarked on measures to curtail rates of pollution (Fay and Golomb 2002). Among the methods used is recycling of waste materials. To this end, waste recycling has provided opportunities for job creation and alleviation of unemployment. SMMEs have also been established where rural people in particular have managed to derive incomes. Commonly recycled objects include paper, plastic, scrap metals and bottles.

4.2.3 Analysis

Waste management has created many opportunities for the SMMEs in many parts of the country. The rural people, particularly the unemployed have found new opportunities to earn a living through recycling for example. The Tswaranang Waste Management Project in Qwaqwa under the Maluti-a-Phofong Municipality and other similar projects for example in the Western Cape and KZN present opportunities for economic development and expanded employment opportunities (HSRC 2007).

South Africa is endowed with a variety of natural species. These could be exploited to the advantage of the country if science and technology are applied economically. In this regard, the rural areas stand to benefit as most of these natural species are obtainable from those areas. With relevant technology, South Africa's rural areas can take a meaningful role in the production of pharmaceutical products and in fighting some of the diseases.

The DST and CSIR have been involved in technology transferring to commercialise herbs in the form of Essential Oils and medicinal plants in rural areas. In this case the DST targets communal areas, resettled communities and unused lands to promote productivity in them. The use of the environment in this way transcends to agriculture for the rural communities. The Onseepkans project in Northern Cape for example employs thirty-five people and has the potential of R9 million in returns. Other such projects are located in Mpumalanga, Limpopo and Western Cape. Besides the Essential Oils projects, DST has established other projects in farming, food processing, weaving, furniture making and brewing. To this effect, the DST had over thirty-five projects using various technologies countrywide by end of 2004 (DST 2006).

Improved fishing methods also present opportunities for those communities that rely on sea harvesting for their livelihoods. Access to fishing boats and aquaculture for example can offer better life opportunities for those involved. Cold storages are required to meet with the needs of the fishing communities for example. In partnership with the University of Stellenbosch, the DST has established no less than thirteen trout farming projects in the Western Cape employing many of the previously unemployed and lowly skilled farm workers. The projects have a collective gross annual income of more than a million rands (DST 2006).

Mintek is also involved in a jewellery project that uses bottles to make beads. The project fits well with this topic as the bottles that are used in the project are mainly what one would consider as recycled waste. This production fills an important gap in the jewellery market. It makes jewels available at relatively low prices to those that would otherwise not afford to purchase jewellery. Above all, the programme affords employment opportunities to people who could otherwise be in the streets without jobs.

We have included this Mintek jewellery programme also as manufacturing in this study. But it must be realised, as indicated earlier, that there is a lot of cross-cutting here. While a programme is used in a particular sector, it might at the same time be sourcing its material needs from another sector. In this case, while manufacturing jewellery, the source is an environmental one and could at the same time be benefactor as this kind of production helps reduce waste profitably. Again, the environmental sector corresponds well with what happens in the agricultural sector. Bad agricultural practices have negative effects on the natural environment. As a result, sound agricultural practices have great influence on environmental practices, and visa versa. The question could also include tourism which presently relies much on the natural environment for its continued successes. Technology can have such widespread multiplier impacts.

The Department for Water Affairs and Forestry (DWAF) conducts a number of projects under its Working for Water Programme. Although the programme is mainly a government poverty alleviation initiative, there is an element of technology transfer inherent in it. The programme is mainly found in conservation areas. In this programme, individuals are trained and contracted and in turn they employ local people to remove alien species for example.

Box 4.2

Rooikrantz Water Catchment is situated outside King Williams Town in the Eastern Cape. The project falls under the Working for Water of the Department of Water Affairs and Forestry. The main activity of the project is the removal of alien species in the area. The project started in 1995 with four teams of 20 members each. The team members have since been reduced to 15 per team. It is not clear what led to the change in the number of team members. Currently the project has a budget of R1 833 445. In the previous years it had R1.60 million (2004/05), R2 million (2005/06) and R1.60 million again in 2006/07 financial years.

The project is taking place on land that is 80% privately owned and only 20% state (communally) owned. The communities that own the land are the Tyusha, Cwengcwe and Nothenga. Other stakeholders are the Departments of Labour, Transport, Health and DEAT as well as the NDA.

Environmentally the project aims at removing the alien species that are seen as consuming more water than the indigenous plants. This is an environmentally relevant objective.

Rooikrantz Water Catchment employs 60 local people. The project offers training to the workers in life skills, herbicides, and in the use of chain saws. The training is offered by the Department of Labour and the service providers. It is a 3 – 7 days course.

Source: HSRC 2007

4.2.4 Conclusion

We indicate here that the environment sector cuts across other sectors such as agriculture, conservation and tourism. Indeed, from an economic point of view, the environment sector benefits from a variety of areas to the extent that even the waste from those other sectors makes economic sense here.

Environmental programmes as applied by DWAF are not necessarily aimed at technology transfer, but rather at nature conservation. They are at most poverty reduction programmes aimed at providing safety nets against destitution. However, these programmes do have an element of technology in them as exemplified by the use of herbicides. Furthermore, water catchment projects involve some form of know-how as these are more technical.

4.3 Agriculture

4.3.1 Introduction

National and international technology spillovers from public agricultural research and development (R&D) are important to understanding technology development in developing countries (Pardey et al. 2006). These countries have depended on the spillover of technologies from the industrialised countries as well as international agencies such as the Future Harvest Centres of the Consultative Group for International Agricultural Research (CGIAR). As Pardey et al. (2006) point out it was only in the very last stage of the R&D process, selection and adaptation of technologies such as new crop varieties, that innovative effort occurred in developing countries. In recent years the changes in the research emphasis of industrialised countries, along with increased emphasis on intellectual property rights (IPRs) and use of modern biotechnology methods such as genetic modification, indicate a shrinking pool of public R&D technologies (Pardey & Beintema 2001). Simultaneously the CGIAR is changing its focus and emphasis. Consequently, these reductions in spillovers from these traditional sources of technology underline the need for developing countries to find alternative ways to meet their demands for agricultural technology. However, under-investment of agricultural research is pervasive and most evident in poorer developing countries. According to Pardey et al. (2006) this under-investment is worrisome for a number of factors:

- The increasing disparity between poor people's priorities and the R&D agendas of the rich countries;
- The persistence of widespread pockets of poverty and hunger in developing countries, despite impressive national average productivity increases in some of these countries;
- The continuous population growth, particularly in developing countries; and
- The increasing deterioration of the natural resource base due to population increase and the desire to produce more food in unsustainable ways.

4.3.2 Literature review

Modern science can only be truly effective in addressing the problems of the poor, especially with regard to income generation and food security, if it focuses on knowledge and technology development that appropriately address their problems.

Despite the need for more and relevant agricultural R&D investment in developing countries investment expenditure patterns illustrate that this is not happening (Pardey & Beintema 2001). While worldwide public spending of agricultural R&D has increased by 51% since 1980 the industrialised countries spent 56% of the public research and a handful of the more-developed countries (South Africa, China, India and Brazil) spent almost 50% of the remaining 44% allocated to developing countries (Pardey & Beintema 2001; Pardey et al. 2006). By 2000 approximately one third of all agricultural R&D investment worldwide was made by private organisations, especially those providing farm inputs and those involved in agri-processing. More than 90% of this private sector investment was conducted in the industrialised countries. So while very little private sector investment takes place in the developed countries they remain increasing dependent on public sector investment. In industrialised countries agricultural investment from the public sector is still significant, at around 45% of total public investment in 2000 (Pardey et al. 2006). Developing countries spend 55% of the global total public investment but only one third of the public-private partnership R&D spending occurs there.

These shifts have policy implications for the international CGIAR, similar institutions and the national agricultural R&D systems in less-developed countries. These can be centred on the type of research that needs to be done and how such activities are to be financed. Industrial countries are unlikely to continue with their previous research roles and less-developed countries that previously relied on technological spillovers from these countries may no longer be able to do this to the same extent. This change involves three elements (Pardey et al. 2006):

1. The technologies developed in the industrialised countries may no longer be applicable to less-developed countries.
2. The new IPR regime may well make any privately owned, but applicable to developing countries, technologies inaccessible.
3. Any technologies, which are relevant and available, are likely to require more substantial local R&D, and adaptation. This means that local R&D is going to have to be more extensive than previously.

Following from this, two things become very clear. Firstly, new methods will need to be developed whereby less-developed countries can get equitable access and utilise the technologies generated in the industrialised countries. Secondly, many of the former countries will have to consider extending their agricultural R&D efforts to encompass more fundamental upstream research.

Preliminary review of the literature indicates that in developing countries diverse technologies are being developed and used to differing degrees to improve income generation and food security of the rural poor. While most of these are directly related to agricultural production, some – like alternative sources of energy and information and communication technologies – are used in agri-processing, the provision of technology information (an alternative form of extension) and to follow market trends. We start with these technologies and then move on to production technologies

Areas of technological development for agriculture in the third world

Alternative energy sources

In a review of the energy problems in rural areas, mainly in Asia, Pachauri and Mehrotra (2001) point out that recent technological advancement, renewable energy technologies (RET) has made alternative energy sources such as solar panels, biogas and windmills more available and less costly. Their study indicated that these alternative energy sources have numerous advantages:

- Provide better lighting which enables them to stretch their period of economic activity;
- Saves the environment from further degradation and gives it an opportunity to regenerate;
- Combining afforestation, agroforestry and energy efficient devices can create a sustainable fuel-use system in rural villages and sustain the ecological balance;
- Reduced dependency on fuelwood and other fuel sources reduces women's labour and drudgery by reducing the distances travelled to collect fuel;
- Improved cookstoves and biogas benefit human health by reducing or eliminating respiratory and eye infections;
- Alternative energy sources aid income production. They can provide employment opportunities through the use of energy in small-scale agriculture and industry, sale of energy and equipment to local utilities, and the maintenance and repair of energy devices. In India biomass gas is used to dry horticultural produce while solar heating panels are used to meet the demand for hot water in hotels and hospitals.

Pachauri and Mehrotra (2001) conclude their review by calling for appropriate policies, market mechanisms, finance and the development of local capacity to support the introduction of RETs which are adapted for the needs of rural communities.

Information and communication technologies (ICTs)

While some people might assume that ICTs are irrelevant to the world's poor numerous poor women in hundreds of Bangledeshi villages would disagree (Pinstrup-Andersen 2001). They have escaped poverty by renting out their mobile phones to other residents. These in turn obtained better prices for their crafts and agricultural products as a consequence of obtaining timely market information by means of these mobile phones.

Chowdhury (2001) stresses that ICTs can improve the economic welfare of the rural poor. He highlights the numerous opportunities now available by means of the Internet and mobile phones. He argues that in the rural areas there is a strong latent demand for more information and that if this is filled it will greatly benefit the rural poor. The brief concludes by calling on policymakers to develop policies and institutions that encourage the rapid spread of ICT infrastructure in the rural areas.

In some countries in Africa radio services operating on the FM band provide programmes for farmers. These services provide information on technologies, warnings, market information and general discussions and interviews with people directly involved in the agricultural sector. In South Africa the Radio Sonder Grense station provides these services twice a week. Unfortunately the service is presently only transmitted in Afrikaans. A DVD produced by Liesl-Dana van Schalkwyk (2006) entitled Voices of the Drylands indicates how farmers in the remote areas of the Northern Cape make use of this radio service and also solar power for electrification.

Farmer based agroecological technology

Pretty (2001) argues, with support of project evidence, that agroecological technology not only increase productivity but also contribute to more effective use of scarce natural resources such as water, soil reclamation, pest and weed control, and the integration of the entire farming system. Technologies include:

- better harvested and conserved water in drylands and rainfed areas;
- adoption of zero-tillage and the use of diverse crop rotations, green manuring and some herbicides have improved soil organic matter content;
- use of integrated pest management (IPM) has reduce the use of pesticides and has allowed Bangladeshi farmers to diversify by including fish, shrimps and crabs into their rice farming system. In east Africa "push-pull" pest management systems have resulted in 60-70% increases in maize yield;
- In Madagascar the system of rice intensification (SRI) is an agroecological technology that has spread to many African and Asian rice producing countries, despite initial scientific scepticism.

He concludes that such technologies lead to sustainable agriculture, reduction in rural poverty and an improvement in rural livelihoods. As a consequence of this evidence he states that these technologies should receive a greater share of the research budget.

African natural resource management technologies

Soil fertility is declining in Africa and failure to replenish it leads to declining output and incomes in agriculture. Old strategies are infeasible. Strategies such as shifting cultivation and long-term fallows break down as these become increasingly constrained by population pressure. According to Franzel, Place, Reij & Tembo (2004) two promising responses have emerged. Firstly, planting basins emerged in recent decades in both Zambia and the Sahel. The system involves the following (Franzel, Place, Reij & Tembo 2004: 1):

- Dry-season land preparation to avoid peak-season labour bottlenecks and ensure timely planting with the first rains;
- Minnimum tillage of only 15% of surface area using grids of 10 000 to 15 000 small planting basins per hectare, which harvest water and focus nutrients in a small area near the plants;
- Breaking of hard crusts and plough plans in soils to enable water and root penetration;
- Application of organic material and sometimes also small doses of chemical nutrients in the basins immediately adjacent to the plants.

Secondly, improved fallows have been used during the past decade in eastern Zambia and western Kenya. Here farmers introduce rotations of leguminous trees. These are planted for between one and three seasons. Then they are removed and crops are planted on the same plots for two to three seasons. Rotation with nitrogen-fixing trees and the retention of organic material from branches and leaves helps to build up soil fertility. The planting of trees ensures that root channels penetrate the soils. These serve as biological ploughs, facilitating water and root infiltration by subsequent crops (Franzel, Place, Reij & Tembo 2004).

Both technologies are recent but have attracted widespread interest for a number of reasons:

- They are environmentally sustainable;
- They reduce the use of purchased inputs;
- They increase farmer yields and reclaim soil fertility.

Reij and Waters-Bayer (2001) describe a number of indigenous soil and water conservation technologies, similar to those described above, used in parts of West, Central and East Africa. These follow from the first and second phases of the Indigenous Soil and Water Conservation (ISCW) programme, initiated in the 1990s and largely funded by the Netherlands Government. While the first phase concentrated on identifying indigenous technologies in fifteen African countries the second phase (ISCW 2) was carried out in seven countries during which researchers, extensionists and farmers collaborated together in many instances to jointly develop appropriate new technologies or to improve and disseminate technologies which farmers had developed. The twenty-seven case studies generated in the first phase indicated that many indigenous technologies and practices were being maintained and developed further by farmers. This was in contrast to the many modern SWC techniques that were promoted by development projects in these countries (Reij et al. 1996). This is relevant for technology development as it suggests that farmers are more likely to maintain and further develop those technologies that are in line with their access to resources, derived from their needs and are based on their knowledge to a lesser or greater extent.

