

FORESIGHT BIODIVERSITY REPORT

Foreword

By any estimation, South Africa is a biodiverse country. It is the only country in the world to have within its borders an entire floral kingdom (the Cape). In addition, it includes two globally significant biodiversity "hot spots" (the Cape and succulent Karoo regions), six Centres of Plant Diversity, two Endemic Bird Areas and the richest temperate flora in the world. Little wonder then that South Africa is recognised as one of the world's few "megadiversity" countries.

Given this spectacular biodiversity, it was entirely appropriate — but nonetheless prescient — that the Department of Arts, Culture, Science and Technology (DACST) decided to include biodiversity as one of the 12 sectors for the National Research and Technology Foresight Project. While South Africa needs to document and preserve its biodiversity as part of a global commitment, this resource also forms the basis of many enterprises that have great potential for sustainable economic growth. We need only think of the burgeoning ecotourism and trophy-hunting industries, rapid developments in the use of indigenous species as medicinal and food products, and the increasing acknowledgement that healthy ecosystems provide a wide range of ecological services that sustain society. Indeed, as pointed out in this document, biodiversity is central to many of the other sectors addressed in the Foresight Project, especially tourism, the environment and agriculture. And let us not forget that many of South Africa's rural poor depend largely on indigenous biodiversity to sustain their lifestyles.

South Africa is in an excellent position to reap the benefits of a strategic and focused research programme for biodiversity. The sheer magnitude of our biodiversity, manifested across levels from the gene to the biome, coupled with extremely high levels of endemism, provides unique opportunities. The relatively long history of scientific endeavour and the existence of many excellent institutions devoted to biodiversity research have resulted in a level of knowledge and understanding that is probably unparalleled in the developing world. Furthermore, with its diverse cultures and long history of human occupation, this country has a wealth of indigenous knowledge that has hardly been tapped.

This report is the first step in a process that will continue to provide strategic directions for the documentation and wise use of South Africa's biodiversity. DACST is to be commended for initiating the process; very few countries have had the foresight to recognise biodiversity as a core sector when establishing national research agendas. I would like to thank DACST for their support and forbearance. A special thanks goes to Phil Mjwara and our capable Sector Coordinator, Khungeka Njobe. I would also like to acknowledge the members of the Sector Working Group for their tireless efforts,

especially the Editorial Subcommittee members, Rob Anderson, George Davis, Brian van Wilgen and Rachel Wynberg.

Our report is the product of a process that was adopted and refined with enthusiasm. We look forward to seeing the speedy and effective implementation of our recommendations.

Prof. Richard Cowling

Chairperson

Biodiversity Sector Working Group

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Executive Summary

Biodiversity was one of twelve sectors in the National Research and Technology Foresight Project run by the Department of Arts Culture Science and Technology. This project was designed to identify national priorities in the field for the first two decades of the new millennium.

Participants in the exercise were selected by a process of peer nomination, with adjustment to correct for the biases of education, training and access to the forums of debate and development of the past. The work was done in a number of workshops comprising a series of predetermined development steps and methodologies tested in foresight exercises in other countries.

In the initial phases of the project, South Africa's current standing in the field of biodiversity as it related to research and technology was assessed, and compared to the global situation. Armed with this baseline information, the working group spent time developing a set of statements that covered all aspects of the sector that should be addressed in terms of national priorities for wealth creation and improvement of the quality of life in the country. A set of 71 such statements, grouped in 13 categories, was formulated and incorporated into a questionnaire for a Delphi survey. The questionnaire was then circulated to almost 900 targeted individuals, and the responses analysed by the working group. This process led to a set of recommendations for the development of biodiversity as a national resource. These were identified as follows:

- Developing and maintaining a basic inventory
- Monitoring global change and its impacts
- Developing strategies for conservation and sustainable resource use
- Identifying and conserving biodiversity in a system of protected areas
- Developing nature-based tourism in South Africa
- Valuation and value addition
- Developing equity and access to biodiversity resources
- Reducing impacts of development on biodiversity
- Developing capacity for managing biodiversity
- Integration of indigenous knowledge systems
- Developing biotechnology products.

A major impediment to implementation of these recommended actions is that responsibility for biodiversity-related issues are divided among several government departments, leading to inefficiencies and anomalies in resource management. The challenge identified is to overcome these hurdles in innovative ways by building on a sound base of scientific and cultural knowledge, for which a set of discrete steps with attainable objectives was outlined.

1. Establishment of a standing Reference Group, to be developed using the experience and insight gained by the Working Group.

2. Conducting of a national audit of current activities in the country with respect to the Working Group recommendations — especially insofar as biodiversity loss has negative impacts on the quality of human life in South Africa — and the human capacity that needs to be built for the effective management of biodiversity.
3. Development of the recommendations of the Working Group as funding priorities in all institutions that support biodiversity-related research.
4. Establishment of a funding mechanism involving inputs from the full range of stakeholder organisations.
5. Explicit identification of human capacity gaps in resource economics as a strategic tool for management of biodiversity resources, and the systematic addressing of these gaps.

Chapter 1: Introduction to Foresight and the Biodiversity Sector

1.1 Foresight: A proactive approach to the future

The National Research and Technology Foresight (NRTF) Project is an initiative of the Department of Arts, Culture, Science and Technology. It aims to systematically identify research and technology areas, as well as market opportunities that are likely to generate socio-economic benefits for South Africa in the long term (10-20 years). In particular, it seeks to—

- identify technologies and latent market opportunities that are most likely to generate benefits for South Africa;
- develop consensus among different stakeholders on future priorities in the selected sectors;
- coordinate research efforts between different players within the selected sectors; and
- reach agreement on those actions that are needed to take full advantage of existing and future technologies in different sectors.

The Foresight Project is South Africa's first priority-setting exercise in research and technology on a national scale. In this respect South Africa joins countries such as Japan, the United Kingdom, the Netherlands and France, all of whom have adopted foresight as a tool for identifying and setting priorities for future development. In other countries, such as Malaysia, Indonesia, and other industrially-based Pacific Rim countries, strategic planning is an intrinsic part of the development process, obviating the need for specific foresight exercises.

Box 1.1 Sectors selected for the National Research and Technology Foresight Project

Sectors

1. Agriculture and Agroprocessing
2. Biodiversity
3. Crime Prevention, Criminal Justice and Defence
4. Energy
5. Environment
6. Financial Services
7. Health

8. Information and Communication Technologies
9. Manufacturing and Materials
10. Mining and Metallurgy
11. Tourism
12. Youth

Cross-cutters

1. Education/Human Resource Development/Skills Development
2. Beneficiation
3. Business Development

South Africa's Foresight Project has been guided by the vision in the White Paper on Science and Technology, which envisages a future where all South Africans will —

- enjoy an improved and sustainable quality of life;
- participate in a competitive economy by means of satisfying employment; and
- share in a democratic culture.

Biodiversity is one of twelve sectors selected by the Foresight Project to determine future research and technology priorities (see Box 1.1 for a list of other identified sectors).

This report describes the results of deliberations of the Biodiversity Working Group, the group constituted to analyse the sector and determine likely directions for future research and technology.

Sectors for the project were selected via a nationwide series of workshops. These involved academic and research institutes, businesses and industries, national and provincial government departments, policy NGOs, the eight major science councils, trade unions and civic and youth organisations. Criteria included the influence on current and projected employment, GDP contributions, export opportunities, and other significant statistics.

1.2 Why biodiversity?

What is biodiversity?

Biological diversity — or "biodiversity" — is the number and variety of living organisms on Earth, the millions of plants, animals, and micro-organisms, the genes they contain, the evolutionary history and potential they encompass, and the ecosystems, ecological processes and landscapes of which they are integral parts.

1.2.1 Biodiversity as a Foresight sector

"Why biodiversity?" is a question often asked of the Foresight Project. Indeed, South Africa is the first country to have chosen it as a sector in the Foresight exercise.¹

Traditionally the domain of wildlife enthusiasts and those within the conservation sector, biodiversity in South Africa is tainted by perceptions that it serves the interests of the elite, and is concerned more about animals than about people.

Far from being the case, biodiversity is absolutely fundamental to the present and future survival of humankind. It is the natural resource base upon which people depend, it brings opportunities for commercial development, and it provides ecological services such as pollution control, crop pollination and climate regulation, which are essential for all forms of life.

In the context of the Foresight Project, biodiversity brings with it crucial needs and opportunities for improving knowledge and public understanding of biodiversity, for managing biodiversity, and for developing novel products, processes and services from biodiversity. These factors, combined with the vigorous global pace at which biodiversity is presently being commercialised, the country's extraordinary biodiversity, its reliance upon this resource, and the enormity of threats to this resource, have established biodiversity as a highly strategic sector within the Foresight Project.