According to Reij and Waters-Bayer (2001:6) ISCW 2 adopted a specific approach which, "... involves training scientists and extensionists in PRA [Participatory Rural Appraisal] and PTD [Participatory Technology Development], identifying farmer innovators and their innovations, networking between farmer innovators, participatory research to develop and validate improved techniques and systems of land husbandry, and disseminating ideas and methods through farmer-to-farmer exchange." The ultimate intention of this programme is to improve local and externally introduced technologies and practices of managing land and water resources. According to Reij and Waters-Bayer (2001) it is the participatory approach that enables this and which makes the programme successful.

Without access to sufficient water and fertile soils very little can be produced. The South African Water Research Commission has been a strong supporter of research into water use and related technology development in South Africa from as early as 1994. A number of supported studies aimed at getting a clearer picture of the water use and irrigation requirements of small-scale farmers in South Africa and in developing appropriate systems. de Lange (1994) describes an early assessment of small-scale farmer irrigation practices and specific needs of this sector. Following a participatory analysis of former homeland farmers practices, recommendations regarding existing practices were formulated and alternative systems were proposed based on resources, terrain and irrigation requirements. At the time the following irrigation technology was used in small-scale agriculture:

- Flood Irrigation (Flood beds, Long-furrow irrigation, Short-furrow irrigation, Small-basin irrigation, Community garden furrow plots);
- Sprinkler irrigation (Conventional moveable pipe, Dragline);
- Centre pivot;
- Micro-irrigation; and
- Drip/trickle irrigation.

While acknowledgement and credit was given to various indigenous small-scale practices such as improved flood irrigation criticism was levelled at the introduction of hi-tech (albeit small-scale) systems by extensionists and others which could not be maintained by resource constrained and remotely situated farmers. De Lange also notes that often small-scale systems involved a mix of conventional and indigenous practices and designs. Criticism was also levelled at the management structure on many former homeland irrigation schemes, many of which were in serious disrepair at the time of the study. A chief criticism directed at management was that instead of empowering farmers to take responsibility many irrigation schemes were "top down" and externally managed. On schemes were farmers had decision making power and freedom of choice with regard to crop selection and water use there was a greater sense of belonging and personal satisfaction. In contrast to "top down" managed schemes the actual systems were in a state of greater disrepair due to lack of access to maintenance skills and required parts. de Lange also points out that despite these findings, in certain circumstances, such as plantation projects, central management was preferable as people need to be employed as labourers rather than creating the false impression that they are farmers. Irrespective of whether one is dealing with individual managed plots or group activities technology needs to be appropriately designed and supported. This study (de Lange 1994) illustrates that it is important for consideration to be given to social circumstances when doing this and when trying to set up management systems for agricultural interventions.

The Prolinnova South Africa Network (Prolinnova-SA) is a network of NGOs, government departments of agriculture and parastatal research institutes that collaborate in order to promote local innovation in ecologically-oriented agriculture and natural resources management by identifying farmers' innovations, including technology development, in order to improve and strengthen these where necessary and appropriate. Since its inception in 2004, Prolinnova-SA in collaboration with farmers and farmers' organisations has identified over 30 farmer developed technologies which have the function of improving farmers' circumstances and/or that of the natural environment (see de Villiers et al. 2005 and Letty et al. 2007). These technologies ranged from water and pasture management innovations through to reclaiming arid land by means of planting pits and to production and grafting innovations. Hart and Vorster (2006) also indicate that many small-scale farmers in South Africa develop their own technologies based on indigenous knowledge and their access to resources. In a later study (Hart and Vorster 2007) they indicate that there is a need for farmers and researchers to collaborate on technology development based on what farmers know. They also point out that there is a strong local knowledge base upon which scientific technology development can contribute towards and that there are good grounds for such a strategy. Given environmental factors, such as the pace of climate change, and the remoteness of many farming households, they argue that it is important that both farmers and researchers collaborate together to develop appropriate technologies that can improve the circumstances of small-scale farmers. In order to be effective researchers need to identify and understand farmers' farming systems and locally developed technologies prior to making recommendations or disseminating existing technologies. An in-depth understanding of social and economic circumstances and relationships is a prerequisite.

Conventional agricultural research and technology

Some social movements and lobby groups in the agricultural sector are opposed to the use of conventional agricultural research methods and technology, including plant breeding, such as used in the Green Revolution. Supporters argue that the indigenous knowledge generated by farmers over centuries is most appropriate for poor farmers. These same people are also against poor farmers purchasing improved seed and plant material, inorganic fertilisers, and other agrochemicals. However, the success of the Green Revolution in certain areas and under certain conditions makes these dependency arguments questionable (Pinstrup-Andersen 2001). According to Pinstrup-Andersen (2001) the poor will only escape food insecurity and poverty if they take the risk of integrating into the exchange economy. Modern science and technology is only one of many factors that will determine the extent of the losses and gains the poor experience. Therefore, in instances where the market, policies and practices, etc. are biased towards the poor it is possible that they may well suffer losses and the dependency argument becomes valid. Appropriate policies and institutions are required along with technologies. As Pinstrup-Andersen (2001:1) states:

> "Modern technology should be viewed as part of a broader effort to help the poor solve their problems and not as a silver bullet applied in isolation."

Pingali (2001) argues that while conventional research has led to ecological stress in some areas but when applied in marginal areas it pays off in higher farm yields. He says that this is evidenced by the success of the Green Revolution in certain marginal areas in Asia. He concludes that this research will continue to play a major role in agriculture and that biotechnology will play an important complementary role, rather than supersede conventional research and technology.

Case studies from the literature

Anglophone West African conventional agricultural technology research

A study commissioned by the Technical Centre for Agricultural and Rural Cooperation (CTA) in 1996 identified five technologies from three agricultural research institutes in Nigeria and three from Ghana (Arokojo 1998). The technologies in Nigeria included:

- Improved lowland and upland rice varieties, respectively FARO 44 and FARO 46;
- A small-scale brown sugar production plant;
- Cocoa and kola hybrids;
- A foundation layer stock; and
- A dual purpose groundnut (Samnut-10) for fodder production.

The Ghanian technologies included:

- An improved protein quality cowpea variety (Ayiyi);
- A foundation poultry layer stock; and
- Wheatbran formulations for livestock feeds.

The study showed that while these technologies had evident advantages over local alternatives their adoption was limited because they required high volumes of expensive external inputs. Thus, despite social and technical feasibility they were economically unfeasible for most farmers.

While these technologies addressed a number of specific situational constraints, such as malnutrition, drought, short growing periods, etc. their R&D was not farmer driven but rather driven by researchers and governments. Both the Nigerian and Ghanian governments were solely responsible for research funding, including external loans to farmers. Private sector involvement was negligible.

Government policies were found to affect adoption behaviour and the impact of these technologies in a number of significant ways:

- Rice has no value added products and in the local markets it is not competitive with imported rice.
- Unlike rice cocoa has some acceptable and value-added products but the adoption of hybrids was seriously limited because of the high cost of the chemical sprays and the farmers' inability to carry out their own propagation of the seedlings.
- The small-scale sugar plant required an extremely high capital outlay, making it both economically and socially unacceptable.
- While the Obatanpa maize in Ghana achieved high levels of adoption the cowpea variety, Ayiyi, was limited as a result of the high cost of farming inputs such as a chemical sprays; a result of fiscal policy constraints.

This study concluded that for R&D results to be successfully adopted by farmers they must meet all the following criteria:

- address the needs and constraints of farmers;
- be technically and economically feasible;
- socially acceptable; and
- environmentally sustainable.

It also argued that greater adoption and impact of technologies was only likely if the farmers/beneficiaries are actively involved in their R&D process and if the policy environment was more conducive in that required inputs are made available at affordable prices. Such a policy environment would complement this with tangible incentives for production.

African cassava development

Coordinated response, to a series of threats to cassava production, by the Nigerian based International Institute of Tropical Agriculture (IITA) and some national research institutes resulted in successful cassava research programmes. These fended of several cassava mosaic virus mutations and the devastating invasion by the South American mealybug. Conventional breeding programmes have yielded a rich harvest of new cassava varieties. As the demand for cassava spread in Africa, so simple processing technologies were developed to reduce processing labour (Nweke, Haggblade & Zulu 2004). Nigeria has now replaced Brazil as the leading producer of cassava. Its appeal to the poor is the following:

- It is vegetatively propagated and therefore requires no purchased inputs, making it widely accessible.
- It is extremely flexible with regard to labour inputs and harvesting as it can be planted throughout the rainy season and can be harvested for up to 18 months after planting. This makes it attractive to household that are labour deficit, such as those with HIV/AIDS patients.
- Sustained production gains have resulted in falling consumer prices that benefit both the rural and urban poor.
- Cassava is more drought tolerant than the other East and Central African staple, maize.

South and East African maize development

During the early 20th Century African farmers transformed maize from a little known imported foodcrop to the main staple. From the 1960s onwards, newly independent countries encouraged agricultural research programmes that expanded smallholder cultivation and production in maize. Zimbabwe (then Southern Rhodesia) was a leader in this field and released SR-52, the first commercial single-cross hybrid in the world, in 1960. At present small- and large-scale farmers in East and Southern Africa plant 58% of total maize area to newly developed high yielding varieties (Smale & Jayne 2004). On average these varieties outyield traditional ones by up to 50%, even without fertiliser (ibid.). However, this success was only a qualified technical success. Once the subsidies for the inputs were withdrawn during the late 1980s and early 1990s production fell and was fiscally unsustainable.

Smallholder cotton in Mali

Cotton is one of the pillars of rural development in much of francophone Africa. This sector is a basic driver of economic development as it generates benefits for various individuals and groups: farmers, rural communities, cotton companies, private traders, and national governments (Teft 2004). In Mali cotton is grown by 30% of Malian households under rainfed conditions and is rotated with coarse grains. Cotton producing households have generally been the most prosperous in rural Mali. This is due to a number of factors that have helped to ensure cotton as a success story:

- The sector has been managed by vertically integrated, state supported cotton companies;
- Prices are guaranteed and so is a market for seed cotton;
- Farmers have access to equipment and inputs on credit and the regional research system, associated with CIRAD, has provided them with improved varieties.

Cotton is considered strategic by farmers and the government as it contributes to 8 percent of GDP (Teft 2004). In recent years the national agricultural research institute, Institut d'Economie Rurale (IER), has been negotiating with Monsanto and Syngenta to carry out field trials of *Bt* cotton (Makanya 2004).

Dairy cattle in Kenya

Commercial farmers in Kenya lobbied for improved dairy cattle breeds in the 1900s and by the 1930s they had supplemented this with favourable policies, including quarantine legislation, price controls, veterinary and agricultural support services. Smallholder growth began sluggishly in the 1950s and 1960s. Introduction of highly productive breeds has been a cornerstone to increased productivity in Kenyan dairy farming. Between 1964 and 1987 the new government heavily subsidised artificial insemination programmes (Ngigi 2004). Despite the high cost this strategy resulted in the widespread adoption of improved breeds. Improved dairy cattle breeds account for 23% of all cattle in Kenya and 75% of all dairy cattle in Eastern and Southern Africa. Immediate neighbours do not fair so well. In Uganda improved breeds account for 3% of dairy cattle and in Ethiopia it is less than 1% of the total cattle population. During the past two decades dairy production in Kenya has grown at 2.8% per annum. Panel data shows that by 2000 nearly 70% of all Kenyan smallholders produced milk with it becoming their fastest growing income source (Ngigi 2004).

Biotechnology and genetically modified organisms

While some groups are opposed to the use of modern biotechnology to help poor farmers and consumers solve food and farming constraints, Pinstrup-Andersen (2001) argues that poor Chinese cotton growers are able to produce more cotton with fewer pesticides. This is due to their access to *Bt* cotton seed and the fact that they obtained access to it before their competitors.

Juma (2001) argues that genetic modification can definitely help poor farmers and consumers. He argues that while most developments in biotechnology have generally only benefited the richer farmer and developed countries incentives are needed to get the private sector and public research institutes to focus on the requirements of poor farmers and to develop solutions using genetic engineering.

According to Fransen et al. (2005:1) the term modern biotechnology can refer to a number of biotechnological techniques, which include cloning, gene therapy, and the production of monoclonal antibodies. They understand modern biotechnology in terms of the Cartagena Protocol on Biosafety and therefore as the use of "in vitro nucleic acid techniques, including recombinant deoxyribonucleic acid (rDNA) and direct injection of nucleic acid into cells or organelles; or fusion of cells beyond the taxonomic family, that overcome natural physiological reproductive or recombination barriers and that are not techniques used in traditional breeding and selection" (Secretariat of the CBD, 2000 – cited in Fransen et al., 2005: 1)[2]. The production of a genetically modified organism (GMO) involves the insertion of genetic material using recombinant techniques or by direct injection. A transgenic organism is the same as a GMO (ibid.). The genetic modification of organisms is only one form of biotechnology practised in the world today. Other forms include plant tissue culture, molecular breeding or marker assisted selection and embryo rescue (AfricaBio 2004).

The transfer of genes or foreign DNA from one plant/crop to another usually occurs using one of two methods (Huttner 1997, Drew 2002):

1. Plasmids of the soil bacterium *Agrobacterium tumefaciens* known as the t-DNA are used and integrated into the target plant's genome;
2. Microscopic particles of gold or tungsten are coated with DNA and 'shot' into the genome of the target plant using a high-pressure gas or electric discharge.

Once transfer has taken place, by either method, the cells or tissues from the plants are cultured *in-vitro* and reconstituted into whole plants. These plants become the source of plant material for future propagation.

[2] We would suggest that this sentence explains why such techniques are often considered as "unnatural".

The first genetically modified organism, a strawberry plant that used modified strains of bacteria to prevent frost damage, was field-tested in the United States in 1987. The Flavr Savr™ tomato was the first commercialised genetically modified plant and was released in the US around 1992 (Drew 2002, Huttner 1997). Genetically modified animal feed was first made available on the US market in 1995. These were glyphosate-tolerant (herbicide tolerant) soybeans and insect resistant maize (Drew 2002). The United States government has granted the GMO industry permission to commercialise over fifty genetically engineered plants, including those used primarily for human food, animal feed and fibre production (ibid).

Globally the area planted with genetically modified crops has increased from four hectares in 1996 to 44 million hectares in 2001. As James (2000) has pointed out this is unprecedented and the highest adoption rate of any new technology brought into agriculture. At present the United States and Canada grow 82% of the GM crops worldwide, with Argentina and China accounting for a further 17%, and South Africa and Australia account for most of the remaining 1% (Drew 2002, Ismael et al. 2000, Orton 2003). While a number of crops have been genetically modified for a variety of traits the two most common traits remain herbicide tolerance and insect resistance, with maize and soybean being the two most widely cultivated of these GM crops (Drew 2002).

Herbicide tolerant (HT) crops are those that are genetically modified to tolerate specific herbicides, most notably glyphosate and glufosinate ammonium. Predominantly soybean, maize, cotton and canola have been modified to exhibit this trait. The theory is that the farmers can apply specific herbicides to their fields, killing the weeds but not damaging the crop. The claimed potential benefits of this technology are (Orton 2003):

- Less herbicide needs to be used to control weeds;
- The herbicides cause less harm to the environment;
- Weed control improves, is easier, requires less labour and yields are increased; and
- Less tilling or mechanical weed control are required resulting in reduced soil erosion and water loss.

Insect or pest resistant crops are engineered with a gene from the soil borne bacterial organism *Bacillus thuringiensis* (*Bt*), giving rise to genetically modified crops such as *Bt* maize and *Bt* cotton – both of which are commercialised in South Africa. This gene gives the plant insecticidal properties, expressing an endotoxin that kills target insect pests such as the maize stalk borer and the cotton bollworm. The claimed potential benefits of this technology are (Orton 2003):

- Lower applications of pesticides;
- Higher yields as a result of less pest damage; and

* Reduced pre- and post-harvest fungal damage to such crops by virtue that there are fewer insects which can bring diseased organisms into the crop.

According to Orton (2003) these two traits (HT and *Bt*) account for 99% of the commercially grown GM crops. Eight percent (8%) of these crops exhibit both these traits (ibid.). Freese has indicated that in the United States the commercial cultivation ratio for HT and *Bt* crops is approximately 5:1 with no other GM crops reflecting the possible needs of resource-poor smallholders (Freese 2005 – personal communication). In other words there are no commercialised varieties that have properties appropriate for resource-poor smallholders in developing countries, such as saline or drought tolerance, etc. A concern with the current emphasis on herbicide and pesticide resistant traits is that the crops have been designed for large-scale monocropping North American farmers, for use in temperate climates and under stable conditions in which the crop leads a virtually stress-free life. This situation is completely different to the circumstances encountered by resource-poor smallholders in Africa who eke out an existence on marginal soils in diverse terrains using limited resources and usually not following conventional practices as a result (Stoop and Hart 2005). In essence current genetic engineering development is largely focused on the needs and circumstances of the wealthier farmers.

Orton (2003) draws our attention to the fact that a small amount of research is now starting to focus on crops that may address the needs of smallholders in developing countries, including:

* Crops that are drought, flood, heavy metal, high acidity or saline tolerant;
* Staple foods such as rice and wheat which produce higher and quicker yields without extra water, nutrients or light;
* Crops resistant to developing country pests, bacteria and viruses;
* Crops that have slower ripening traits when harvested, stored or shipped;
* Crops with enhanced nutritional content ("functional foods") such as Golden Rice[3].

But she notes that often the focus is on export-oriented crops rather than crops which are consumed daily by African households, even when these come from developing countries. She identifies tropical and sub-tropical export crops such as papaya, bananas and tomatoes.

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[3] In order to enjoy the benefits of increased Vitamin A, induced into 'Golden Rice' by genetic engineering, consumers must eat 7kgs of rice a day. Despite this they will be unable to absorb beta carotene without additional inputs of oils derived from green leafy vegetables and a diverse diet (ISIS-TWN, 2005; BIOTHAI *et al.*, 2001). As Orton (2003) emphasises Vitamin A deficiency (VAD) is not because rice does not contain sufficient Vitamin A, rather it is a result of people being so poor that their diet is reduced to little more than rice. A diet rich in diverse foodstuffs would be a better solution. The Golden Rice Humanitarian Project is producing new lines with higher beta-carotene content. It aims at providing the recommended daily allowance of Vitamin A in approximately 100-200 grams of rice, the daily consumption of rice by children in rice-based societies (GRHB, 2005).

However, genetic engineering is a new and extremely complex science and the chances for each gene/trait explored in the research phase reaching the market is about 1 in 250 (Orton 2003). The likelihood of these crops being used by the majority of the smallholders in developing countries who are resource-poor is very low as they are unlikely to be able to afford this technology, especially given the manner in which it is currently transferred (Thirtle et al. 2003) and the associated costs and intellectual property obligations. Similarly, GM crops for the resource-poor smallholders are not a commercial priority for the transnational companies that develop and market GM technology. They are more interested in increasing the kinds of *Bt* and HT crops that can be used by the relatively better–off farmers in developing and developed countries (Orton 2003). According to Orton (2003: 16) the current private sector biotechnology strategy has some serious potential consequences:

> "Because the private sector biotechnology favours the breeding of varieties that are simplified and uniform, and because the little research that it has done on developing country crops has so far focused on high-cash-yielding export crops, the adoption of the GM crops has the potential to exacerbate inequalities between large and small farms."

With its current focus and in its current form it seems that genetic engineering may increase the socio-economic inequalities brought about by the green revolution in some parts of the world. The success or failure of the green revolution has been met with much debate (Tripp 1996). The green revolution was successful in those areas where the socioeconomic status of farmers and the agroecological environment was suitable. This includes areas with fertile soils, sufficient water for irrigation purposes and farmers whose socioeconomic standing enabled them to purchase the required inputs. Where these conditions were not met, most notably in marginalised areas in sub-Saharan Africa, the green revolution did not have a positive impact (Anderson and Jackson 2005).

Biotechnology and GMOs in Africa

In July 2002 Zambia made world headlines when its government ordered the United Nations World Food Programme (WFP) to take back over 35 000 tons of food aid – at a time when three million Zambians faced hunger because of a severe drought in the Southern African region. Part of the WFP food consignment contained genetically modified (GM) maize from the United States. Malawi and Zimbabwe also took exception to this genetically modified food aid (ISIM 2004). The Zambian government argued that this consignment of GM-maize might contaminate non-GM Zambian farms and threaten agricultural exports. In 2004 Zambia was still upholding its ban on milled and unmilled GM products (Makanya 2004). While a bill concerning the regulation of GMOs has gone before the Zambian Parliament, the outcome is uncertain. Other countries in Southern Africa have reacted differently to the presence of genetically modified food crops. The Government of Malawi has banned all unmilled GM crops since 2002 (Makanya 2004). It is felt that this will prevent GM crops that may have the potential from contaminating non-GM crops. Zimbabwe has a ban on the importation of unmilled GM crops and does not carry out any related research. In April 2004 Angola took up a similar stance, despite receiving criticism from the WFP (ibid.). South Africa on the other hand seems to have openly embraced GM crops. The public and private sectors are carrying out a number of trials on various transgenic crops (such as genetically modified eucalyptus, canola, potato, cotton, soybean, sugarcane and strawberries) and have already commercialised transgenic white and yellow maize, soybean and cotton (AfricaBio 2004). South African research institutions are field-testing potato with the view to commercialise within a year. South Africa is considered as a leader in genetic engineering on the African continent and has strong infrastructure for genetic engineering and research in comparison to the rest of Africa (AfricaBio 2004).

In Africa only two countries have actually 'commercialised' GM crops: South Africa and Egypt. Kenya, while not at the same level as these two countries, is further ahead of other African countries with regards to research on genetically modified crops. These three countries have their own research programmes based on the US developed technologies of herbicide tolerance and pest resistance. While Algeria introduced a ban in 2000 on the importation and utilisation of GM plant material other African countries such as Nigeria, Senegal, Mali and Burkina Faso have received or are trying to get money for GM research and in some instances have field-tested *Bt* cotton.

The current US government, transnational companies such as Syngenta and Monsanto, and the various pro-GM lobby groups make a number of general claims about GM crops:

- Will conserve and sustain the environment due to lower applications of pesticides;
- Higher yields as a result of less pest damage;
- Reduced pre- and post-harvest fungal damage to such crops by virtue that there are fewer insects which can bring diseased organisms into the crop – one valuable characteristic of *Bt* maize and *Bt* cotton; and
- These crops will therefore be a means for the resource-poor farmer to overcome poverty and hunger.

The results of a number of studies in both Kenya and South Africa, each of varied duration and often focusing on different issues, have far from supported these claims (de Grassi 2003, Pschorn-Strauss 2005, Witt, Patel & Schnurr 2006). In South Africa, the Makhathini Flats cotton production has often been cited as a transgenic crop success, but numerous researchers have clearly pointed out that its success is heavily qualified (Gouse et al. 2002, Gouse et al.

2005, Ismael et al. 2000, Ismael et al. 2002, Thirtle et al. 2003). Other studies amongst smallholder farmers in developing countries have been carried out in Argentina, India, Mexico and China. Even here the results have often been far from supportive of the claims of the pro-GM lobby, whose research is largely in the hands of the transnational companies standing to benefit from the sales of GM crops and it is seldom peer reviewed (Tripp 1999).

The current interest in GM crops (for both human food and animal feed) is largely related to directly feeding an increasing world population. Yan and Kerr (2002) forecast that on the basis of the current population growth rate (1.4% per annum) world population will increase from the 2002 level of around six billion to between nine and twelve billion in the next fifty years, predominantly in developing countries. They go on to say that providing food to a population this size will require an enormous increase in agricultural production. Endo and Boutrif (2002) suggest that the world is already reaching critical thresholds of arable land, water supply and yield ceilings imposed by plant physiology. While some stress that biotechnology and specifically genetic engineering alone will achieve food security, others such as Endo and Boutrif caution that this is only possible if genetic engineering is realistically integrated with other agricultural technologies. It alone is not the magic cure or silver bullet for reducing poverty and eliminating world hunger. As Tripp (1999: 8-9) argues:

> "It is true that any increase in food output may potentially lead to lowering global food prices. But it is disingenuous to argue that a technology aimed at US soybean farmers is part of a strategy to address poverty and hunger in the South. National policies need to ensure that the poor have the resources to acquire their food (imported or domestically produced), and that new technology is used to promote equitable agriculture."

Endo and Boutrif suggest that it is possible that the use of GM crops might enable countries that do not grow enough food to do so by achieving higher yield on marginal lands. Of course this assumes that those living on marginal lands are able to afford this new and more expensive technology (cf. Ismael et al. 2000).

4.3.3 Analysis

For many organisations contacted during this study the shift in technology requirements and development from the requirements of commercial large-scale agriculture to small-scale and semi-subsistence agriculture has been difficult. Despite this, the information obtained during the study and the diverse technologies entered into the database show that they are reducing the gap, even if this is a slow process. While national directives are moving towards low-cost, small-scale, and low-external inputs and natural resource management geared towards smallholder farmers the achievement of this appears gradual, given the dualistic nature of South Africa's agricultural sector.

Financing by both the public and private sector is still more readily available for the large-scale commercial sector, which is obliged through the various producer commodity trusts to contribute a portion of its profit to further commodity specific agricultural research. Private sector financing is geared to create markets for its technologies and mainly concentrates on the better-off farmers i.e. those who can actually optimise the use of new and more costly technologies. Often it is only a few creative scientists and researchers based in research institutes, provincial departments and NGOs who are making strides in developing technology that is appropriate to the small-scale and semi-subsistence agricultural sector. That these numbers are increasing is suggested by the number of entries denoting the specific development of technology for this sector or the subsequent adaptation of spillover technology.

The success rate of many technology-oriented poverty reduction initiatives and technology dissemination programmes generally appears low in that they suffer from lack of skilled personnel, lack of resources (especially financial), low farmer involvement and continuation with the projects. However, one must also take cognisance of the fact that for most of the technologies listed in the database the respondents did not provide any evaluation data. Many of the projects and programmes identified in this study indicated a need for regular government funding in order to continue. This includes the financing of technology development, adaptation and transfer. Often regular funding is required to maintain the infrastructure, purchase inputs or new crops and stock, and enable expansion to other rural sites. This suggests that these particular projects are not sustainable in themselves after technology transfer i.e. they require ongoing financial support. The study also indicates that some agricultural oriented projects initiated in the 1970s, 1980s and 1990s received funding from the Government's Poverty Alleviation Fund during the earlier part of this decade. Such information illustrates that it is unlikely that many of these initiatives are able to continue without external funding and support. There are of course others that illustrate that such technology-oriented poverty reduction initiatives do work and enable people to improve their lives. However, these are rare and require closer scrutiny.

Evaluation of programmes and technology-oriented poverty reduction initiatives is generally difficult as often poor records are kept or baseline data for comparison purposes is not available. In this study we got very little access to evaluation reports (one was received while some organisations said they had too many and we would need to visit them and read the reports at their offices – financial constraints prevented this option). Many of the reports focused on the evaluation of the development of the technology rather than on the impact of its application with small-scale farmers. Other reports indicated how the agricultural structural environment (policy, funding and practice) is far from conducive to the upliftment and support of the poorer farmers. However, during the interviews some information was provided that allows a very tentative assessment of the various initiatives identified. It must be borne in mind that a large number of technologies were recorded and entered onto the database. Given this high number and the fact that neither an extensive nor an intensive evaluation was a requisite of this study it is only possible to report on some general trends that emerged during the course of the study.

Irrespective of the shortage of evaluation reports a serious complication to any evaluation are the different criteria used in the agricultural sector during such processes. Public sector agricultural researchers tended to focus on the quality and performance of the technology they had developed or introduced based on research station results. If technology transfer was the activity then the success of this was determined by the usefulness of the technology to a number of participants. However, once the technology transfer process was stopped, further evaluation was seldom conducted. Consequently, it is unclear whether farmers continued or discontinued with the technology and why they did so. Often inputs were provided during the technology transfer process and the stopping of this provision at the end of the process prevented farmers from continuing to use the technology.

The private sector often considered an initiative to be successful if it increased market share of sales of seed, plant material and other manufactured inputs. Increase in market share was seen as a direct indication of the quality and effectiveness of the technology. While this may suggest that the technology is useful to farmers it can be distorted by the lack of further information such as the availability of alternative technologies and observation of farmers' actual use of this technology. For example farmers in remote areas might only have access to a specific brand and cultivar of seed or plant material. Their access to variety is limited, as is their choice, and often they are unaware of alternatives. This is a result of their remoteness and reliance on others for provision of technology. Availability is influenced either by the presence of technologies that are favoured by commercial producers in the area, cost of technologies or because this is what extension officers purchase on their behalf.

Technology transfer was often assessed in terms of the number of sites where technology projects were implemented and/or the number of people trained in the use of the technology. Many of these interventions were not monitored over time (often due to insufficient finances) to gauge sustained use of technologies. Similarly the numbers of people trained says nothing at all about the numbers of people who are able to and do use the technology after training.

Some organisations considered the continued use of the technology over time, annual increase of land under cultivation and confirmation by users that it was benefiting them as a means of evaluation of the programme/projects effectiveness. Gauging this over time along with numbers of participating farmers was also a strategy used by a few organisations, but given the cyclical nature of small-scale and even emerging farmer involvement this type of evaluation is also considered problematic. Farmers' involvement in evaluation, based on their criteria is probably the most effective strategy although again cyclical engagement in agriculture could distort the results. Based on the interviews, it seems likely that those organisations which not only disseminated and provided support with regard to the technology, but also provided other services such as credit, transport and market access could provide more realistic evaluations of the benefits of their technology. Rainman Landcare Foundation was able to use these criteria in its evaluation as was Monsanto. However, Monsanto noted that sustained use of its transgenic crops was more likely achievable by well supported emerging farmers than by small-scale farmers who could not afford this technology. Consequently the small-scale farmers would opt for conventional seeds as they were cheaper or would use a mixture of their own landraces and conventional seeds. If support is stopped, it is possible that farmers might not fair so well, but this is still to be seen. While markets, credit facilities and ongoing extension support and advice are often provided to projects initiated by the private sector seed companies and NGOs it is impossible to expect South Africa's current extension service to be able to do this on a nationwide basis. This is one of the reasons why alternative and appropriate technologies that suit farmer's needs and requirements are of enormous importance.