BOX 1.2

Foresight Mission

To promote technological innovation and deployment by identifying opportunities for economic and social development through a national research and technology foresight project.

Biodiversity Sector Mission

To ensure adequate and strategic investment into research and technology for the conservation, utilisation and beneficiation of South Africa's biological diversity, thereby enabling this resource to contribute effectively to South Africa's socio-economic development in the next 10-20 years.

(see also 3.1.1) 1.2.2 Our rich but vulnerable heritage

Without doubt, the value and potential of South Africa's natural assets are underpinned by its exceptional diversity and uniqueness. The country is ranked as the third most biologically diverse country in the world, containing between 250 000 and 1000000 species of organisms, many of which occur nowhere else in the world. The rich biodiversity of South Africa is reflected in the vast traditional knowledge of plant and animal uses developed over millennia, first by hunter-gatherers, and later by pastoralists and farmers.

The survival of a significant part of South Africa's remarkable biodiversity is, however, seriously threatened. Virtually every ecosystem has been modified by human activities such as agriculture, urban development, afforestation, mining and dam construction. In addition to habitat loss and degradation, the overexploitation of certain species, the

introduction of exotic invasive species, and the pollution of the soil, water and atmosphere have had a profound impact on South Africa's natural heritage. Thousands of plant and animal species are threatened and many ecosystems and ecological processes impaired. Action is urgently needed to ensure that our crucial life-support systems are not further eroded. Action is also needed to ensure that traditional knowledge about biodiversity is not lost. Research and technology development can deepen our understanding of these issues and provide solutions to impending crises.

This action is all the more pressing given the direct reliance on biodiversity by the majority of the poor in South Africa. Many rural people, for example, rely on wild species for food, medicine, shelter, fuel, building materials and trade. The use of these resources provides an important buffer against poverty, and provides opportunities for self-employment in the informal sector. Loss of biodiversity and degradation thus represents a direct threat to rural livelihoods. Innovative approaches and technologies are urgently needed to guard against the deterioration of this lifeline.

In the formal sector, industries such as agriculture, fishing, hunting, horticulture and tourism are also reliant upon species harvested in the wild, and generate billions of rands in income each year and many employment opportunities. Other industries, such as mining, forestry and recreation, and also tourism, are dependent upon South African ecosystems and the effective functioning of such systems. All of us, and indeed all life on Earth, require the ecological services provided by biodiversity, including the provision of clean water, pure air to breathe, and the generation and conservation of soils.

1.2.3 Untapped Potential: South Africa's Green Gold

Increasingly, losses to biodiversity are being recognised as "opportunity costs". This, together with technological advances such as molecular tools for screening chemicals, and an ever-growing market for natural products, is resulting in an unprecedented surge of commercial interest in wild species. New types of foods, medicines, agricultural inputs, ornamental plants, and other products form the economic base for large corporations and industries that have established themselves as "life science giants", some having annual turnovers of up to \$30 billion.

South Africa is uniquely placed within this context because of the country's rich biodiversity, well-developed infrastructure, scientific and technical capacity, and comprehensive knowledge of the fauna and flora. Historically, the country has largely failed to benefit from its genetic resources, and there has been little interest shown in the domestic development of indigenous species. If harnessed in a strategic but sustainable manner, South Africa's biological resources have the potential to reap significant economic benefits for the nation. The Foresight Project can assist in determining future directions to realise this objective.

1.3 Methodology

The biodiversity sector operated according to an overall foresight methodology. The Foresight mission (see Box 1.2) was based on the vision articulated in the White Paper on Science and Technology, and served as a basis for each sector's mission and particular focus. Once constituted, the sectoral working groups were responsible for finalising the boundary conditions and terms of reference within the overall Foresight framework (Figure 1.1). Specific steps were required to ensure the consistency of the process between sectors. These steps consisted of —

1. surveys of relevant studies and initiatives in the field, both nationally and internationally, to produce what are referred to as the local and international scans;
2. a SWOT analysis of the sector (Strengths, Weaknesses, Opportunities and Threats);
3. a STEEP analysis (consideration of all major factors pertaining to Social, Technological, Environmental, Economic and Political issues as they impacted on the sector);
4. application of the Logic Chain Methodology to check consistency and context;
5. an iterative process to compile a situational assessment — including the Delphi survey described in Chapter 4;
6. a strategic analysis and the available choices in the context of possible future scenarios;
7. setting long-term objectives and identifying key technologies; and
8. implementation and incorporation of the products into the programmes driven by the Foresight process.

1.3.1 Phases of the project

The project was carried out in three phases:

- a pre-Foresight phase;
- a main Foresight phase; and
- a post-Foresight or implementation phase.

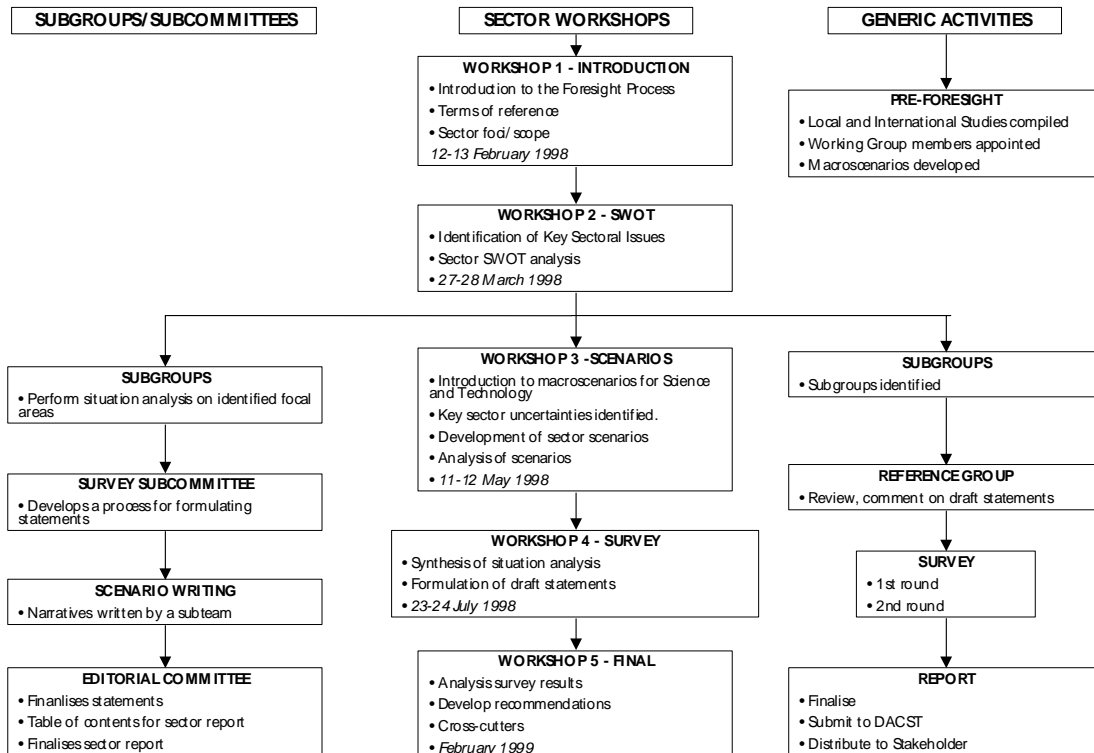
The pre-Foresight stage was aimed mainly at refining the design of the project, consulting with various stakeholders, and selecting Foresight sectors. International and local "scans" were prepared for each identified sector to review areas of need and probable future trends, and to provide an information base for the sectoral working groups.

The work of the main Foresight phase, and the topic of this report insofar as it pertains to the Biodiversity sector, was focused on analysing the sector and establishing likely priorities and directions of future research and technology. This work was

conducted by the twenty-seven individuals who constituted the Sector Working Group (Appendix 1).

The work of the post-Foresight stage will centre on implementation of the project outputs, and will address the recommendations of the 12 sectors and the cross-cutting influences of the development environment.

Figure 1.2 The process and work programme adopted by the Biodiversity Sector Working Group (see also Appendix 1)



1.3.2 Terms of reference for the Working Group

Working Group members were given responsibility for implementing the terms of reference for the sector. These were to —

- identify sector issues for future research and technology areas;
- identify market opportunities; and
- compile a report of findings.

A detailed version of the terms of reference for the biodiversity sector is included in Appendix 2.

1.3.3 Co-nomination

The co-nomination process used to identify participants in the Foresight process was adapted from that developed for the United Kingdom's Foresight project. Co-nomination is a technique of "snowball" sampling, whereby identified stakeholders are instructed to nominate individuals whom they consider to be appropriate experts for particular areas of the Foresight process. Nominees are then themselves asked to nominate individuals who they consider to have the appropriate expertise for the task. This process is repeated a number of times, and individuals are then ranked according to the number of times they were nominated for a particular set of duties. While this process helped to identify nearly half of the participants² in the biodiversity sector (see below), it had the following limitations:

- It failed to identify adequate numbers of women, individuals from disadvantaged groups³ and young people.
- It failed to identify adequate numbers of individuals from non-governmental and community-based organisations.

Consequently, more individuals were identified from other sources, such as the databases of policy processes and professional associations.

1.4 Participation in the Biodiversity Sector

Typical of processes where national and future priorities are being decided upon, the Foresight process had to be conducted in an inclusive and transparent manner. Consequently the process was designed to include a wide range of stakeholders, including industry, government, non-governmental organisations, research organisations, labour organisations and academic institutions. A survey-based

methodology, co-nomination, was employed to identify working group participants from the wide-ranging stakeholder groupings.

1.4.1 Biodiversity sector participation

1.4.1.1 Sector Working Group

The Biodiversity Sector Working Group has a membership of 27 individuals (see Appendix 1 for names and affiliations of working group members). Of the total, 63% were identified via the co-nomination process and the remainder were appointed directly. The members of the group represented diverse areas of expertise, ranging from research and technology, education and training and policy development to market and business development. Members came from a wide range of stakeholder groups representing government, higher education institutions, small enterprises, research organisations and non-governmental organisations.

1.4.1.2 Sector stakeholders

Nearly 950 individuals were identified as possible participants in the Biodiversity Sector activities. About half of these were identified via the co-nomination process and the rest from various other sources, including databases from other policy processes and professional associations.

An information newsletter was published at bimonthly intervals to communicate Sector Working Group progress to stakeholders. Through the newsletter, stakeholders were able to receive information about and give input into the process. The survey process, which is reported on in Chapter 4, was another tool used to obtain input from a wider group of stakeholders.

1.5 Structure and purpose of this Report

The purpose of this report is to provide a synoptic account of the main phase of South Africa's Foresight exercise for the Biodiversity sector. There is, however, no distinct boundary between the main phase and initiation of the implementation phase. Active and progressive practitioners in the sector were the source of ideas for the working group, and, to some extent, implementation will necessarily precede formal implementation through mechanisms such as policy, investment, subsidy, capacity building and communication. Nevertheless, this report is seen by the working group as an important vehicle for the synthesis of ideas, the consideration of future scenarios, and the dissemination of knowledge to the broader community of Science and Technology.

In general, the report covers the Biodiversity Foresight process by presenting the context and framework of the exercise (Chapter 1), the place where South Africa finds

itself relative to the rest of the world during the last years of the 20th century (Chapter 2), the specific methods and tools adopted by the Biodiversity Sector Working Group to fulfil its mandate (Chapter 3), the results obtained from the key exercises, most importantly the Delphi survey (Chapter 4), and the set of recommendations to practitioners and policy makers that the Working Group felt was the voice of the Sector as reflected by the outcome of the survey and other communications (Chapter 5).

The exercise did, in addition, generate some interesting and valuable debate. It drew attention to some of the biodiversity issues that are now — at the turn of the millennium, when human pressure on the environment is at unprecedented levels — being identified as key factors of sustainable economy. The group could not fully resolve many issues, such as those of indigenous knowledge of biodiversity and its application, intellectual property rights and benefit-sharing of the products of biodiversity, the balance between conservation of biodiversity and the impacts of natural resource utilisation, and many others.

Every effort has been made by the drafting committee to include the essence and the quality of thinking of the working group as was presented in the general workshops and sessions of the subcommittees. It is inevitable that there should be gaps, precipitated by both imperfect recording and the pressure of space. All the same, this report is a summary record and a distillation of the process that provides attachment points for further thinking, discussion and networking.

Chapter 2: The Biodiversity Sector in South Africa: Comparative Analysis of the Country's International Standing

This chapter compares activities of the biodiversity sector in South Africa to those in other countries. The analysis is based upon the international and local "scans" which were prepared at the beginning of the Foresight process, as well as information acquired during the course of the Foresight process.

2.1 Social and Political Context

2.1.1 South Africa's Isolation from the International Community

South Africa has only recently joined the international community, following a long period of isolation during the apartheid years. This isolation has had an impact on the country's approaches both to biodiversity and to sustainable development. The United Nations Conference on Environment and Development (UNCED)(the Rio Earth Summit) in 1992 played a major role in catapulting biodiversity and environment to the fore of economic and political agendas. It also resulted in the adoption of several key international agreements, one of them being the Convention on Biological Diversity (CBD). Because South Africa did not fully participate at UNCED and its associated meetings, the country was largely excluded from the major shifts in thinking that occurred in the environmental field during this period. Only recently have the new paradigms ushered in by these agreements started to infiltrate national policies and thinking.

2.1.2 The Convention on Biological Diversity

South Africa's political transformation in the 1990s saw the country rejoining the international community and becoming a party to several international treaties. The most notable and relevant of these is the Convention on Biological Diversity (CBD), ratified by South Africa in 1995. The CBD is extremely far-reaching in its scope and considers not only the protection of threatened species and ecosystems, but also recognises the importance of using resources sustainably, of ensuring equity in the exploitation of such resources, and of the need for development in developing countries.

2.1.3 South Africa's Policy on Biodiversity

One of the most far-reaching obligations of the CBD is the requirement for parties to develop or adapt national strategies, plans or programmes to address the provisions of the Convention. In South Africa this was achieved through a national consultative process to ensure that new policy reflected the interests and aspirations of the South African population. The end result, published in July 1997 as a White Paper on the Conservation and Sustainable Use of South Africa's Biological Diversity, is a comprehensive policy that breaks markedly from past approaches to biodiversity conservation in South Africa. It additionally places South Africa on a par with many nations with respect to the conservation and sustainable use of biodiversity. The public process followed to develop the policy has established South Africa as an important leader in participatory processes to formulate biodiversity policy.

2.1.4 Implementation of the CBD

Implementation of the CBD has been slow in many countries, including South Africa. Although the new ecological approaches embraced by the CBD have received some attention in the country, those within the conservation sector continue to lack understanding and awareness of many of the social and political issues addressed in the CBD. Evidence from other developing and industrialised countries suggests that South Africa is not alone in this respect, although it probably lags behind countries such as Thailand, Brazil, Ethiopia, India and Australia, which have been more vocal with respect to their sovereignty over biological resources.

2.1.5 South Africa as a microcosm of the world

South Africa's economy and society are often characterised as dichotomous, comprising a mix of both developing and industrialised economies. Consequently, the country's environmental problems are said to represent a microcosm of the world's environmental concerns. For example, South Africa shares with many developing countries the challenges of a growing population, natural resource depletion, increasing urbanisation, and high levels of poverty and unemployment. Yet concerns typically associated with industrialised countries are also extremely prevalent. These include severe air and water pollution, over-consumption by the affluent, and problems associated with waste disposal.

At the global level, this mix of economies provides a potentially advantageous situation for South Africa. Often environmental conflicts stem from the different states of economic development in different countries. South Africa can play a mediating role due to its understanding of circumstances in industrialised and developing economies. A case in point is the myriad of trade and agriculture agreements presently under discussion (e.g. the TRIPs — or Trade Related Intellectual Property Rights — Agreement of the World Trade Organisation; the International Undertaking on Plant Genetic Resources of the United Nation's Food and Agriculture Organisation; the 1991 UPOV

[Union for the Protection of Plant Varieties] Agreement). Many of these agreements have profound implications for the manner in which biodiversity is conserved and used, yet these concerns have largely been overridden by industrialised countries. South Africa could play a pivotal role in finding solutions that both promote economic development and protect biodiversity and the communities that nurture it.

2.1.6 South Africa in the Southern African and African Region

South Africa has the potential to play a leading role, not only in the global biodiversity arena, but also within the African and southern African region. With the transition to democracy in 1994, South Africa was readmitted to both the Organisation of African Unity (OAU) as well as the Southern African Development Community (SADC), and plays an increasingly influential role in regional forums. The country's relatively well-developed economy, infrastructure, and science and technology base affords an opportunity to be central to regional initiatives to conserve, sustainably use and develop local biodiversity. However, careful balances need to be struck to ensure that South Africa both provides and obtains opportunities in the region, and does not over-dominate.