Those technologies listed on the database are generally cited by the respective technology development organisations as being successful. However, it is clear that such assessments do not involve any deep analysis of contribution to poverty reduction. In order to do this greater cooperation is required amongst natural scientists and social scientists in the development and transfer of technology. Previous studies along a similar line (HSRC 2004 and HSRC 2006) raise concerns about sustainability of projects should donor funding cease. Many projects are expensive to initiate, are capital intensive and require ongoing financial support for maintenance. For example, the Mechanisation Centre project in the Western Cape is making a difference to the lives of many farmers but is seemingly unsustainable. Farmers are unable and in some cases unwilling to pay the required fee for hiring tractors and implements. This fee should cover the costs of maintenance and replacement of the tractor and implements. However, seven years later and farmers are still not paying even half of the recommended fee in 2001. This begs the question as to whether the design and implementation of such projects are suitable for poverty reduction and how is poverty reduction actually measured. An analysis of programme partners indicates that almost no social scientists are involved in the technology development and transfer process for those technologies provided in the database. Based on this it is unlikely that technologies have actually been evaluated for their impact on poverty reduction. Consequently, such an assessment is unlikely based on the current information. Many respondents note that technologies are aimed at improving/increasing yield and/or quality of produce. This is used as a synonym for poverty reduction. The assumption is that increased yield and quality means increased food supply and can also mean increased income from agricultural activities. However, this is not necessarily the case as improved technologies may increase costs, so increased yields cover increased production costs and there is no real benefit. Similarly, increased yields often results in a decrease in farm gate prices so in a worse case scenario a loss in income might occur.

In a country like South Africa, where consistent water supply is a problem to most small-scale and semi-subsistence farmers technologies that increase the availability of water (storage tanks, mulching, etc.) would be of use to the poor as this would improve their ability to irrigate crops out of the rainy season. Also they could irrigate crops in times of drought. Soil conservation and reclamation technologies (increasing organic matter content, bio-fertilisation and composting) would also be of use to farmers as would similar practices that invoke permaculture principles. Low-cost technologies that reduce the vulnerability of the poor to extreme climate changes such as flash-floods and droughts would benefit the poor over the long-term. The development of low-cost drought tolerant food crops would be particularly useful to poor rural households if the seeds could be saved and planted in subsequent seasons. In many parts of South Africa the lack of access to water means that households can only plant foodcrops during one season every 12 months. The presence of poor soils in many of these areas means that the yields for this season are in any event lower than could be expected.

The current study identified a number of general constraints experience by technology developers and extension/advisory personnel. These are as follows:

- Technology development projects are threatened by lack of sustained financing, even when the technologies themselves are not expensive;
- Expansion curtailed by budgetary constraints, inadequate transport and lack of skilled personnel;
- Technology development was severely hampered by lack of sufficiently trained research staff;
- Farmers are generally poor, having insufficient access to financing and other resources to make optimal use of some technologies, so while they are effective on station they do not perform well on farms and plots;
- Sometimes farmers, research and extension/advisory services found it difficult to collaborate and this hampered both technology development/adaptation and subsequent implementation;
- The requirements of farmers (especially the poorer farming households) are not understood. There is a general trend to supply farmers with what is known and available than to focus more directly on farmers' specific needs and agricultural practices.
- Developed technologies could not be effectively implemented in certain areas due to infertile soil, lack of sufficient water and climate variations in the form of severe periodic droughts and floods.

While trying to obtain information on technology initiatives it became apparent that in many PDAs research and extension directorates were not aware of what one another were doing. For example research directorates were unable to advise us on the technologies disseminated by the extension services. There seemed to be a lack of central integration between directorates, both at provincial and national level. However, some people in PDAs, DoA and the science councils seem to take the initiative in co-jointly developing handbooks, manuals and media that can be used to disseminate technology to farmers. This study did not look at these but was more interested in manuals and literature when they were included along with physical technology dissemination. Technology in the forms of booklets, manuals, etc., does exist and government is attempting to make it available to extension officials and farmers via publications as well as via electronic media. Extension officials are tasked with distributing such manuals to farmers and farming households. Examples include various booklets on fruit and vegetable crop production developed by the ARC and published by the DoA. Unfortunately, this information is not always in the appropriate language and many of the farmers cannot read the guidelines. The ARC's InfoToons is another type of manual whereby technology is transferred in an animated form making it more available for the less literate. However, nothing can make up for the benefit of practical demonstrations and examples.

On the upside there are a number of technology oriented projects that have overcome various structural and other constraints, ultimately making a change to people's lives. Understanding of these projects and their processes could lead to understanding of the factors that lead to apparent success. However, this requires a more detailed assessment, which falls outside the scope of the current study. Further assessment of all projects could also be done, where this is warranted, in order to understand the effects of the constraints identified. It should further be realised that poverty takes many forms and that the effectiveness of some of the technologies identified in the database are often constrained as a result of the different facets of poverty and also the different reasons for technology development such as increasing yields rather than reducing vulnerability. Often a number of agricultural or natural resource management technologies need to be implemented in an ordered fashion before a particular technology such as improved plant or livestock quality and quantity can be realised. Furthermore integration with other service providers engaged in development is important as there are a number of factors contributing to poverty which agricultural scientists and service providers cannot and do not address. Only for a few of the technologies listed die respondents mention the use of an integrated approach, and this was in the form of agricultural technologies rather than collaboration with other development organisations.

4.3.4 Conclusion

Comparison of the literature review with other findings of this study indicates that many similar technologies are being developed in South Africa and the rest of Africa. In this study many of the technologies are spillover or are based on adaptations of technologies for the large-scale commercial sector. Because spillover technologies are generally more prevalent we tentatively conclude that most technologies are benefiting the emerging farmers rather than the poorer farmers and farming households (small-scale and semi-subsistence). Transgenic crops, for example, are only being used by the emerging farming sector, which a review of surveys suggests are a very small group (somewhere in the region of 4-8% of all Black farming households.

There is also evidence that some spillover technologies such as exotic vegetable crops reach poorer farming households by way of community garden projects. What is of interest here is that at home many of the members of such projects do not use these crops or follow the conventional farming practises used at the projects, as these are considered too expensive to be done without government support (Hart and Vorster 2007). In fact most women resort to traditional food crops and use traditional (local) knowledge based practices (ibid). Despite this anomaly, community garden projects are numerous and are a key component of the food security strategy of the extension services of many PDAs. It is likely that this strategy needs some further assessment and revision.

Soil and water conservation technologies in various forms are relatively plentiful as a specific technology aimed at the poorer farming households. This is largely based on South Africa's water constraints and very arid soils, especially in the former homeland areas. This is were most of the poorer farmers reside and the areas are often subject to droughts, flash floods, erosion, overgrazing and the depletion of natural resources. In many cases these technologies need to be introduced before other technologies, such as improved livestock breeds and improved crop varieties can improve farmers' circumstances in anyway.

The data obtained during the study suggests that science councils, PDAs and others seem to be gradually focusing on technologies that might have a significant and positive impact on the lives of rural people. This is evident from the number of technologies that are recorded in the database and the many people who are receiving and using them to various degrees. These technologies are apparent in the database. However, there is a tendency to focus more on emerging farmers (the better-off) than on the truly poor. This is probably due to the fact that existing technologies can be more readily adapted to the former group. Where technologies are focusing on the poorer farmers and rural households, this is often hampered by a lack of research and extension capacity, and the lack of sufficient financing. It is also hampered by the periodic engagement of households in agriculture, which is often one item on the portfolio of livelihood strategies. This does not mean that the technologies listed in the database are not effective in what they do and it is likely that many of them make a positive contribution to farmers' lives at present. If not, it is unlikely that farmers would remain involved in these activities for long periods. What is questionable is the sustainability of some of these activities if the current support mechanisms are removed and the likelihood of further dissemination given the lack of capacity and resources that hamper most PDA extension services (DoA 2005).

The study also suggests that it is very uncertain if policy makers in agricultural and the service providers understand the various dimensions of poverty and if agricultural research in its current form – still concerned with increased yields rather than stability or consistent yields in marginal areas – can effectively address the needs of poor farming households. While the international Future Harvest Centres of the CGIAR and research institutes in other countries have included social scientists in their work this has not been the case in South Africa. This study found virtually no presence of social scientists as partners or collaborators in technology development and dissemination activities. These scientists contribute widely to agricultural development in other countries and towards understanding issues such as motivation, choice, poverty and cultural dynamics.

A criticism could be levelled that agricultural technology-oriented poverty initiatives in South Africa are not on a par with those in other developing countries. However, it is the feeling of the research team that this would be over critical given South Africa's history. What is evident is that in the past 13 years the country's researchers have come out of isolation and made significant inroads into addressing the requirements of small-scale and emerging farmers in South Africa. While this has been more evident in some scientific disciplines (water engineers for example) it is likely to increase in other disciplines as the necessary capacity is achieved along with a greater understanding of what is required by the poorer farming households. Social scientists can help bridge the gap between poorer farmers and natural scientists and policy makers. Engagement with and support for farmers in this sector is not easy, as limited funds prevent agricultural service providers from reaching the remote areas where they reside. If poverty reduction is the future focus of agricultural research then it is imperative that these remote areas are reached and appropriate technologies are developed for them based on their requirements and circumstances. Failure to do this will be a failure of agriculture to address the needs of the poor.

4.4 Energy

4.4.1 Introduction

Data collection on energy technologies mainly focused on areas that have a limited supply of electrification due to not being connected to the Eskom electricity grid. Most of the rural areas in South Africa are faced with this problem and there have been initiatives either by the government (provincial and local), the private sector (social responsibility projects), foreign donors and education institutions to provide this "basic" need to such areas. The programmes explored in search of information on energy technologies, consists mainly of energy used by households or programmes that have specifically targeted households instead of institutions, except for the Department of Minerals and Energy's (DME's) school-based and clinic-based projects.

In searching for information on the energy technologies in rural South Africa, provision of lighting, cooking, thermal purposes, space heating, cooling and income generation activities were explored. For lighting, solar home systems and mini-grid hybrid programmes have been highlighted. Cooking and heating energy technologies are also mentioned and how these benefit households.

It was difficult to source information from different organisations and government departments implementing such projects. Some people did not respond to the information requests making it difficult to complete the database and the interview schedules. It proved most difficult to source information from DME because of the lack of a proper system and capacity in developing a database of all the initiatives in place around the country. Some programmes or projects that were initiated some years ago and paid for by DME are no longer in place because of lack of technical support. The Department has also not made efforts to track the progress of such projects.

4.4.2 Literature review

Bassey (1992) groups energy into three main classes, namely commercial energy which consists of oil, gas, coal and hydro-electric power; traditional energy in the form of fuelwood, charcoal, agro-waste and animal power; and renewable energy like solar, wind, ocean and wave power and small-scale hydro. These are forms of energy that are also obtainable in rural areas. The use of renewable energy in rural areas presents the opportunities for sustainable rural electrification. Hegazi (1992) and Davidson et al. (*2007*) point out that the system can help provide power for lighting, water pumping, communications and refrigeration as well as cater for small rural firms.

In a review of the energy problems in rural areas, mainly in Asia, Pachauri and Mehrotra (2001) point out that recent technological advancements in renewable energy technologies (RET) has made alternative energy sources such as solar panels, biogas and windmills more available and less costly. Their study indicated that these alternative energy sources have numerous advantages:

- Provide better lighting which enables them to stretch their period of economic activity;
- Saves the environment from further degradation and gives it an opportunity to regenerate;
- Combining afforestation, agroforestry and energy efficient devices can create a sustainable fuel-use system in rural villages and sustain the ecological balance;
- Reduced dependency on fuelwood and other fuel sources reduces women's labour and drudgery by reducing the distances travelled to collect fuel;
- Improved cook-stoves and biogas benefit human health by reducing or eliminating respiratory and eye infections;
- Alternative energy sources aid income generation, for example by furnishing energy to small-scale agriculture and industry, through the sale of energy and equipment to local utilities, and the maintenance and repair of energy devices; in India biomass gas is used to dry horticultural produce while solar heating panels are used to meet the demand for hot water in hotels and hospitals.

Pachauri and Mehrotra (2001) conclude their review by calling for appropriate policies, market mechanisms, finance and the development of local capacity to support the introduction of RETs which are adapted for the needs of rural communities.

The other challenge is taking stock of the available information on rural energy. In this regard Karekezi (1992) states that obtaining information on the energy sector in rural areas is typically a difficult exercise. In many countries the best one can do is derive a snapshots of the situation, which fails to give the 'dynamic and fluid nature of rural energy'. This problem has continuously led to poor access to data regarding rural technologies. The result is that the performance of energy technologies are poorly understood. In the table below we show some of the needs by rural people that require energy and the technology that is used.

Table 4.1: Technological needs of rural inhabitants

Type of activity	Identified need	Available energy technology
Food preparation	Cooking, drying, processing	Woodstoves, solar energy, diesel-powered equipment
Health maintenance	Provision of portable water, refrigeration	Wind pumps
Agriculture & village industrial production	Irrigation	Micro-hydro

Karekezi, 1992

Concerns about the use and availability of energy resources became acute in the 1970s during the "oil shock", raising the public awareness of the need for renewable energy. Among many considerations were micro-hydro plants for electricity generation and shaft-power, biogas for cooking and lighting, wind-powered equipment for water pumping and electricity generation, direct solar energy devices, photovoltaic equipment for refrigeration and communication and grid electricity for providing power to rural agro-processing and manufacturing areas (Karekezi 1992).

Coal deposits are becoming more and more expensive to exploit. At the same time, the burning of coal for electricity generation has been identified as a significant source of carbon dioxide emissions associated with the greenhouse effect and the resultant climate change (Juma et al. 2005). Renewable forms of energy therefore are more sustainable. The question is whether rural areas can benefit from the use of renewable energy, and whether there might be economic spin-offs – say in manufacturing – as the demand for these technologies grows.

A major constraint in the development of energy technologies lies in human capacity. Without the necessary skills developing countries are forced to source these from outside their borders, particularly from the developed world. Foreign personnel represent a financial drain on host developing countries, with serious implications for extending energy use to rural areas where energy is critical to poverty reduction (Davidson 2007).

South Africa grows sizeable sugarcane areas. Sugar cane can thus be used to produce ethanol. Juma et al. (2005) point out that Brazil benefits greatly from producing ethanol and consequently ethanol-only cars. This did not only help to increase rural incomes but has helped to reduce dependency on foreign oil. Lessons from ethanol use led to the development of flex-fuel in Brazil in 2003; by the end of 2004, 20% of new cars in Brazilian used flex-fuel. Like Brazil, South Africa can greatly reduce rural unemployment, increase rural incomes and reduce dependency on foreign oil supplies. On the other hand, concerns are being raised as to the economic and environmental advisability of large-scale bio-fuels programmes. The current upward trend in international food prices has been positively linked to the international move towards bio-fuels (von Braun 2007), because a certain amount of land dedicated to bio-fuels production was previously planted to food crops; the resulting food price inflation are most keenly felt by the poor, including the rural poor. As for the environmental concerns, to the extent some of the land currently devoted to bio-fuels production was rather cleared from grasslands or forests, the net impact is an increase rather than a decrease in greenhouse gasses (Fargione et al. 2008 and Searchinger et al. 2008). The inference is that 'renewable energies' are a heterogeneous category, with some more benign than others.

Be that as it may, Botswana presents a case where improving the supply of energy to rural areas has long been identified as a rural development priority. Realising the fact that 80% of the Batswana population lived in rural areas, in 1985 the Botswana government introduced the Sixth National Development Plan. With regards to energy, the Plan aimed at maintaining and increasing sources of energy to rural people. Attendant to that was to make people accountable for the cost of delivery. The process included the electrification of the farming area of Tuli Block and other villages. The Plan also looked at increasing renewable energy, for example solar heating to reduce the reliance on woodfuel and the environmental degradation associated with it.

The Department of Minerals and Energy (DME) in South Africa has followed the Botswana example in providing solar energy for people living in rural areas. An ambitious pilot project was developed in the late 1990s in which service providers were appointed to install stand-alone solar home systems for rural households. These were partly paid for using subsidies from the DME and the households pay for the service they receive from the appointed service provider on a monthly basis (ERC 2004). Similar to the Botswana case study, the progress with provision of this type of electricity has been very slow because of households' lack of finance to meet the costs for monthly payments. Although it is government's plan to have a sustainable energy mix that will benefit people's livelihoods, progress of the programme has been hindered by high costs hence bringing uncertainty to the service providers and consumers.

In Tanzania, the introduction of the biogas generator, adapted from India, had remarkable results. Its makers were able to create employment and earn incomes, fuel costs were reduced to zero and deforestation was greatly reduced while it saved villagers time collecting firewood. The biogas generator did not only provide jobs and incomes; it enhanced local skills. Co-operatives and individual entrepreneurs sprang up in the vicinity of Arusha (Roberts 1979).

Roberts (1979) explains that the technology was adapted to meet the felt needs of the local population. Instead of using wood and charcoal as fuel, the villagers turned to the use of the biogas generator as a source of cooking fuel. As the technology was expensive for the rural Tanzanian, it was adapted to be affordable to the people. The technology was adapted to running with manure. Manure from two cows proved enough to satisfy the fuel needs of a family of eight persons over a period of forty months with semi-annual servicing.

In South Africa, the Department of Minerals and Energy (DME) classifies energy technology as indicated in the table below.

Table 4.2: Classification of energy technology

Non-electrical (TWh)		Electrical (TWh)	
Thermal	*Mechanical*	*Liquid fuels*	*Electrical grid*
Biomass	Hydro	Bio fuels	Solar
Solar	Wind		Wind
			Biomass
			Hydro

Source: adapted from DME, 2005

DME believes that technological transfer should assume a holistic sustainable approach. This approach implies linking all three spheres of sustainability – the environmental (biophysical), economic, as well as the social. In this regard, technology transfer implies that (2005):

- Environmental sustainability should be ensured; i.e. integrate principles of sustainability into country programmes and reverse the loss of environmental resources and/or the environmental impact associated with the specific RE technology in this case;
- Targets on how to use energy resources efficiently should be set; and
- Energy efficiency should be considered in all functions and activities and that energy waste should be reduced.

Ensuring sustainability of energy use is believed to have the potential to affect the following areas (DME 2005):

- Reduce crime – renewable energy for lighting of dark areas especially in rural areas
- Economise on household energy costs – use of passive solar design measures, as well as solar water heating and cooking could significantly improve livelihoods
- Promote economic growth, development and poverty alleviation – renewable energy opportunities (for example installation of pylons) could lead to local economic growth
- Conserve natural resources – renewable energy provides an alternative to using natural resources for basic household needs, as well as commercial and industrial applications.

4.4.3 Analysis

The data collected on energy technologies for this study explored energy for different end uses such as lighting, cooking, small business development, and poverty alleviation and employment opportunities in the rural areas.

The energy programmes and projects captured for the purposes of this project reveal a modest number of technologies that are developed and used in rural areas. These are presented below by means of six case studies.

Case studies

Restio Energy

Restio Energy has energy projects running in KwaZulu-Natal that provide alternative energy solutions to households and businesses. They get funding from overseas for such projects. Their latest project explores the Productive Use of Renewable Energy (PURE) whereby they provide solar systems and communication facilities to people in rural areas running their businesses from shipping containers.

They have the intention to develop mini-grid hybrid systems in rural areas and have completed a feasibility study for such work. They have developed partnerships within the energy sector with other organisations that develop energy technologies for the purposes intended for rural communities. Their projects are evaluated throughout but such documents are not available for external use.

Energy Technology Unit, Cape Town University of Technology

The ETU was developed in 2004 and started the worlds' first solar sewing station in the Northern Cape. The project has helped families with job creation and has provided energy to an area that was not previously electrified. The ETU has plans to develop affordable domestic refrigerators that will use solar energy, new generation geysers, and solar systems for the community. As it is an academic unit, most of the technology is developed by students and staff or partner institutions. Monitoring of their projects is done by their sponsors annually and the evaluation reports are available online (http://staffnet.ctech.ac/uken), however some reports are confidential and meant only for clients.

Parallax

Parallax has been in the energy sector since 2002 with the intention of providing energy services to rural households. This has been done through the provision of Solar Home Systems (SHSs) and alternative sources of energy such as LPG where possible.

In one of their projects in rural KwaZulu-Natal, Parallax has provided 88 families with SHSs with an output of 55Wp, a 6kg gas cylinder, and 2-plate gas stove. Parallax trained local people to provide maintenance and technical services to the community and to deliver and refill the LPG canisters. The project was partly funded by USAID and DEAT and community members paid a monthly service fee for three years where after they would own the energy technologies provided. Unfortunately, Parallax has declined to provide detailed information on this and other initiatives.

Department of Minerals and Energy (DME)

The DME has various energy projects that are using technologies meant for service provision and poverty alleviation throughout the country. By May 2005, the DME had electrified 232 287 households, 50 clinics and 2 233 schools. At the time of the interview, the DME could not confirm the number of households that have been electrified in rural areas and urban areas separately. Most of the projects in rural areas are done using grid electricity, where there is capacity to do so. These are fully funded by the DME, which gives the funds to Eskom. Some of the households, schools and clinics are electrified using non-grid electricity, either SHSs or a combination of alternative and renewable energy sources.

These projects are often difficult to maintain and sustain due to various challenges. An example of such a project that was visited partly for this study is that of Lucingweni village in the Eastern Cape, about 60 kilometres from Mthatha towards Port St Johns. The DBSA spent R9 million on the installation of a mini-grid hybrid project whereby 210 households were to benefit from the technology. This project was launched in 2003 with the purpose of providing off-grid electricity using solar panels and wind turbines from which the energy generated was stored and later distributed to households. It was envisaged that the system would provide an equivalent of up to four hours of electricity per day to each household connected to it.

Although the system was working well at first, on the last evaluation of the project by the DME in 2006, it was found that the system was malfunctioning and there was no technical support provided for such failures. The installing company was no longer contracted to support the system and there was no local knowledge and capacity to take care of it. This led to a lot of frustration by the community, and at a rapid rate more than half of the 125 photovoltaic panels were stolen. One reason why people were unhappy with the project was the perception that because of the project's existence, Eskom would never connect the community to the grid. Presumably this concern was particularly strong among the households who were not benefiting from the project. At some stage following the 2006 evaluation, DME had the rest of the solar panels removed to prevent them from being stolen. The community is again left without electricity.

Other initiatives have been implemented by DME in various rural communities. In 1999, the DME together with foreign donors funded the installation of SHSs through a concessions programme. Service providers were identified to install stand-alone SHSs in rural households that would not be receiving electricity from Eskom in the next 10-15 years. These were identified by Eskom and the installations began. The funds were used to subsidise the households in getting this technology using a fee-for-service model. Households pay up to R60 towards maintenance and service of a system which provides sufficient power for four lights, a small TV, a small radio and a cell phone battery charging facility. A few problems have been encountered since the beginning of the programme whereby households have not been able to pay the monthly fees which has led to the removal of the systems from their homes. Although the programme started out with six companies that were identified as service providers, only three are currently in place.

Solar Engineering Services

Solar Engineering Services (SES) has established and run successful projects in KwaZulu-Natal, particularly in the Valley of a Thousand Hills where they have developed a programme that explores different alternative energy services for a rural community. Amongst other things provided by SES are bio-digesters, treadle pumps, and solar systems for schools and clinics. The communities benefit from these for the provision of energy for cooking with the use of bio-digesters to the use of water pumps for community gardening. The programme has a number of funders but the community is also encouraged to generate an income by using the technology for their benefit. The community members can also purchase their own solar systems through a community-run trust using loans to finance those in need. The project has been evaluated through by the University of KwaZulu-Natal and other partners.

Agama Energy

Although appointments were made with Agama Energy representatives, it was difficult for them to honor these. They submitted the interview schedule with the information for the database.

Agama is a consulting and implementation organisation that provides renewable energy services to rural areas. They are currently working on a project that provides biogas for thermal purposes such as cooking. They aim to install up to 2 million of these 5m3-60m3 size biogas plants for households. Other work that Agama does involves other energy interventions such as solar in other African countries, energy production at abattoirs, and investigating methane conversion for South African energy purposes.

Agama Energy has also conducted a feasibility study for the Ministry of Development Co-operation in the Netherlands for funding purposes of a South African National Rural Biogas energy project that will be carried out for the DME which in turn will co-fund the project. The potential implementation of the project is most likely in the rural areas of the three provinces, namely Eastern Cape, KwaZulu-Natal and Limpopo.

4.4.4 Conclusion

The energy sector does not have many technology types specifically designed for rural poverty eradication and economic development. The technologies tend to be too expensive and programmes and projects often have to be wholly funded or at least significantly subsidised. Even when the technologies are in place, it becomes difficult for the end users to sustain it if there is no technological support in place, hence a few projects that have introduced alternative energy sources in the rural areas have failed. Some of the implemented programmes fail because the ownership of the initiative is not made clear from the beginning hence no accountability.

In the programmes that were explored for purposes of the current study, it was found that most of the technology was specifically designed for the particular energy output and end uses. Some of the smaller projects were meant to be pilots at first to test the technology and upon its success to implement at a larger scale. The Solar Home Systems programme is one of these where it first started in a small area and then spread to the most impoverished rural areas in the country.

The number of programme beneficiaries depends on the size of the project, its take-up by the community and the type and amount of funding that it receives. The state-funded programmes tend to reach a larger number of beneficiaries than those implemented as private initiatives.

Management of these projects and programmes is mainly in the hands of the implementers or consultants that are appointed. This takes place during the implementation phase and most of the time, projects on a small scale are given over to beneficiaries, e.g. communities, schools (Department of Education), clinics (Department of Health) and municipalities, if they have the needed capacity. Where there is lack of capacity and technological know-how, it becomes a problem to sustain such programmes.

In small rural communities, the energy projects have achieved providing basic energy services for households and much needed institutions such as schools and clinics. In some projects, the technologies have been used to give skills to the local communities, whilst at the same time providing economic improvement for business people in the area.

Some of the constraints include not being able to use the technology to its full capacity as there are no resources to do this. Some communities get frustrated at such technologies and end up vandalising them because of the lack of service that they are getting. As a recommendation, it would be best to provide such technologies with the aim of giving skills to the local people and municipalities so that they can solve technological problems when they arise. Ownership and responsibility of the programme must also be made clear at the planning stages so that those involved can be accountable and take full responsibility when the need arises.

In conclusion, the energy sector data on technology used in the rural areas is limited. Although the literature review points out that there is potential for different energy technologies to be used, as it is happening in other African countries, South Africa still lags behind. Technology such as hydro electricity production on a small scale does not stand a chance especially in the rural areas where there is often shortage of water and infrastructure to generate energy. Although most of the programmes are specifically designed for the beneficiaries, it should be emphasised that there is a need to skill people on how to handle technological problems. The failure of development efforts with regards to technology transfer relates to what Castells (1989) refers to as "endogenous capacity" as discussed earlier on. This proves that without training local people to service and maintain the technology, efforts at development are likely to come to naught.

In collecting data it was clear that there is lack of information dissemination about development and technology initiatives in rural areas. The leading sector department such as the DME lacks capacity to systematically collect data on such programmes so that it is easy to find the information for referencing. The other problem is that the programmes are implemented in silos instead of integrating them to other development initiatives by the communities, funding agencies, municipalities and even corporate organisations delivering their social responsibility initiatives.

4.5 Small-scale mining

4.5.1 Introduction

Small-scale mining in South Africa represents an emerging sector, yet in other countries in the world – and indeed in Southern Africa – it constitutes a large, well-established sector that makes major contributions to local and national economies. However, South Africa has in common with most of these other countries the fact that support to small-scale farmers is sparse, and that one of the areas most lagging in respect of that support is the making available of appropriate technologies.

4.5.2 Literature review

'Small-scale mining' does not have a generally agreed definition, but the most commonly used parameters for classification of the scale of a mine are the number of employees and the gross annual turnover (HSRC 2004). The South African Small Business Act of 1996 lists criteria for each industrial sub-sector in terms of number of employees, total annual turnover, and total assets, according to which a small business is classified as micro, very small, small, or medium (Mutemeri et al. 2002 and Labonne 2003). In South Africa, 'small-scale mining' could therefore be defined as a mining activity employing less than 50 people and with an annual turnover of less than R7.5 million, however in practice and for purposes of this section, much of what we mean by 'small-scale mining' is well below this threshold, e.g. 'artisanal mines'.

Small-scale mining is widespread, employing over 13 million people in the developing world. Moreover, it is becoming more common as an economic activity, complementing more traditional forms of rural subsistence earnings (Labonne 2003). Dreschler (2001) estimates that the SADC region alone hosts about 1.5 million small-scale miners – about a quarter of whom are women – and that in some countries (e.g. Tanzania and Zimbabwe) informal small-scale miners outnumber those employed in the formal large-scale mining sector. According to Svotwa and Sibanda (2000), between 1990 and 2000, the number of small-scale miners in Zimbabwe tripled.

In post-1994 South Africa, four distinct categories of small-scale miners can be identified (HSRC 2004):

- Formal, well-organised operations using simple to sophisticated technologies, operating within the legal framework and making reasonable profits
- Semi-formal operations of groups of miners who have organised themselves to form sustainable ventures

- Informal and sometimes illegal mining using very basic technologies, chiefly as a means of self-employment among the poor
- Service providers who are mostly formal and well-organised and who provide services to mining operations ranging from technical mining-related activities to business consulting services.

Although there is anecdotal evidence of growth in South Africa's small-scale mining sector – partly as a result of changes in the legislation governing mining operations coupled with various Black Economic Empowerment related initiatives, and presumably partly as a response to job loss in the formal mining industry -- it is difficult to place a figure on its size or these trends. In 2000, Dreschler estimated that for South Africa, there were roughly 10 000 small-scale miners, presumably most of whom fit third category, i.e. self-employed in the informal sector (Dreschler 2001: 5). However, the Labour Force Survey of March 2004 did not pick up a single rural small-scale miner, and only a few thousand urban-based ones. This is contrast to 60 000 in Mozambique, 350 000 in Zimbabwe, and 550 000 in Tanzania. Thus South Africa's involvement in small-scale mining is relatively modest, suggesting that it may have a great deal to learn from its neighbours if it does indeed decide that the promotion of small-scale mining represents part of a broader anti-poverty strategy.