2.2 Sustainable use and adding value to biodiversity

The surge of international interest in the natural environment, and in products derived from nature, provides many opportunities for a biologically rich country such as South Africa. These range from the consumptive use of biodiversity — through activities such as hunting, fishing and the development of new medicines, crops and ornamental plants — through to its non-consumptive use, and activities such as tourism and the use of indigenous knowledge about biodiversity. The economic significance of this situation is notable: Natural product-derived pharmaceuticals alone contributed an estimated US\$120 billion to global pharmaceutical sales in 1997, approximating 40% of total sales. For raw botanical materials, world trade was estimated at US\$8 billion in 1997. In 1995, the world tourism industry represented 10,9% of the world economy. Hunting in South Africa alone generates over R400 million per year. South Africa has a competitive edge over many other countries with regard to these activities but until recently has not given adequate attention to the use of biodiversity and associated economic activities.

2.2.1 South Africa as a "provider" of genetic resources

The Convention on Biological Diversity sets conditions for recognising the commercial value of biodiversity within existing trade and intellectual property frameworks and thus establishes a commodity trade in genetic and biochemical material. In what has been described as the "Grand Bargain," "provider" countries receive technologies that use the resource, financial benefits from the commercial exploitation of the resource, and the benefits of participating in research stemming from the development of genetic resources. "User" countries, on the other hand, gain access to the genetic resources to

be developed by their industries. The biodiversity of the South is thus considered to provide a new competitive advantage for less developed countries. This has important implications for South Africa, one of the most biologically diverse countries in the world.

Compared to other biologically diverse countries, South Africa presents unique opportunities for the commercialisation of its biodiversity. Firstly, it has extremely high levels of endemism: 80% of the 18000 plant species contained within the country occur nowhere else. Intraspecific genetic diversity is also unusually high, adding to the potential for developing new drugs, crop varieties, ornamental plants, and other useful products. Secondly, the country has a well-developed infrastructure and considerable scientific and technical capacity. Thirdly, comprehensive knowledge exists of local fauna and flora. Fourthly, protected areas and living collections in the country are well-managed, allowing for reliable collection.

Despite these assets, South Africa has limited experience in the commercialisation of its biodiversity. There are exceptions, such as the local development of rooibos tea from the plant *Aspalathus linearis*, but in general South African species have largely been developed by foreign concerns, which have also derived the benefits from such commercialisation. South Africa thus lags behind other countries with similar research capacities.

There are, however, indications that this situation is changing, and South African institutions and companies are beginning to launch initiatives aimed at developing nature-based products. The CSIR, for example, has launched a major bioprospecting project aimed at investigating most of the country's 23 000 plant species for commercially valuable properties. Similarly, the National Botanical Institute is to develop the horticultural potential of several South African species, in collaboration with a multinational horticultural company. The Agricultural Research Council has for many years dedicated research to the development of indigenous ornamental plants. This work, especially that with the Proteaceae, has led to the national and international registration of plant breeders rights, and models for the sharing of benefits. Many universities are also involved in collaborations with the private sector.

2.2.2 Sports hunting and fishing

Two areas of consumptive use in which South Africa has considerable experience are the activities of game hunting and fishing. The latter includes commercial, subsistence and recreational fishing. South Africa has long supported the hunting industry, although this has largely been to the benefit of a privileged few. With diminishing hunting opportunities in northern countries, Africa is increasingly being looked to for continued hunting experiences. The South African private sector has reacted to this demand and in some areas farms are being amalgamated to form large hunting areas. In many respects South Africa is far advanced relative to other countries which offer hunting.

The fishing industry is another area in which South Africa is far advanced. South Africa has a long history of using marine resources, dating back to prehistoric times. Although many marine species are over-exploited, when compared to other countries South Africa has a relatively well-managed fishery. The marine science research capacity is additionally well developed, with South African scientists at the forefront of many international endeavours. Public education and awareness programmes have, however, been slow to develop by comparison. Although South Africa is on a par with industrialised countries with respect to the management of its commercial fisheries, its understanding of subsistence fisheries lags behind other countries.

2.2.3 Tourism

South Africa is currently a major destination for foreign tourists, with its unique biodiversity and natural landscapes being major drawcards. Up until the country's transition into democracy, countries such as Kenya and Tanzania were major tourist destinations in Africa - their wildlife being the major attraction. South Africa contains rich wildlife as well as the infrastructure that makes the country competitive in wildlife-based tourism.

2.2.4 Community-Based Natural Resource Management

Increasing recognition is being given to the importance of invoking locally-driven solutions to manage the use of natural resources. South Africa has historically adopted a top-down approach towards natural resource management and is less experienced than other African countries with respect to community-based natural resource management (CBNRM). Several CBNRM projects are, however, currently under way in the country, led by agencies such as the South African National Parks, the KwaZulu-Natal Nature Conservation Service, various provincial departments, as well as several non-governmental and community-based organisations. Many of these projects have been launched only recently, and therefore it is premature to assess their success. Zimbabwe boasts the longest-running CBNRM programme in the region (CAMPFIRE) and provides good examples for practice in South Africa. South Africa in turn can provide useful lessons for other countries with respect to its experience in resolving conflict over the use of natural resources, and negotiating solutions that are acceptable to all stakeholders.

2.3 Biodiversity-related research and technology

2.3.1 Research and development trends

In general, South Africa is not a leader in research and development. The World Competitiveness Yearbook (1997) ranks South Africa 40th in science and technology, out of 46 countries. Research and development (R&D) expenditure in South Africa was

0,75% of the GDP in 1993. When compared to developed countries, this is not substantial. South Africa's share of innovations and high technology activities is also very low. For example, of the 4 102 patents granted in South Africa in 1994, 0,21% were granted to South Africans. Of home-grown patents filed in South Africa, fewer than 5% are for biotechnology innovations; a significantly lower proportion than that for foreign applications.

2.3.2 Research Output

South Africa's research output is also relatively low, but in line with the investment in R&D. Only 0,6% of research papers listed between 1990 and 1994 in the Science Citation Index (SCI® — a global record of scientific publishing) originated in South Africa. However, quite a high proportion of South Africa's effort in this regard is in fields related to biodiversity. Of the 1 867 papers listed in the SCI® between 1995 and 1997, a total of 23% were in the fields of plant and animal science (11%), biology and biochemistry (5%), ecology/environment (3%), agricultural sciences (2%) and microbiology (2%).

2.3.3 Key research areas

However, South Africa has played a leading role in some niche research areas. In the area of nature conservation, the country has developed expertise that is world-renowned. For example, South Africa is ahead of many countries in the development of marine reserves. Other fields in which South Africa has made a notable contribution include forest hydrology, fire ecology, and the ecology of invasive organisms. The country's research infrastructure, supporting biodiversity-related research, is also a noteworthy strength. In this respect, South Africa is ahead of many developing countries, and is often competitive with developed countries with regard to intellectual content.

2.3.4 Research institutions and capacity

Universities in the country play a role in developing human resources, and largely perform basic research in the biodiversity field. Of the eight science councils in the country, four of these are active in biodiversity-related research and development. Parastatals, such as South African National Parks (SANP), the provincial parks boards and the National Botanical Institute (NBI), also play a major role in conservation research and in developing tools for the management and use of biodiversity. The natural history museums and zoos are also important in terms of furthering our understanding about biodiversity. At present, the private sector in South Africa is not a major player in biodiversity-related research and development, although this pattern is beginning to change with the establishment of several commercial enterprises focused on developing and exporting indigenous plants for various medicinal, cosmetic and other purposes.

Much of South Africa's strength in biodiversity-related research arose from cooperative research efforts in the 1970s and 80s. For example, the CSIR's National Programme for Ecosystem Research sought to develop a predictive understanding of the structure, functioning and dynamics of South African terrestrial and inland water ecosystems. It involved the participation of over 500 researchers, managers and administrators within an "invisible college" drawn from government departments, universities and the private sector. The approach led to very healthy cross-disciplinary collaboration, which in turn led to a spirit of sharing and testing of ideas. These initiatives produced a cohort of trained ecologists that today forms an important component of our capacity to understand, manage and develop biodiversity in the country.

2.3.5 New Policies and Approaches

The post-1994 political dispensation has resulted in new policies and approaches to research funding and practice. Many government research institutes have been placed on a competitive footing, and must now compete for funds on a contract research or consultancy basis in a "market-focused" environment. Scientists working in the field of biodiversity now have new opportunities for regional collaboration with neighbouring countries, a situation not possible before the emergence of a new South Africa. Generally, however, South Africa has retained its leading edge in many areas of biodiversity research. The challenge is to ensure that this competence is not lost through attrition, a failure to train new scientists, and a failure to transform the scientific community to be more representative of South African society. Given that these challenges must be faced in an environment of declining funding, a carefully crafted strategy is required.

2.3.6 Technology areas relevant to biodiversity-related research and development

Important technology areas that are relevant to biodiversity research include:

- Information and communication technologies (ICT);
- Biotechnology;
- Environmental quality and conservation technologies; and
- Indigenous knowledge (IK) systems.

In the first three areas, South Africa is a user of technologies developed by countries such as the United States of America, Japan, Germany and the United Kingdom. These countries continue to dominate technology development in these fields. It is difficult to comment on how fast the biodiversity sector in South Africa follows in terms of applying ICT, biotechnology, environmental quality and conservation technologies. There is an indication, however, that South Africa is emerging as a leading country in terms of the application of some conservation technologies. Additionally, capacity is being developed in the field of bioprospecting through collaborations with foreign institutions and corporations. National and parastatal institutions such as the CSIR, the NBI, and various universities are actively engaged in such ventures.

South Africa possesses rich indigenous knowledge of its biological diversity. An area that has received some attention from research and commercial sectors is that of medicinal plants. More than any other area, indigenous knowledge of medicinal plants is fairly well documented in South Africa, largely through the research of botanists in colonial times. However, indigenous knowledge relating to the management and conservation of biodiversity is poorly documented and underutilised. Additionally, South Africa — like many other countries of the world — has limited experience in developing appropriate models to protect the intellectual property of holders of traditional knowledge. Some useful examples may however be provided through the country's experience in establishing Community Property Associations. Generally, indigenous knowledge in South Africa is yet to play a significant role in socio-economic development. In this respect, South Africa is behind other countries, such as China, India and Zimbabwe, in the development of IK.

2.4 Conclusion

South Africa has important strengths in the biodiversity sector which provide it with a competitive advantage over many other industrialised and developing countries. The tremendous wealth of biodiversity in the country, combined with its considerable research capacity, provide enviable opportunities for economic development. Yet for such opportunities to be realised, significant weaknesses must be overcome. Many of these weaknesses stem from the country's apartheid past, and negligence of social issues. Without doubt, biodiversity will feature prominently as South Africa proceeds into the new millennium, and the African Renaissance becomes a reality. The following chapter examines the key drivers, trends and issues that will shape the maturation of biodiversity in the 21st century.

Chapter 3:

Assessment of the issues and key drivers

3.1 Mission and Scope of the Biodiversity Sector

3.1.1 Mission

The mission statement, as formulated by the Working Group, was —

"...to ensure adequate and strategic investment into research and technology for the conservation, utilisation and beneficiation of South Africa's biological diversity, thereby enabling this resource to contribute effectively to South Africa's socio-economic development in the next ten to 20 years."

3.1.2 Scope

The scope of the sector was considered to embrace three themes:

- Improving knowledge and public understanding of biodiversity.
- Management of biodiversity.
- Beneficiation of or adding value to biodiversity.

Several cross-cutting themes were identified, including business development, education and capacity development, policy, technology transfer, institutional framework, intellectual and material property rights, integration and multidisciplinary approaches.

Figure 3.1 provides a schematic summary of these themes and also illustrates links with other sectors. A detailed version of the sector's scope is attached in Appendix 3.

3.2 Key Issues, Drivers and Trends

3.2.1 Approach

One of the first tasks of the Working Group was to identify issues, trends and drivers that may have a potential influence on the Biodiversity Sector in ten to 20 years. This was done through investigation of relevant Social, Technological, Economic, Ecological and Political (STEEP) factors, and also through examination of the Strengths, Weaknesses, Opportunities and Threats (SWOT) of and to the biodiversity sector. These deliberations were further informed by the local and international Foresight scans. The process described allowed for the identification of important areas for research and

technology, as well as likely market opportunities. The results of this analysis formed the basis for the survey, described in Section 4.

Factors considered in the STEEP analysis included the following:

- **Social factors:** poverty, resource use, urbanisation, population profile and growth.
- **Technological factors:** biotechnology, information and communication technologies, and indigenous knowledge systems.
- **Economic factors:** market trends in other sectors (e.g. medicines, food and drink, tourism) and economic opportunities based on biodiversity (e.g. drug development).
- **Ecological factors:** knowledge generation and utilisation, and understanding and management of biodiversity.
- **Political factors:** national policies, and international and regional agreements.

A range of issues, drivers and trends that will influence the sector were discussed. These were categorised as presented in the following section.

3.2.2 STEEP Results

The results of the STEEP analysis are provided below, in bullet form. Where necessary, explanatory text accompanies the bullet.

S

Social issues, trends and drivers

- The value of biodiversity is unacknowledged in the informal economy.¹
- Overharvesting is threatening many commercially important and subsistence resources.
- Pressure on biological resources may decrease as the quality of life of South Africans improves.²
- Urbanisation, changes in population profile, and population growth will have an impact on biodiversity.
- Most South Africans, the poor in particular, have limited access to biodiversity and are not full participants in its management.

T

Technological issues, trends and drivers

- South Africa's well-developed science and technology infrastructure and skills base, combined with the country's rich biodiversity, could result in South Africa becoming a leader in the development of technologies for managing and adding value to biodiversity.
- Biotechnology is an important tool for the management and beneficiation of biodiversity, but needs careful control to avoid adverse environmental impacts.³

- Information and communication technologies have potential applications in the management of biodiversity.⁴
- The merging of information and communication technologies with biotechnology may improve the management of biodiversity.⁵
- Indigenous knowledge of biodiversity is underdeveloped and unappreciated in South Africa, but it has the capacity to unlock many economic opportunities. Commercialisation must, however, ensure the development of appropriate intellectual property models to ensure that holders of traditional knowledge receive a fair and equitable share of benefits.

E

Economic issues, trends and drivers

- An increasing "green consciousness" and demand for nature-based products is influencing product development and quality.
- Ecotourism is expanding and diversifying all over the world, and South Africa has enormous opportunities in this area.
- There is an increasing awareness among government and the private sector of the economic value and potential of biodiversity.
- Bioprospecting, if managed well, could yield important economic and social benefits for South Africa.

E

Ecological issues, trends and drivers

- Biodiversity is under pressure because of development and other economic activities such as agriculture and forestry.
- There is a lack of awareness about the social, ecological and economic roles of biodiversity.
- Knowledge about some components of biodiversity is poorly documented and understood.⁶ The complex processes involved in the functioning of ecosystems (e.g. hydrological cycles, nutrient cycles, soil genesis and waste disposal) are also poorly understood.
- Gaps in knowledge make it difficult to conserve and derive economic benefits from biodiversity.
- Technologies that facilitate the rapid identification of unknown species and models to enhance understanding of ecosystem structure and functioning are important tools to conserve biodiversity.

P

Political issues, trends and drivers.

- Biodiversity issues are receiving attention in both international (Biodiversity Convention) and national policy (e.g. Biodiversity White Paper) arenas.

- There is increasing conflict between the objectives of the Convention on Biological Diversity and those of the TRIPs Agreement of the World Trade Organisation.
- There is an emerging trend among industrialised countries towards patenting elements of biodiversity.⁷
- Intellectual property protection mechanisms need to be developed to ensure that South Africa derives benefits from its biological resources.
- National trends and policies present opportunities in terms of popularising biodiversity and its value in human economies.⁸
- If managed carefully, the commercialisation of biodiversity can play a role in achieving the goals of both the RDP and GEAR, although activities arising from these national policies may also run counter to the protection of biodiversity.

3.2.3 Strengths, Weaknesses, Opportunities and Threats (SWOT)

The following table summarises the SWOT analysis of the Biodiversity Sector prepared by the Working Group.

Strengths

- Rich genetic diversity within South African borders
- High species diversity and levels of endemism
- Ecosystem diversity
- South African cultural diversity complemented by indigenous knowledge of biodiversity
- Rich paleontological heritage
- Long history of biodiversity conservation
- Well-developed science and technology infrastructure
- Well-developed science and technology skills
- Well-developed private sector
- Knowledge of the country's biodiversity is well documented.

Weaknesses

- Limited resources (especially financial and technological resources) to add value to biodiversity.
- Limited experience in beneficiation of/adding value to biodiversity
- Limited experience in management of intellectual property rights with regards to biodiversity
- Divide between indigenous knowledge system and western system
- Indigenous knowledge system is underdeveloped.
- Stakeholders within indigenous knowledge system are fragmented, rendering it difficult to fully harness this knowledge system.
- The majority of South Africans are not yet full participants in the management of biodiversity.
- The majority of South Africans still have limited access to biodiversity.