Small-scale miners are involved in various kinds of activities ranging from diamonds, gold, platinum, coal, clay, sand and so forth. However, according to (Mutemeri et al. 2002), in South Africa there seems to be a bias towards gold and diamonds, with activities concentrated in the known mineral regions of the country, e.g. gold in the green-stone belts, diamonds in the alluvial deposits of the Northern Cape and North West, and coal mining in Kwa-Zulu Natal and the Eastern Cape (Mutemeri et al. 2002).

Although small-scale mining contributes towards poverty reduction and economic development of developing countries, small-scale miners face a number of challenges, including lack of skills (technical and business), lack of appropriate and safe technologies, insufficient institutional support, bureaucracy, and lack of access to markets. In many countries where small-scale activities are present, the necessary services are made more accessible through government programmes.

On the specific issue of technology, Dreschler summarises his findings in respect of small-scale mining in the SADC region as follows:

> "Technical support & appropriate technology dissemination has been main task for many development organisations (e.g. Intermediate Technology Development Group). Machinery and mining equipment is usually developed for medium to large-scale mining operations and is not always fitting for small-scale mining. Old and outdated machinery and mining

> equipment used to be (and still is) exported from industrial countries into developing regions following the paternalistic argument that *"for them, it still can do..."*. Nothing could be more wrong. This equipment was developed to match the situation in the 70s and 80s, when the industrial countries' mining sector faced a desperate lack of labour force and extremely high labour costs, while at the same time financial capital for investments was not an issue. Therefore, mining equipment was developed to save human labour at any cost.
>
> "Unfortunately, this machinery is found in Southern Africa's small and medium scale mining industry where in some cases unemployment is as high as 50% and labour costs are extremely low. At the same time investment capital is not at all available to the miners. It is therefore necessary to develop technology appropriate to the scale of mining operations, but as well according to the special needs of the region." (Dreschler 2001: 17)

On the question of what kinds of appropriate technologies are the greatest priority for supporting small-scale miners (bearing in mind the huge diversity of types of small-scale mining operations in the region), Dreschler goes on to say:

> "Appropriate minerals processing is obviously the weakest spot within small-scale miners technology skills. In the industrial minerals sector minerals processing is the most important part of a mining operation in order to match market demand and to optimise profits. Minerals processing is also mainly responsible (rather than the mining itself) for environmental damages." (Dreschler 2001: 17)

Some attempts at introducing improved technologies for the benefit of small-scale miners have been well-intentioned but ineffective. Dreschler cites the example of a project conducted by the Intermediate Technology Development Group (ITDG) at the request of the Government of Malawi. The purpose of the project was to improve the efficiency of lime burning, thereby enhancing incomes and slowing the destruction of local hardwood forests.

> "Unfortunately, the cost of the kiln...was well beyond the reach of individual artisanal lime burners. A high degree of entrepreneurial and managerial acumen is required to run the kiln at full capacity and efficiently. The introduced technology was therefore not taken up and lime burners continued to use their traditional and fuel inefficient box kilns." (Dreschler 2001: 11)

Some of the most successful interventions have in fact been institutional rather than technological. In Zimbabwe, for example, the government made a deliberate attempt to improve market access for small-scale gold miners, as well as introduced specialised credit instruments, supported miners' co-operatives, etc. In South Africa, most of these measures are absent; some assistance with accessing foreign markets is available through the Department of Trade and Industry, however most artisanal miners are unaware of this.

In keeping with Dreschler's observation noted above about the particular importance of processing technologies, one of the biggest challenges associated with small-scale mining is the health risk related to the extraction of gold from gold-bearing ore. For example, in much of Africa where small-scale miners mine gold, mercury is used for amalgamating gold, with adverse health implications for the miners (Hilson et al. 2006 and HSRC 2004). It is unclear whether this is primarily a technological or an institutional challenge. On the one hand, non-mercury-based technologies available to large-scale mining operations could in principle be downsized for use by small-scale gold miners; on the other hand, it may be that the most efficacious approach is to determine models and systems whereby small-scale gold miners do not attempt processing themselves, but rather are offered reasonable prices based on fair and objective measurement of the value of the ore they supply to larger-scale processors. However, according to the Mintek case study in the following subsection, it seems there has been recent progress in respect of technological approaches.

At an international level, the Association for Responsible Mining (ARM), launched in 2006, is promoting responsible and safe mining practices and at the same time seeking to discourage conflicts that revolve around the diamond trade. The Certified Green Gold Programme, one of the programmes which receives support from ARM, provides support to underprivileged mining communities by sponsoring fair trade and mining practices. Through the support of this programme, metals are sold to both local and international fairs. The Green Gold Certification has enjoyed wide acceptance by beneficiary communities and by the traditional miners in general (www.communitymining.org/piloteng.htm).

However, generally speaking, efforts to improve conditions in most cases have been too few, too unambitious, or poorly designed and executed. Interventions are designed without sufficient interactions with miners and have thus led to the adoption (or non-adoption) of inappropriate and ineffective technologies. The small-scale mining sector has the potential to grow and contribute positively towards economic development of countries if more effort is placed on appropriate support strategies (Mwaipopo et al. 2004 and Hilson et al. 2007).

4.5.3 Analysis

For purposes of this study, the team contacted a number of mining companies regarding their activities in respect of technological transfer to small-scale miners. Based on the few that responded, it appears that mining companies are by and large not involved in such initiatives. To the extent they have corporate social investment programmes, the activities in these programmes are unrelated to mining as such.

The case studies that follow, therefore, related on the one hand to the activities of a parastatal, Mintek, and a provincial government department in Mpumalanga.

Case studies

Mintek

Mintek is a parastatal that focuses on various aspects of the mining industry. It has a division called Small-Scale Mining and Beneficiation (SSMB) where small-scale mining programmes are run. Mintek is involved in both development and transfer of technology to the most underprivileged areas of South Africa which are also labour-sending areas. By 2004, Mintek had trained over 2000 individuals in its various programmes.

Mintek's SMME activities can be divided into minerals mining and clay mining. The iGoli plant within the premises trains people in using mercury-free gold extraction techniques and makes the intellectual property freely available to beneficiaries in the country and in Tanzania as well. The technique helps miners to, among other things, determine exactly how much gold they produce. This helps them against unscrupulous gold dealers who tend to prey on small-scale miners. Other mining activities run by Mintek include a small diamond panning plant near Lichtenburg and a sandstone feasibility study aimed at reviving the sandstone industry in Qwaqwa (Mintek 2006).

Clay mining involves mining and testing clay for use in pottery and/or brick-making. At Mapuve village in Limpopo a group of 21 women were trained in using the technology in their pottery. A ceramic factory was opened in Grahamstown but it collapsed resulting in job losses. Mintek is currently in discussion with the local municipality in that area to re-open the factory (Mintek 2006). It is not clear how or what led to the failure of the factory.

'Rock flour' is produced by means of grinding igneous rocks, such as basalt, and mixing the powder with cattle manure. Rock flour can be used as fertiliser instead of commercial chemical fertilisers; it offers the normal benefits of manure, while the inclusion of the powdered rock corrects for some of the acidifying properties of manure. So far, a mill has been started at Giyani and trials are being made on vegetables (Mintek 2006).

Small-Scale Mining Programme, Mpumalanga

The Department of Economic Development and Planning of Mpumalanga has a "Small-Scale Mining Programme" through which it seeks to assist small-scale miners to obtain authorisation to start mining businesses, and to access funding for operations and appropriate machinery. In respect of machinery, the programme seeks to ensure that miners are supplied with machines which have already been developed but which are more likely to appropriate to the scale of operations of small-scale miners, e.g. small-sized crushers and ball mills, and small James tables which are used to sift minerals. Where access to the electrical grid is lacking, miners are also assisted with appropriately-sized generators. Miners receive training via the Mining Qualification Authority on how to operate these machines.

Individuals or groups of people who are interested in mining and also have identified areas of potential mining, may approach the Department for assistance in terms of getting authorisation to do mining. The Department takes them through the process of applying for mining license, and then puts them in touch with possible funders such as the Development Bank of Southern Africa (DBSA), the Community Based Private Partnership Programme (CBPPP) and DME. The funding is given during the first three years of operation with the expectation that mining operations will be sustainable from that point.

The Department works closely with Mintek's Small-Scale Mining and Beneficiation division which, depending on the size of the mining operation, may design machinery suitable for that particular operation. The Council for Geo-Science assists with the provision of geological data. Local municipalities are also involved with the provision of water, land and electricity. Currently the programme benefits five small-scale mining projects located in Albert Luthuli Municipality, Makhaseni Municipality and Mbombela Umjindi Municipality.

4.5.4 Conclusion

South Africa's small-scale mining sector is small relative to that of most other countries in the southern African region. It is only recently that the potential of small-scale mining to contribute to poverty reduction is being explored. While the legal hurdles to small-scale mining have largely been removed, there remains a long way to go before the potential of the sector can be properly gauged. One perspective is that the potential of small-scale mining is naturally limited by the fact that the large-scale, formal mining sector is so large and well-established in South Africa. What could be the comparative advantage of small-scale miners in such a scenario? Part of the answer to this question is evident in the case studies, where some of the activities undertaken by agencies seeking to support and promote small-scale miners are unrelated to traditional mining activities, or seek to create and cater to markets in which traditional mining houses are not interested. This underpins the role of technology in promoting the small-scale mining sector, since these initiatives tend to involve the development and transfer of new technologies. As for whether artisanal gold and diamond mining will ever grow significantly beyond their current modest size, that is unclear. What one can say with certainty is that, to the extent these activities are already a source of livelihoods for poor rural South Africans (the precise number of which is unknown, not least because of the previous illegal status of most such activities), there are measures that can and are being put in place to make them less hazardous and more remunerative.

4.6 Information and communication technologies

4.6.1 Introduction

Developments within the field of information and communication technologies (ICTs) have improved access to information and effectively shortened travelling distances, thereby reducing the 'cost of doing business' and contributing to the growth of economic opportunities. Most of the impact of ICTs on poverty is indeed indirect and difficult to trace with rigour; either ICTs contribute to general economic growth, which means more people absorbed into the employment; or it facilitates communications and access to information in such a way that small-scale entrepreneurs are able to function more effectively. Arguably the most visible pro-poor use of ICTs in contemporary South Africa is the introduction of computers in schools, and in multi-purpose community centres. While initiatives such as these are no doubt laudable, they remain rather far from the focus of this study, which is on poverty reduction by means of enhanced production, rather than via the longer term impacts of better education or more computer-literate public. However, one very visible direct impact of ICTs on development in this sense is the manner in which the cellular phone industry has facilitated the development of SMMEs, even in former Bantustan rural areas. Whether there might be many other such examples we are not sure – unfortunately, this study suffered greatly as only one service provider was willing to share information with the research team regarding relevant initiatives.

4.6.2 Literature review

ICTs, as represented by for example telephones, computers and the internet, have impacted on all sectors of society. Roy (1984) points out that ICTs have in fact become the major force driving contemporary globalisation. Economically they connect consumers and producers, but in principle can also facilitate access to information to promote the political and social integration of disparate communities.

Although their study does not differentiate between rural and urban areas, Tlabela et al. (2007) point out that most of the ICT technology in South Africa is concentrated in major cities where there are higher incomes and good infrastructure. The fact that ICT technology is concentrated in urban areas is also supported by the study conducted by the World Bank (2008) on technology diffusion (see figure below).

Figure 4.1: The pace of technological diffusion in urban and rural India

Source: World Bank, 2008

In the South African situation, about 33% of households have access to ICTs, 24% to landlines, and 14% to computers (see table below). However, the figures are not additive, particularly in that most of those with computers are most likely among those having phones, and many people have both cellphones and landlines. The situation for black rural areas is not clear, but Tlabela et al. indicate that it is dramatically worse than for urban areas.

Table 4.3: Household access to various forms of ICT

Province	% Cell-phones	% Land-lines	No. of MPCCs*	No. of CSTs**	% PCs	% Internet	No. of PITs***	No. of libraries
Gauteng	48.7	28.5	16	21123	25.2	20.0	78	215
Limpopo	26.1	7.1	9	9272	4.4	3.0	91	32
Free State	33.9	21.8	4	6008	10.3	7.3	74	136
Mpumalanga	26.3	17.6	5	5485	7.6	5.5	75	90
KZN	35.2	31.7	6	12521	13.3	8.2	80	205
Northern Cape	20.0	20.0	4	850	9.8	3.9	52	101
Western Cape	46.7	55.3	12	5791	33.8	23.4	70	237
Eastern Cape	25.7	15.9	4	8205	7.9	5.5	94	141
Northwest	35.3	15.0	6	4755	9.9	5.0	84	85
National	*33.1*	*23.6*	*66*	*74010*	*13.6*	*9.1*	*698*	*1242*

Source: adapted from Tlabela et al. 2007

*Multi-Purpose Community Centres

**Community Service Telephones

***Public Information Terminals

Having said that, the transfer of ICTs to poor communities has led to a range of opportunities. These are new kinds of work, life-long opportunities of learning, consolidation of democracy at grassroots, community informatics, obtaining work opportunities, access to phone within reasonable distance. They also state that access to ICT is not without constraints. Among these, although they provide no detail, they refer for example to: content and language, social relevance, and literacy. It is nonetheless clear that the use of PCs and Internet for example require some level of literacy. In the table below, we provide some preliminary oversight of the extent to which ICTs are available in the country.

The present availability of telecommunications technology in various areas was made possible by the passing of the Telecommunications Amendment Act of 2001 which compelled service providers to make this service available to as many people as possible. The Act required for example that each service provider roll out a specific number of units of Community Service Telephones (CSTs) to under-serviced areas. Telkom was required to roll out 120 000 CST payphones, MTN 7 500, Vodacom 22 000 and Cell C 52 000. The Telecommunications Amendment Act of 2001 also provides for Under Serviced Area Licences (USAL) to be issued to SMMEs and thus facilitating the creation of job opportunites (Tlabela et al. 2007).

These kinds of technologies can be made available either through individuals or SMMEs. But telecommunications is accompanied by its own problems, as shown in the following table:

Table 4.4: Examples of technology and attendant problems

Technology	Problem
Fax machine	Can be costly Recipient to have fax
Photocopy machines	Copyright infringements Paper availability
Telephones	Recipient to have a phone Long distance calls expensive Theft of cables
Computers	Constant changes in technology Software may not be readily available Availability of technicians and programmers
Internet	Needs to be paid for – can be expensive Reliability of information Slow access in other places Relevancy of information Higher levels of literacy required

Adapted: North Central Regional Educational Laboratory, 1997

4.6.3 Analysis

The four main telecommunications companies in South Africa each play a role in supporting the establishment of SMMEs, including in rural South Africa. Although the Telecommunications Amendment Act obliges them to meet certain targets as mentioned above, in fact it is unclear whether they would not to a large extent be doing the same thing just in terms of pursuing what appears to be a viable business model. The SMMEs in question consist of public telephones, whether landline or cellphone based, operated by entrepreneurs either in stand-alone kiosks or together with other enterprises, e.g. laundries or cafés. In some instances the businesses are conducted in zozo huts specifically designed for the purpose, or in specially adapting shipping containers. These businesses are usually owned by individual members of communities, rather than by 'communities' in some corporate sense. Lately the industry has introduced both solar and battery-operated portable instruments.