Opportunities

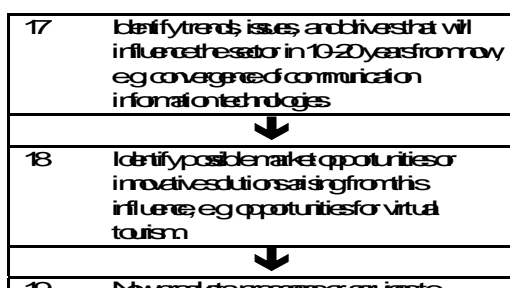
- Increased international demand for nature-based products
- Increased interest in South African wildlife by tourists
- Increased buy-in and awareness of the sustainable development philosophy
- Increased international (political) interest in biodiversity issues
- Increased interest in bioprospecting by multinationals potentially provides opportunities for investment.
- Increased international recognition of indigenous knowledge issues potentially increases the marketability of this knowledge.
- Improved relations between South Africa and neighbouring countries (e.g. SADC countries) potentially provides opportunities for joint management of bioresources.
- Developments in biotechnology will potentially provide tools for managing and adding value to biodiversity.
- Developments in information and communication technologies will potentially facilitate research, information management, and access to information on biodiversity.
- National socio-economic development imperatives (as embodied in the RDP and GEAR strategies) provide an opportunity for the creation of biodiversity-based enterprises and may lead to sustainable development in poor areas.
- Change of lifestyle among South Africans from subsistence to income-generation will potentially relieve pressure on biodiversity that many poor people subsist on.

Threats

- Increased international interest in biodiversity issues
- Increased interest in bioprospecting by multinationals can lead to the overexploitation of biological resources.
- Biotechnology products can have negative effect on biological diversity.
- Change of lifestyle among South Africans from subsistence to income-generation may increase resource consumption.
- Overharvesting of subsistence and commercially valuable species
- Socio-economic development imperative (as embodied in the RDP and GEAR strategies) may lead to increased resource consumption.
- Lack of legal mechanisms regulating access to South Africa's resources may lead to biopiracy.

3.3 Logic Chain Methodology

The methodology adopted to analyse information generated from the SWOT and STEEP processes was adapted from that used in the United Kingdom's Foresight Programme. This has been dubbed the Logic Chain Methodology, and is a framework for considering the implications, constraints, synergies and knock-on effects of initiatives at all stages of development (Figure 3.2).



3.4 Scenario-building as a tool for testing perspective

Scenario-building has become a popular and constructive tool for creative forward planning. Its use in science and research foresight has been to unlock the visionary imagination that can project scientific and technological thinking into an age when the array of tools available may be well beyond those that we are familiar with today. The method has been employed in many circumstances — from strategic planning in multinational companies such as Royal Dutch Shell, to the rapidly shifting political scene in South Africa in the early 1990s when the Mont Fleur sessions in Cape Town paved the way for the consensus forums of CODESA.

DACST's Foresight Project placed scenario-building right at the forefront of the exercise. During 1997 two workshops were held to construct what have been labelled the Macroscenarios for Science and Technology 2020. These scenarios have been published as a booklet under this title (see References). The scenario-building exercise was done by a group of experienced and progressive-thinking professionals who set their collective imagination to work to devise these four provocatively varied scenarios that could describe the state of South Africa in the year 2020, depending on what circumstantial constraints might be experienced and what proactive planning the nation might muster during the intervening decades. These scenarios ranged from the pessimistic "Frozen Revolution" to the internationally competitive "Global Home", from the SA-centric "Our way is the way", to the SADC-sensitive "Innovation Hub".

3.4.1 Development of the macroscenarios

In developing scenarios, two to four descriptions of the future, which between them cover a spectrum of future possibilities, are normally developed (CSIRO, 1994). These descriptions of the future are developed on the basis of identified key uncertainties for

the organisation or sector. Key uncertainties are issues that are important but highly unpredictable for the organisation or Sector.

The idea of developing macroscenarios for Science and Technology was conceived to help contextualise sector work. These scenarios were therefore aimed at providing a uniform frame of reference for the twelve Foresight sectors.

Development of macroscenarios involved:

- Interviewing of high-profile individuals from government, science councils, business, non-governmental organisations, labour and media, on key uncertainties for future of science and technology in South Africa.
- Processing interview data and formulating a strategic agenda document. The issues of concern included globalisation, economic competitiveness, economic development, human resource development, social development, environmental sustainability, the role of science and technology, the roles of government and the private sector, vision and leadership, societal values, national integration and crime. These issues formed the basis for the development of macroscenarios.
- Two three-day workshops in which over thirty delegates participated. Participants came from diverse stakeholder backgrounds. Four scenarios were developed from these workshops. Summaries of the scenarios are presented in Box 3.1.

3.4.2 Development of Biodiversity Sector scenarios

It was the task of the Biodiversity sector to consider what South Africa might look like in 2020 if these scenarios came to pass, and how the nation's biodiversity resources would have been affected in the interim. Would they have been ignored or exploited, developed or decimated? The Our Way is THE Way

South Africa believes in its ability to challenge the conventional route to globalisation by rallying developing countries' support for the development of a significant South-South economic block. This catalyses isolation by the developed world.

Innovation Hub

South Africa's comparatively developed infrastructure creates opportunities for strategic regional investment. Building on a skills base and knowledge generates comparative advantages and a competitive edge regionally and globally:

- Some national identity is lost, while regional identity is strengthened.
- Initially, slow economic growth, but picks up later.
- Incremental social development towards a shared regional vision.

Global Home

In line with global trends and opportunities, government embraces global liberalisation, and facilitates private sector empowerment to respond to global market forces, leading to:

- "hands-off" role of small government;
- initially, good economic growth;
- tendency towards global identity.

Frozen revolution

The non-implementation of government policy towards socio-economic upliftment that leaves masses dissatisfied and key players fragmented and individually focused.

key questions that arose from this scrutiny enabled the Working Group to contemplate the probable impact of Science and Technology on how well biodiversity might have been developed as an economic resource, secured as an environmental service provider, or preserved for its aesthetic and scientific value.

Sector Working Group members identified twelve areas that they perceived to be important but unpredictable (key uncertainties) for the Biodiversity Sector. The key sector uncertainties identified included global market trends, political leadership, the level of economic sophistication, the value of biodiversity, access to biological resources, environmental ethics and awareness, management of global-change issues, management of disasters, environmental sustainability, the compatibility of indigenous knowledge and intellectual property rights, and the state of infrastructure. Sector scenarios were then developed on the basis of these issues (key uncertainties) and macroscenarios.

3.5 Conclusion

The techniques described in this chapter have all been adopted from other studies and adapted to the South African situation. Furthermore, they have been combined in what is probably a unique way, to provide a probing analysis of the sector, which is of value in its own right. For the purpose of this report, however, the analysis provides an essential platform for the semi-quantitative Delphi survey presented in Chapter 4, upon which reasonably reliable comparisons can be made with other sectors.

Chapter 4: The Delphi survey: Stakeholder views of future priorities

Pivotal in the Foresight exercise was the detailed survey that canvassed assessment from stakeholders of a range of topics relating to biodiversity. The main purpose of the survey was to consult and obtain the opinions of a wider range of stakeholders on the ideas generated by the Working Group. The survey technique adopted was the Delphi method, which has been applied widely in the Foresight context. Initially developed by the RAND Corporation in the United States for military applications, it is now used in numerous contexts in countries such as Japan, the United Kingdom and Germany. The Japanese are considered experts in conducting Delphi surveys, and applied the method in a significant study ahead of the 1997 Climate Change summit in Kyoto. However, this is the first time that the technique has been used in South Africa on a national scale.

In the Delphi approach, stakeholders are asked to respond to questions on a series of statements about the future. Following synthesis of this input, respondents are supplied with the processed aggregate results, and asked to modify their views in the light of the general expert opinion. This chapter provides a brief overview of the outcome of the survey process as applied to the Biodiversity Sector of the South African Foresight exercise. These results have in turn been central in the formulation of the recommendations of the Working Group listed in Chapter 5.

4.1 The survey process

The Foresight Biodiversity survey was conducted by means of a questionnaire compiled from the discussions and opinions of the Working Group, which was sent by post and via the Internet. The Internet option, although clearly less popular than conventional mail, was another first for South Africa in terms of conducting a Delphi survey.

The strong point of the Delphi survey is that it accommodates many individuals, and taps a wide spectrum of opinion as a contribution to the setting of priorities. The most cited weakness of this methodology, however, is that it is too time-consuming. South African respondents' comments in this regard were in line with international opinion.

The survey questionnaire comprised two major components.

The sector-specific information requested was phrased as a series of statements that reflected the most important issues for the sector. Each statement was formulated as the description of an activity that could conceivably be achieved through research

and technology development over the next twenty years. The Biodiversity Working Group generated 71 such survey statements in 13 subcategories for consideration by the survey respondents. (See 4.1.1 below. The full set of statements is provided in Appendix 4.)

Underlying the questionnaire, and common to all twelve of the Foresight sectors, was a framework comprising six major variables. This was to provide a common basis for the comparison of information between sectors. Five of these parameters guided the input of information with regard to —

1. The importance of the statement to South Africa in terms of wealth creation and quality of life;
2. South Africa's standing in respect of this activity relative to southern Africa and the rest of the world;
3. the likely time frame for realisation of the statement;
4. how South Africa might acquire the necessary technology or capacity; and
5. the key constraints to realising the statement.

The sixth class of information requested for each statement was the level of confidence that the respondent had in the information that he or she was supplying, i.e. low, medium or high, depending on whether they were unfamiliar with, or knowledgeable or expert in the field outlined in the statement.

In short, the survey set out to produce an aggregate table of results in a 5 x 67 matrix. (See Appendix 5 for a sample of the questionnaire.)

4.1.1 Biodiversity sector statements

The survey statements included in the questionnaire articulated the ideas and perceptions generated by the Working Group activities outlined above. An attempt was also made to use concepts and terminology similar to those used in other Delphi surveys. Specific terminology, for instance, was adopted from the UK and Japanese studies to indicate the state of advancement of an activity described in a statement. Statements therefore often include the following terms:

- **'elucidation,'** indicating that the principles or phenomena had been identified scientifically or theoretically, but had not come into practical or widespread use;
- **'development,'** indicating the attainment of a specific technological goal or the completion of a prototype;
- **'practical use,'** indicating the first practical use of an innovative product or service;
- **'widespread use,'** indicating significant market penetration to a level where a product or service is in common use.

The biodiversity statements were grouped according to the following categories:

1. Making inventories;

2. conservation and sustainable use;
3. valuation;
4. impacts;
5. global environmental change;
6. indigenous knowledge systems;
7. equity and access;
8. biotechnology products;
9. natural products;
10. tourism;
11. other services;
12. capacity development; and
13. intellectual property rights.

The structure of the biodiversity survey questionnaire is summarised in Table 4.1. Here the number of statements in each category, and the number that pertained specifically to each of the states of development, are shown.

Of the 71 statements that were included as part of the biodiversity survey, and in terms of the state of development, 44% were in the widespread use, 24% in the development, 18% in the elucidation, and 14% in the practical use categories. The large number of statements falling into the widespread use category indicates that a large number of the objectives in the sector could be achieved through utilisation of the existing technologies. It seems, however, that biodiversity-specific innovations or customisation of existing technologies is equally important. This is reflected in the number of statements in the development category. The statements place less emphasis on research and application of technologies that are in development. This is reflected in the relatively low number of statements in the elucidation and practical use categories.

4.1.2 Respondents and response rate

The questionnaire was sent to 878 individuals representing the major stakeholders. The profile and breakdown of the individuals according gender, age, race and institutional affiliation could not be determined as only the names and addresses of these individuals were available. Only the co-nominated individuals could be profiled in this respect and, because they accounted for only half of the respondents, the breakdown is not presented in this report.

Table 4.1 The number of statements relating to different categories and states of development that were included in the survey questionnaire sent to stakeholders.

Category of statement	Number of statements	State of development			
		Elucidation	Development	Practical use	Wide-spread use
Making inventories	8	0	4	2	2
Conservation and sustainable use	14	4	6	3	1
Valuation	3	0	2	0	1
Impacts	4	2	0	0	2
Global environmental change	4	4	0	0	0
Indigenous knowledge systems	6	0	2	0	4

Table 4.2 Response rates and summary profile statistics of respondents to the survey of stakeholders in the biodiversity sector. A second round of the survey revealed a similar pattern.

Overall response	Sent	878
	Returned	148
	Response rate	16,8
Response mode	Mail	95,9
	Internet	4,01
Gender of respondents	Male	81,3%
	Female	18,8%
Aged respondents (years)	< 20	0,7%
	20- 30	7,6%
	31- 40	31,7%
	41- 50	29,7%
	51- 60	24,8%
	> 60	5,5%

The survey was conducted in two rounds. The overall response rate, the gender-age percentage distribution of the respondents and the percentage breakdown according to institutional affiliation for the respondents are summarised in Table 4.2 and Figure 4.1.

The rate of response to the questionnaire was 16,8% in the first round. At the time of this report going to press, results for the second round had not yet been synthesised. This pattern is normal for the Delphi survey for reasons already cited. Indeed, some respondents expressed their frustration with the length of the questionnaire. Other factors accounting for the poor return related to the technical nature of the questionnaire and the broad scope of subject areas covered. Some stakeholders and individuals, particularly those from the NGO sector, indicated informally or in writing their difficulty in responding to what they characterised as highly technical topics. The fact that the scope of the subject areas covered was a factor determining the response rate, is supported by the findings of the co-nomination study which concluded that expertise in South Africa is 'compartmentalised'.

The pattern that emerged in respect of the gender and age profiles of the respondents again reflected the national picture which was captured by the co-nomination study. The respondents were largely male and about 60% were over forty years of age.

The respondents to the biodiversity survey questionnaire were largely from government-funded institutions and included individuals working for government, higher education institutions and research institutions. The second largest group of respondents was not affiliated with any of the institutions referred to in the questionnaires. It is more likely that this category absorbed individuals working on a consulting basis in the 'knowledge sector'. The private sector and NGOs accounted for the lowest responses. The low response from the private sector perhaps indicates that biodiversity is still outside the mainstream of commercial interests. Even though there are commercial entities based on biodiversity and many commercial companies whose income depends on biodiversity, some of those approached for the purposes of participating did not feel they were competent in respect of biodiversity-related research and technology. Furthermore, at the commercial level, biodiversity-related research is often classified as part of sectors such as agriculture and pharmaceuticals (see also Figure 1.1 for linkages with other sectors).

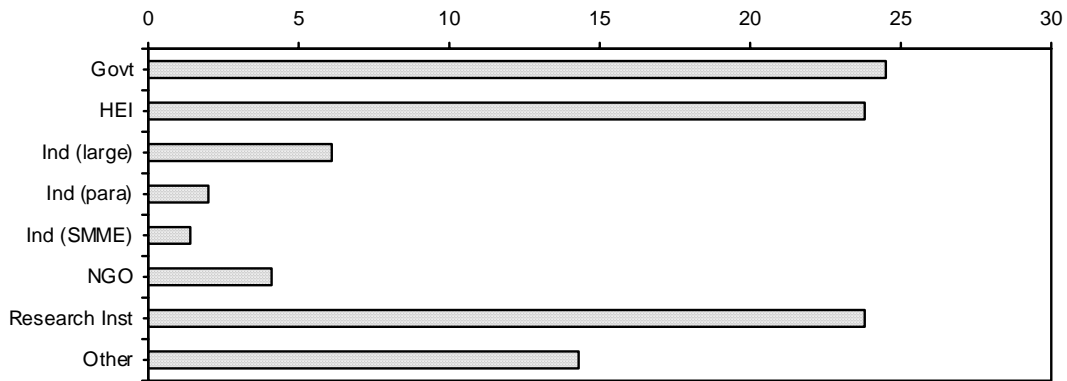
4.2 The survey analysis and results

The major objective of the Foresight initiative is to identify the ways in which research and technology can (a) promote wealth creation, and (b) improve quality of life for South Africans. The framework variables described in 4.1 were used as a basis for analysis in this regard and for indices quantifying the importance of each statement in these two respects, were calculated for each of the statements in the questionnaire. Respondents who indicated a low level of confidence in their ratings were excluded from this analysis. The two indices for each statement were calculated as the percentage of respondents rating the importance as high, minus the percentage rating it low. This allowed for a range of scores from -100 to +100, for each statement, in respect of (a) wealth creation, and (b) quality of life. The final score for each statement was a joint index that was the average of (a) and (b). These are the scores reflected in Table 4.3, where the top 20 statements are listed in descending order of importance. It is this set of statements, and associated information, that form the basis for major conclusions drawn in this report.

Table 4.3 The 20 statements from the Delphi survey that were rated as most important in respect of wealth creation and quality of life. In respect of all statements, South Africa was rated as being behind developed countries, but equal to, or ahead of, other southern African and developing countries. Respondents also rated the realisation period as six to ten years, and thought that the technology should be acquired in South Africa in all cases. Constraints considered were: Financial (F); Social/Cultural (SC); Policy (P); Market (M); Human Resources (HR); Technology (T); or Infrastructural Research and Development (I). These are listed in descending order of perceived importance for each statement.