Case study – Vodacom's Community Services Programme

Through its Community Services Programme, for example, Vodacom has made available over 100 000 entrepreneur-managed public cellphones nationally, many of which are situated in the 4 300 shipping containers that it has distributed. Vodacom describes all of these phones as being within 'under-serviced areas', but is unable to indicate what share are in rural areas. The Programme includes provision of phones, vouchers and airtime dispensing devices.

Vodacom regards as partners those entities they do business with. For example, Psitek which manufactures handsets, Cointek which manages the recharging system and PD Nixon and Hawstone who supply the containers. It is these partners who also play a crucial role in identifying technologies to be developed and places to locate them.

Vodacom makes the telephone equipment and containers available for the use of selected entrepreneurs, but they remain Vodacom's property. Service operators only have to purchase airtime to get started and undergo basic training. This suggests that there are no huge entry constraints in this industry for the SMMEs. In many cases, a single entrepreneur may operate two or more containers, but in this case she must hire employees to main a physical presence in the additional containers. Vodacom directly monitors its profits per entrepreneur, underlining the fact that, the Telecommunications Amendment Act notwithstanding, its motivation is primarily profit-driven, presumably mainly directly from the kiosks, but with the bonus of the expanded market share and exposure they promote.

Vodacom intends to make available internet and fax facilities in all its containers where the infrastructure allows this. Constraints include the fact that operators have low levels of computer literacy relative to what would be desirable to successfully run internet facilities. Theft of phones is currently a major problem for Vodacom. However, there are no problems experienced with the technology itself, so to this effect, we can say that the SMMEs presently have no problems using the technology applicable in the industry.

How large or small is this contribution to the rural economy? This is very difficult to say, not least because we do not know how many employment opportunities are represented by these 100 000 Vodacom public phones, nor how many of these are rural-based. Assuming for sake of argument that half of these phones are in rural areas, and that a single entrepreneur/employee manages six instruments, then it represents about 8 300 employment opportunities created in rural areas. Supposing that Vodacom accounts for about a quarter of the collective contribution of telecommunications companies that operate according to a similar model, the total job creation in rural areas is in the order of 33 000. It is not enormous, but is about three times as large as our rather rough estimate as to the number of small-scale miners there are in the country. Arguably more significant than these direct employment opportunities is the service that is rendered to 'under-serviced communities,' but as indicated above, venturing the tangible significance of this goes beyond the ambit of this study.

At another level, it would have been interesting to know how OpenSource is functioning. The Department of Communications (DoC) and CSIR are having a major role in the development of this exercise. The question would be, as far as this study is concerned, to understand the extent to which OpenSource reaches the rural areas of South Africa.

4.6.4 Conclusion

In spite of the difficulty indicated earlier that only one service provider made itself available to assist in the study, we can positively say that the ICT industry is having a noticeable economic impact in rural areas. General observations show that there are indeed many SMMEs operating in the field of telecommunications. The result, one can positively conclude, is that rural areas are economically and socially less isolated today than they were twenty years ago before the advent of cellular phone service providers in particular. Economically, rural people have also found opportunities to boost their economic standing – either as employees or as employers in their own right.

4.7 Manufacturing

4.7.1 Introduction

Since the 1990s, a consensus has emerged that, although the development of agriculture is and always will be vitally important for rural development, much of the scope for improving rural livelihoods in fact lays in the promotion of rural non-farm enterprise (Reardon et al. 2006). To some extent this emerging consensus is based on the increasing awareness as to the *current* importance of non-farm enterprises in rural areas; in light of the fact that land is increasingly in short supply and that agricultural incomes are risky, the suggestion is therefore that much of the possible future growth in rural areas will be based in non-farm/off-farm activities.

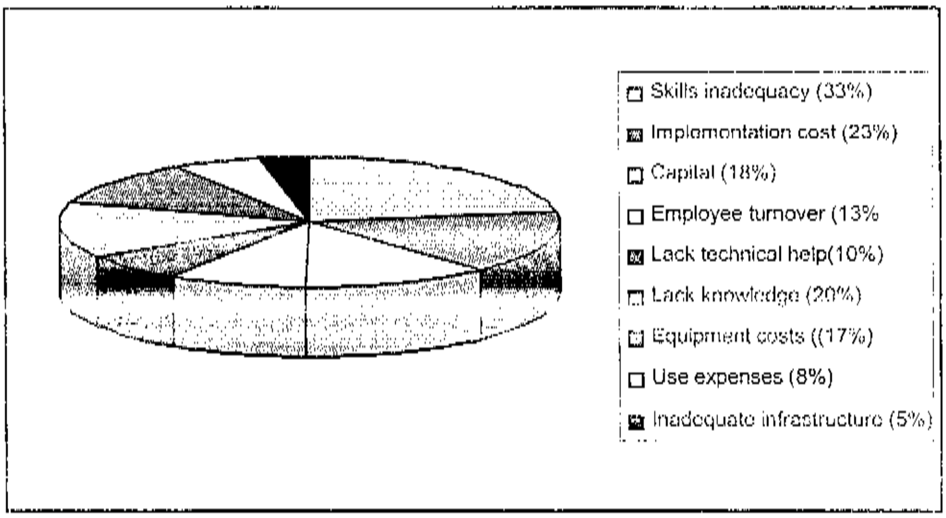
Presently, much of this rural non-farm enterprise is in commerce, i.e. petty trading, the value-addition of which and returns to which is very modest. The question therefore is where more vibrant non-farm economic activities can be introduced, and in particular those for which being rural is not a crippling disadvantage. The prototypical example is agro-processing, which consists of manufacturing activities which take advantage of being located close to the site of primary production.

4.7.2 Literature review

Manufacturing can be divided into two types, namely production of capital and of consumer goods. With relevant technology, and all other things equal, both lines of production can occur in rural areas, though in reality the likelihood of the latter is considerably greater.

Manufacturing uses a variety of technologies depending on what is being produced. The technology for example that is used in the making of furniture cannot be the same as that used in wine making. Notwithstanding these differences, there are basic kinds of technology that are common to all firms – big or small. High-speed telecommunication is one example. Using the USA experience, Gale (1996) explains that in the industrial machinery and equipment industry, the use of advanced production technology is about 25% higher among rural plants than the overall average, but about 34% below average in lumber and wood products (primarily saw mills) and leather products. Many rural-oriented industries (food and tobacco, textiles, apparel, and lumber and wood products) are among the lowest in using advanced production technology. Gale (1996) refers to specific areas that are constraining the use and adoption of technology by rural industries. These constraints are indicated in the figure below.

Figure 4.2: Technological constraints in manufacturing



Source: adapted from Gale, 1996

At a continental level, the manufacturing sector in Africa is in general performing poorly and contributing far too little to job creation:

> "The small manufacturing sector in many African countries is a symptom of a bigger problem: the lack of private investment in large labor-intensive firms, especially those producing for export. Investment in Sub-Saharan Africa as a percentage of GDP was only 19.8 in 2006, compared with 36.3 in Asia, 23.1 in the Middle East, and 27.3 in other emerging and developing countries (IMF 2006). Low investment is a reflection of two factors: (a) low domestic savings rate, which creates a very small source of capital for domestic investors, and (b) low foreign investment outside natural resource enclaves. Furthermore, low foreign investment means

> low technology transfer, impeding productivity improvements and higher wages....
>
> "In other low- and middle-income countries, exports have created new urban jobs. The share of manufacturing in total exports in China is 88 percent, in Bangladesh 92 percent, in India 77 percent, and in Morocco 64 percent, while for African countries the share is 15 percent." (Fox and Sekkel 2007: p.7)

However, for purposes of this exercise, the focus is not on the means of encouraging industrial-scale rural manufacturing (that is more the province of incentive strategies such as those devised by the Department of Trade and Industry), but of 'group', household, or individual-level activities.

First, on the genesis of rural manufacturing, the generic story is that it is not a function of rural dynamism, but more typically of desperation:

> "Falling agricultural labor productivity, low opportunity cost of labor, and declining household purchasing power induce diversification into low-return, labor-intensive nonfarm activities, such as basket making, gathering, pottery, weaving, embroidery, and mat making. Specialized nonfarm enterprises and households emerge, not to exploit potential productivity gains, but because of an absence of opportunities in agriculture and a shortage of investible capital. Declining economic conditions likewise motivate labor migration in search of more favorable opportunities elsewhere" (Haggblade et al. 2005: p.161).

Moreover, to the extent rural households may venture into manufacturing (i.e. if they don't simply migrate), this is not the only option, and it may well be supplanted by other developments:

> "Contrary to conventional wisdom..., service sector income is often more important than rural manufacturing. In spite of common emphasis on rural industries, manufacturing typically accounts for a minority of rural nonfarm income, except in the most hinterland areas. For example, in rural El Salvador, service sector jobs are twice as prevalent as small-scale manufacturing jobs. In poorer zones and among poorer households, however, labor-intensive household-based manufacturing may predominate, as with beer brewing in much of Africa, production of straw products in Andean zones and weaving in Northeast Thailand.
>
> "One often sees a march of diversification first into self-employment manufactures (for example food processing and preparation), and then into wage-employment in manufactures, then self-employment in services

(such as petty commerce, bicycle repair, and so on) and then wage employment in services such as transport, teaching, truck or farm equipment repair. As a result, at the start of a long growth process, one often sees manufacturing self employment dominant, and at the end, services wage employment dominant..." (Reardon et al. 2006: pp.7-8.)

Does this imply that there is no point in seeking to expand opportunities in rural manufacturing in South Africa and the region? Not necessarily, however it worth noting that ultimately the long-term potential of any such strategy is limited. Meanwhile, the tangible short-term challenge of stimulating rural manufacturing lies in addressing two main constraints: relatively higher costs (e.g. transport and communications) in conjunction with thinner markets. As mentioned above, the comparative advantage of rural dwellers in respect of manufacturing is with agro-processing, as well as with certain crafts that make use of natural resources such as wood and stone. To what extent are existing initiatives contributing to these challenges by means of promoting technologies?

4.7.3 Analysis

According to Statistics South Africa's Labour Force Survey of March 2006, of the 3.1 million black South Africans employed or self-employed in the informal sector in that year, only about 175 000 (5.5%) were active in the manufacturing sector. Of these, about 82 000 – just under half – were rural-based. This compares to 410 000 rural dwellers involved in trading activities, and 106 000 in construction. In other words, rural manufacturing is not a major activity at present, though it is possible that some such activities were (mis-)classified as agricultural.

Of the 11 manufacturing programmes in the dataset produced for this exercise, DST funds more than three-quarters, and most of these are implemented by CSIR. While to some extent this could be a function of the incompleteness of the dataset, it almost certainly also suggests that DST is a very important player in this particular area. Most of these projects, not surprisingly, are in agro-progressing, e.g. production of essential oils, leather beneficiation, etc. A small handful involve beneficiation of materials yielded from mining, as mentioned in sub-section 4.1 above.

A number of DST-funded and CSIR-implemented projects were examined and analysed in the course of earlier HSRC studies for DST (HSRC 2004, HSRC 2007) (see Box 2.1 for some general comments). To summarise a lengthy analysis, the greatest weakness of many of these projects is their 'projectness', i.e. the fact that they are designed as projects that attempt to function as businesses, but which nevertheless have (and suffer from) many of the trappings of group projects. Put another way, the technologies promoted through these initiatives in the manufacturing sector – while arguably involving a scaled-down version of industrial technologies – are nonetheless designed for groups rather than households, and thus struggle with issues that are typical of group projects. By way of contrast, most agricultural technologies promoted in the cause of poverty reduction, are designed for household-level use, which is consonant with the dominant mode of production of poor and emerging farmers. Returning to the data from the Labour Force Survey, of those employed or self-employed in the informal rural manufacturing sector, 85% work in enterprises comprising four or fewer workers; in fact 62% consist of a single lone entrepreneur. While it may be that the 'projectness' of interventions in the manufacturing sector is a way of seeking to overcome the limitations associated with micro-enterprise, they are introducing elements that are incongruous with the way most small-scale manufacturers choose to operate. The problem perhaps is that for manufacturing, there is a relatively high lower threshold that is practicable for many or most remunerative manufacturing processes, which makes it difficult to find candidate poor households or individuals who can reasonably be expected to manage them on their own. Thus of the 11 programmes manufacturing programmes in the dataset, perhaps only one requires some sort of group entity in order to function within the ambit of conventional delivery strategies.

As for whether there are alternatives, indeed there are but they appear to be rarely attempted. As in the example of the essential oils projects described in Box 2.1, the size of the group project management problem was exacerbated by the fact that the project involved not only the processing facility but the production of essential oils plants themselves. HSRC (2007) suggested that an outgrower models – whereby the processing facility would purchase plant material from independent producers – would reduce the management burden, and potentially increase the pool of people benefiting in some manner from the project, as well as bringing the use of the plant to somewhere closer to capacity. More discussion of the question of business model is provided in Box 4.3.

Box 4.3

The many projects that assume the form of 'income generating projects' are generally very different in structure from spontaneously emerging SMMEs. The issue is not merely one of size (spontaneous SMMEs tend to be smaller), but of structure, with income generating projects typically structured as collective enterprises, which as frequently as not encounter serious management problems and fail to wean themselves from direct outside support. There are in fact at least three distinct business models evident among the income-oriented projects that were included among the case studies, and it is useful to dwell on their differences. First, there are income generating projects that are structured as collective enterprises and which are not infrequently characterised by internal conflict and a lack of dynamic entrepreneurship. Second, there are projects in which common infrastructure and facilities are used by effectively independent individuals; these projects often struggle with the management and maintenance of the common infrastructure, not least because of the financial costs involved and a lack of sense of 'ownership.' And third, there are projects in which two distinct entities partake in a symbiotic relationship, whereby the one is responsible for the collection and delivery of raw materials, and the other for the processing and marketing.

To illustrate this third model, the Aloe Ferox project involves a single central processing facility, which draws on raw aloe material (bitters and leaves) collected by independent, widely dispersed tappers and harvesters. The introduction of the facility has provided a better market than that on which the tappers and harvesters previously depended, and it also creates a mechanism through which the tappers can receive training and, indeed, benefit in other ways. It is also worth noting that the tappers/harvesters sell their material to the Aloe Tappers Co-operative, of which they collectively own 90%. The Co-op in turn sells the bitters and leaves to the pre-processing company, which owns the other 10% of the Co-op, and in which the Co-op itself has a 10% stake. Thus the fact that the collectors are not employees as such does not necessarily mean that they are not organised, nor that they do not have an ownership stake in the different aspects of the enterprise.

The virtue of this third model is that it allows for a large number of people to benefit without the need to create a large, unmanageable entity. It maximises the expression of entrepreneurship -- not only is the core processing facility managed in an entrepreneurial fashion, the suppliers of the raw materials operate as entrepreneurs in their own right, and yet still typically enjoy a more stable and remunerative market than they did previously. Unlike the other models, it is not as apt to be burdened by 'free riders.' Whether this model could be applied more commonly instead of some of the others is not altogether clear, but in principle it could especially be applied where there is a possibility of building on people's existing economic activities, rather than merely introducing new ones.

A general observation we can offer is that sometimes the choice of business model and choice of technology can be made more or less independently, but in general this is not the case, or at least it *should* not be the case. It appears that a common problem is that the business model and the technological package do not complement one another.

Source: adapted from HSRC 2004.

Case study – the 'Incubator Programme', Mpumalanga

The Incubator Programme was initiated by the Department of Trade and Industry and handed over to the Mpumalanga Department of Economic Development for implementation. Under this programme, incubator centres are established in various peri-urban communities in the province, which are fully equipped with machinery for the manufacture of stainless steel products and furniture. The establishment of these centres is determined by the availability of minerals in that particular area. For example, the furniture technology centre which has been established near White River focuses on wooden furniture that can make use of nearby timber resources. Apart from the physical infrastructure and materials, the funding covers salaries of managers who are employed permanently to run the incubators, and fees for service providers who are contracted to provide specialised training.

Only ten people are given chance to participate in an incubator centre within an 18-month period. Within this period, incubator participants are equipped with business skills, marketing and also utilising the machinery from the centre to generate their income. After 18 months, they have to exit the centre since at that time it is believed they have acquired necessary skills and funds to start their own businesses. According to the Department of Economic Development, the centres are working well, although the 18-month is proving to be rather brief in terms of getting the participants to a point where they can operate independently.

Figures as to the exact number of 'graduates' of the centres were not made available to the research team. For sake of argument, if one assumes (generously) that on average there are 50 graduates from all of the centres per year, and that, furthermore, all of these graduates succeed in establishing and sustaining their own enterprises and each hires four people, then the total impact over five years is in the order of 1250 employment opportunities. Whether or not this represents value for money (financial data were also not made available) is unclear, but one can reasonably discern that, while laudable, the overall collective impact of the incubator programme is probably very modest, especially given that there are already over 20 000 informal operators in the manufacturing sector in Mpumalanga.

4.7.4 Conclusion

The rural small-scale manufacturing sector is characterised by a contradiction, whereby the primary mode of project-based approach through which technology transfer is promoted is out of sync with the manner in which most informal rural manufacturing enterprises are organised. In fact, by and large these projects seek to introduce new enterprises, rather than assist existing manufacturers improve the operations that they already have. The main alternative appears to be intensive training programmes – as represented by the Mpumalanga based incubator case study – but here the project is that the overall reach of the programme remains modest if not minimal.

It may be that even if one were able to identify more efficacious modes of delivery of manufacturing technology to rural areas, the overall longer-term prospects for the sector are dim. Among other things, international experience suggests that rural manufacturing is rarely a long-term, large-scale prospect, even where rural non-farm activities grow in prominence. An entirely different point of view, however, is that the function of rural manufacturing – and in particular agro-processing – is not for the direct employment opportunities it may create, but as a means of stimulating demand for agricultural products, which is an area in which there clearly remains much room for expansion. This is the notion of 'reverse linkages' (see e.g. Haggblade et al. 2005: p.168). If this is the case. however, then a more holistic strategy needs to be developed and put into place. Such a strategy is not presently on the horizon.

5 Conclusion

The overall objective of this study was to provide baseline information in respect of the technology-oriented initiatives that seek to promote economic development and contribute to poverty alleviation in rural areas of South Africa. Six specific economic sectors were identified as areas of investigation.

At a general level, the literature review revealed that technology is the main driver of economic development and poverty reduction, not only in the developed world but also in the developing world. In this respect, however, South Africa represents an anomaly: within the African continent, it is among the most technologically advanced, and yet due to extreme inequalities inherited from the pre-democratic era, the benefits of its economic wealth are not widely shared. The question then is, to what extent can technology assist those who have been left behind, if not to 'catch up,' then at least to be less poor than they presently are? The overall impression generated by this report is that technology does hold out some promise of contributing to the fight against poverty, but that, with the singular exception of the agricultural sector, there is not nearly enough going on, even taking into account the awareness that the database produced as part of this exercise remains incomplete. Within agriculture, on the other hand, it is debatable how significant is the contribution of the current stable of activities; the diligence in procuring technological improvements does not appear to be matched by actual poverty reduction.

We conclude with a number of general reflections, based in part on the content and analysis presented in the previous sections of the report, but at least as much on the process of obtaining the information upon which the report is based:

- *Accessibility of information.* The difficulty of accessing information from government departments and officials was striking. Apart from the obvious fact that there exists a need to develop ethos on sharing information, it suggests an ironic and generally sub-optimal working environment for those who share common goals, namely using technology to promote better rural livelihoods: ironic in the sense that, after all, this is a pursuit that is itself largely about producing and using information; and sub-optimal in that it frustrates efforts to learn what is and is not working, what has and has not been tried, etc.

- *Institutional knowledge management.* Some of the difficulty of accessing information was simply due to the fact that officials whom the team contacted are busy and sometimes struggled to spare the time to either be interviewed or share documentation. However, at least as often it appeared to be the case that relevant officials do not possess written information at hand. This would imply that many government departments in particular do not have sufficiently strong institutionalised systems for generating, storing, and retrieving information, all of which we would subsume under the general heading of 'institutional knowledge management'.

- *Monitoring and evaluation.* While programmes and projects exist, there is little telling of what works or does not work as monitoring and evaluations do not seem to be conducted, or if they are, they are poorly done. In the majority of instances, no records are available especially at provincial level. This deficiency makes it difficult to understand how provinces function if they cannot provide records of what happens in the districts for example. As with the paucity of available factual information mentioned above, it suggests a sub-optimal pattern for a sector that seeks to deploy knowledge and technology towards the public good.

- *Indigenous knowledge.* Very few programmes are dedicated to or even make casual use of indigenous knowledge. This happens despite the existence of specific focal areas of research by the NRF and DST on indigenous knowledge.

- *Markets and business models.* The literature review shows that developing technology without taking appropriate measures to ensure markets exist is self-defeating. A related concern is that of business models; to the extent projects serve as vehicles for promoting technology transfer, they typically are based on business models that may or may not be suitable to the economic environment in which they are trying to operate. The value of the technological package may be obscured by problems that have nothing to do with the technology itself, or worse, the technological package may have been tailored to particular business model which is fatally flawed.

- *Massive agricultural programmes.* This study found that the agricultural economic sector has a relatively massive number of programmes and projects that are aimed at technology transfer, while other sectors lag behind. While the importance of agriculture cannot be down-played as a major sector in rural development, it would appear that too little is happening in other sectors.

We therefore conclude this study by stating that South Africa is on the right track in terms of technology transfer. However, there is still much that needs to be done. As said above, there exist a huge number of agricultural programmes aimed at technology transfer, but the need now is to intensify the efforts in other economic sectors. More so because those agricultural programmes have not managed to reverse the poverty situations found in rural South Africa in particular. The development of other economic sectors will further ensure better service delivery in rural areas, and as the African Peer Review Mechanism (APRM) (2007) points out, people should not leave rural areas because these lack essential basic social services but should do so on the basis that they can economically contribute better elsewhere. To this end, technology transfer appears to be part of the solution.

Appendix: Summary tables for SADC member states

Table A.1: Economic and Demographic Indicators

Country	Gross Domestic Product (GDP), 2004E (Billions of U.S. $)	Real GDP Growth Rate, 2004 Estimate	Real GDP Growth Rate, 2005 Projection	Per Capita GDP, 2004E	Population 2004E (Millions)
Angola	$20	12.2%	14.4%	$1,381	14.8
Botswana	$9	5.4%	4.8%	$4,852	1.7
Comoros	$0.4	1.6%	2.8%	$579	0.6
DRC	$6.0	5.7%	6.0%	$110	54.8
Lesotho	$1.5	4.4%	4.8%	$682	2.1
Madagascar	$3.7	4.7%	5.5%	$211	17.4
Malawi	$2.8	3.6%	4.5%	$248	11.2
Mauritius	$6.3	4.1%	4.3%	$5174	1.2
Mozambique	$6.0	7.3%	6.1%	$305	19.2
Namibia	$5.0	4.4%	3.8%	$2,524	1.9
Seychelles	$0.7	-2.0%	0.5%	$8,348	0.1
South Africa	**$213.1**	**3.7%**	**4.0%**	**$4,562**	**46.7**
Swaziland	$2.0	2.1%	1.8%	$1,772	1.1
Tanzania	$11.0	5.7%	5.8%	$266	42.1
Zambia	$5.0	4.6%	4.8%	$489	10.7
Zimbabwe	$3.9	-4.3%	-1.4%	$296	13.2
Regional Total/Average	$296.4	[illegible]	4.5%	$1,985	[illegible]

Source: Global Insight

Table A.2: Total Energy and Carbon Dioxide Emissions, 2003

Country	Total Commercial Energy Consumption, (Quadrillion Btu)	Total Commercial Energy Production, (Quadrillion Btu)	Net Energy Exports, (Quadrillion Btu)	Carbon Dioxide Emissions (Million metric tons of carbon)
Angola	0.135	1.960	1.825	4.34
Botswana	0.052	0.023	-0.029	1.04
Comoros	0.001	0.000	-0.001	0.03
DRC	0.080	0.112	0.032	0.49
Lesotho	0.007	0.004	-0.003	0.06
Madagascar	0.037	0.006	-0.031	0.61
Malawi	0.025	0.013	-0.012	0.22
Mauritius	0.052	0.001	-0.051	1.01
Mozambique	0.166	0.157	-0.009	0.47
Namibia	0.051	0.015	-0.036	0.63
Seychelles	0.016	0.000	-0.016	0.32
South Africa	**4.901**	**5.916**	**1.015**	**112.16**

Swaziland	0.021	0.011	-0.010	0.37
Tanzania	0.078	0.032	-0.046	0.96
Zambia	0.108	0.090	-0.018	0.61
Zimbabwe	0.189	0.136	-0.053	3.01
Regional Total	**5.919**	**8.473**	**2.557**	**126.33**

Sources: Energy Information Administration

Table A.3: Petroleum Overview

Country	**Petroleum Production, 2004 (Thousand Barrels Per Day)**	**Petroleum Consumption, 2004 (Thousand Barrels Per Day)**	**Petroleum Net Exports, 2004 (Thousand Barrels Per Day)**	**Crude Oil Reserves, 1/1/2005 (Million Barrels)**	**Crude Oil Refining Capacity, 1/1/2005 (Thousand Barrels Per Day)**
Angola	1,051.2	57.0	994.2	5,412.0	39.0
Botswana	0.0	13.0	-13.0	0.0	0.0
Comoros	0.0	1.0	-1.0	0.0	0.0
DRC	21.1	7.0	14.1	187.0	0.0
Lesotho	0.0	2.0	-2.0	0.0	0.0
Madagascar	0.0	12.0	-12.0	0.0	15.0
Malawi	0.0	6.0	-6.0	0.0	0.0
Mauritius	0.0	27.0	-27.0	0.0	0.0
Mozambique	0.0	11.0	-11.0	0.0	0.0
Namibia	0.0	23.0	-23.0	0.0	0.0
Seychelles	0.0	4.0	-4.0	0.0	0.0
South Africa	250.8	466.0	-215.2	15.7	439.5
Swaziland	0.0	3.0	-3.0	0.0	0.0
Tanzania	0.0	22.0	-22.0	0.0	14.9
Zambia	0.1	13.0	-12.9	0.0	23.8
Zimbabwe	0.0	18.0	-18.0	0.0	0.0
Regional Total/Average	**1,323.2**	**685.0**	**639.1**	**5,614.7**	**582.2**

Sources: Energy Information Administration, Oil & Gas Journal

Table A.4: Natural Gas Overview (billion cubic feet)

Country	**Production, 2003**	**Consumption, 2003**	**Reserves, 1/1/2005**
Angola	25.43	25.43	1,620
Botswana	0.00	0.00	0
Comoros	0.00	0.00	0
DRC	0.00	0.00	35
Lesotho	0.00	0.00	0
Madagascar	0.00	0.00	0
Malawi	0.00	0.00	0
Mauritius	0.00	0.00	0
Mozambique	2.12	2.12	4,500
Namibia	0.00	0.00	2,200
Seychelles	0.00	0.00	0

South Africa	**82.99**	**82.99**	**1**
Swaziland	0.00	0.00	0
Tanzania	0.00	0.00	800
Zambia	0.00	0.00	0
Zimbabwe	0.00	0.00	0
Regional Total	**110.54**	**110.54**	**9,156**

Sources: Energy Information Administration; Oil and Gas Journal

Table A.5: Coal Overview (million short tons)

Country	Production, 2003	Consumption, 2003	Reserves
Angola	0.00	0.00	0.00
Botswana	0.99	1.02	44.00
Comoros	0.00	0.00	0.00
DRC	0.11	0.26	97.00
Lesotho	0.00	0.00	0.00
Madagascar	0.00	0.01	0.00
Malawi	0.00	0.02	2.00
Mauritius	0.00	0.32	0.00
Mozambique	0.05	0.01	234.00
Namibia	0.00	0.00	0.00
Seychelles	0.00	0.00	0.00
South Africa	**263.78**	**187.76**	**53,738.00**
Swaziland	0.41	0.41	229.00
Tanzania	0.09	0.09	220.00
Zambia	0.22	0.21	11.00
Zimbabwe	3.74	3.53	553.00
Regional Total	269.39	193.64	55,128.00

Sources: Energy Information Administration

Table A.6: Electricity Overview (billion kilowatt-hours except where noted)

Country	Consumption, 2003	Generation, 2003	Installed Capacity, 1/1/2003 (gigawatts)	Exports, 2003	Imports, 200s
Angola	1.78	1.92	0.635	0.00	0.00
Botswana	2.26	0.94	0.132	0.00	1.39
Comoros	0.02	0.02	0.005	0.00	0.00
DRC	4.32	6.04	2.548	1.30	0.01
Lesotho	0.36	0.35	0.076	0.00	0.04
Madagascar	0.77	0.83	0.284	0.00	0.00
Malawi	1.21	1.30	0.303	0.00	0.00
Mauritius	1.81	1.94	0.655	0.00	0.00
Mozambique	10.46	15.14	2.392	9.50	5.88
Namibia	2.37	1.46	0.00	0.06	1.07
Seychelles	0.22	0.24	0.028	0.00	0.00
South Africa	**197.37**	**215.88**	**40.481**	**10.14**	**6.74**
Swaziland	1.16	0.39	0.124	0.00	0.80
Tanzania	2.96	3.15	0.862	0.00	0.03
Zambia	5.76	8.35	1.786	2.00	0.00

Zimbabwe	11.56	8.88	1.961	0.00	3.30
Regional Total	**244.39**	**266.83**	**52.272**	**23.00**	**19.26**

Source: Energy Information Administration

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