Statement	Subsection	Joint Index	Constraints
Development of techniques to add economic value at local level to harvested or cultivated products (e.g. medicinal or food plants).	Valuation	71,88	F, SC, HR (M, T)
Elucidation of sustainable levels of direct and indirect resource utilisation in South African ecosystems (e.g. carrying capacities in fishing, ecotourism and rangeland-based animal production).	Conservation and sustainable use	71,10	F, HR, P
Contribution of nature-based tourism to South Africa's gross domestic product doubles.	Tourism	70,91	F, M, SC
Elucidation of techniques to sustainably harvest commonly used species (e.g. medicinal plants).	Conservation and sustainable use	63,36	F, SC, HR
Widespread use of restoration technologies to renew and renovate damaged ecosystems.	Conservation and sustainable use	57. 61	F, HR, P
Increased international demand for "greener" products opens opportunities for South Africa to develop nature-based products (such as nutraceuticals, phytomedicines and biopesticides).	Natural products	56,44	F, M, T
Widespread use of biodiversity valuation techniques to inform decisions about land use in South Africa.	Valuation	51,19	F, HR, P
Development of a system of protected areas that represent all of South Africa's biodiversity.	Conservation and sustainable use	50,14	F, P, SC
Innovative theme-based ecotourism packages (e.g. packages based on viewing botanicals, wildflowers, butterflies, palaeontological sites for the disabled) are widely available to tourists in South Africa.	Tourism	46,37	F, M, HR
Development of methods to model the effects of disturbances and management practices on ecosystem functions (e.g. fire, grazing, water flow, fishing practices).	Conservation and sustainable use	46,22	F, HR, I
Elucidation of option for innovative co-management of protected areas leads to improved ecological sustainability and increased economic benefits.	Equity and access to biodiversity	45,65	SC,P,F
Development of a system to ensure that benefits from the use and development of South Africa's biodiversity serve the national interest.	Equity and access to biodiversity	45,28	F, SC, P
Community-controlled ecotourism ventures cater for 10% of the tourists in South Africa.	Tourism	44,09	F, SC, M
Widespread incorporation of biodiversity considerations in all development planning procedures and environmental impact assessments.	Impacts	43,80	F, SC, P
Elucidation of alternative resources in poor, rural communities to minimise impacts on biodiversity.	Impacts	43,35	F, SC, HR
Practical use of bioprocessing techniques in indigenous microbial, plant and animal cells to produce chemical products on a commercial scale (such as pharmaceuticals).	Biotechnology products	40,79	F, T, HR, I
Shared-benefit bioprospecting projects improve economic conditions in the least-developed parts of South Africa.	Equity and access to biodiversity	40,43	F, SC, P
Development of techniques to assess the monetary and non-monetary value of South Africa's biodiversity and the ecosystem services it provides.	Valuation	38,65	F, HR, I
Development of expertise in the design and application of ecosystem restoration and rehabilitation techniques.	Capacity development	38,50	F, HR, I
Design of tourist attractions and ventures ensures that ecological sustainability and cultural integrity are not compromised.	Tourism	35,00	F, SC, P

Figure 4.1 Institutional affiliation of respondents to the first round of the survey. Categories on the vertical axis are: Government; Higher Education Institutions; Industry (large companies); Industry (parastatal); Industry (Small, Medium and Micro-enterprises); Non-governmental organisations; Research institutions; Other.



4.2.1 Statements considered important to South Africa

On average, statements in the biodiversity questionnaire (see Appendix 6) did not score highly on the three indices described above. The highest scores were 71,9 according to the joint index, 78,18 according to the wealth creation index and 75,00 according to the quality of life index, while the mean joint index score for the top 20 statements was about 50. (It should be recalled that a score of +100 indicates unanimity, a score of 0 means that respondents were equally divided in their opinion between 'high' and 'low' importance, and that a score of 50 means that 75% of the respondents thought that the statement was of 'high' importance).

Joint Index

Of the top 20 statements that were ranked by joint index, 65% also ranked in the top 20 of either the wealth creation and quality of life indices. These statements spanned eight of the 13 categories on the questionnaire (see Table 4.3). The categories with no statements in the top 20 of the joint index included making inventories, global environmental change, indigenous knowledge systems, other services and intellectual property rights. The conservation and sustainable use category accounted for 25% of statements in the top 20 of the joint index, tourism accounted for 20%, valuation, equity and access categories each accounted for 15%, and the impacts category accounted for 10%. Nature-based products, biotechnology and capacity development categories each accounted for 5% of the statements in the top 20 of the joint index.

Lowest ranking statements

The 20 statements that scored the lowest in the survey, when ranked by joint index, wealth creation and quality of life (i.e. they were not regarded as important by respondents) included those relating to 'emerging' technologies in biotechnology and ICT areas. Some examples of these included:

- Application of artificial, intelligent devices (such as robotics);
- application of automated, user-friendly, interactive ICT systems;
- application of miniaturised devices (such as biosensors);
- application of genetic 'tagging' technologies.

Many of these technologies are not yet well established applications in biodiversity science, and perhaps many respondents failed to appreciate their potential. Although the Working Group identified the customisation of technologies for local application as having wealth creation potential, the respondents to the survey did not perceive this to be so. Despite the explicit goal of the Foresight process to project a 20-year horizon, the respondents generally failed to appreciate this futuristic slant when ranking statements. Perhaps the fact that short-term policy (e.g. the White Paper on Biodiversity) is yet to be implemented contributed to this. On the other hand, it is true that biodiversity science as currently practised is not in the realm of cutting-edge technology, and practising biodiversity scientists do not habitually have a need for devices other than the analytic and databasing capabilities of computer technology.

Respondents did not perceive indigenous knowledge (IK) to be important for wealth creation or quality of life either. Again, despite recognition by the Working Group, the potential of IK is obviously not appreciated by the biodiversity community, perhaps because of its relative newness in this sector. These patterns suggest a conservative approach among respondents to the role of technology in biodiversity science.

4.2.2 Other variables

The above discussion is based on the importance variable that included wealth creation and quality of life. The pattern that emerged with regard to other variables, is summarised as follows:

- For most of the statements ranked as important by the joint index, respondents felt that South Africa's comparative standing was behind developed countries, and equal to or behind other southern African countries and developing countries.
- The time frame for realisation of the statements was generally regarded by respondents to be between six and ten years.
- In almost all cases, respondents felt that the strategy for acquisition or development of technologies or capacity to achieve the statements lay in local development, rather than through importing or customising technologies, or engaging in joint ventures.

- The most cited constraints to achieving the statements were a perceived lack of finances and human resources, an appropriate policy and regulatory framework, and socio-cultural factors such as acceptance by society for ethical reasons.

4.3 Conclusions

The Working Group reviewed the findings of the surveys, and was able to identify a number of issues and ideas, over and above the statements that were highly ranked, that would need to be considered when the final recommendations of the foresight process were formulated. These included the following:

- Although making inventories was not rated as a priority area for future research investment, it was recognised that basic inventories are central to all biodiversity research. This aspect cannot therefore be ignored in the development of a research strategy to enhance the value of the nation's biodiversity.
- Inventories should also focus on indicator organisms. Lists of species that are useful indicators of a range of environmental conditions and trends can be developed and their distribution mapped. This would also be an opportunity to apply ethno-ecological solutions.
- Methods of rapidly assessing biodiversity status could be complemented by parataxonomy, where local indigenous concepts are utilised to assist in inventories and surveys.
- Off-reserve conservation could be promoted by providing incentives and encouraging sustainable utilisation.
- There is also a need to incorporate local knowledge of biodiversity into educational material. Citing local examples in such material could promote a culture of understanding in society as a whole.
- There is a clear need to develop a better understanding of the magnitude and value of ecosystem services that are underpinned by biodiversity. Ignorance of these services (for example the generation of valuable water resources from catchment areas covered in indigenous vegetation; the harvest of food resources from the sea; the provision of grazing in agricultural systems; and the recycling of waste products) often leads to suboptimal management or development decisions.
- A need to link the concept of indigenous knowledge (IK) systems to the education systems was proposed. Models for the incorporation of IK into formal curricula could be developed in pilot programmes by universities in close proximity to communities holding IK.

These concepts, which have been combined with those embodied in the top-ranked statements to derive recommendations, are presented in the next chapter.

Chapter 5: Recommendations

5.1 Introduction

This chapter presents the recommendations of the Biodiversity Sector Working Group. These are based primarily on an analysis of the Delphi survey, and the statements perceived by the respondents to be important for both wealth creation and improving the quality of life for the people of South Africa (Chapter 4). The Working Group used the survey results together with their own expert knowledge to identify the underpinning requirements of research and technology that will be necessary to translate potential capacity into reality.

The Working Group also took a number of local features and broader principles into account when formulating their recommendations. South Africa has a very high biological diversity, complemented by diverse cultural diversity, and South African society should attempt to harness and build upon these features to the benefit of all. In doing this, a number of principles need to be considered. South Africa has international and national obligations in terms of the conservation of biodiversity (it has ratified the Convention on Biodiversity, for example), and activities in the sector should help facilitate meeting those obligations. Because conservation (or rather, preservation) and utilisation are often seen as opposite ends of a spectrum, the two need to be harmonised to achieve maximum sustainable benefits without degradation of the primary resource. Dovetailing these two driving forces is by no means an easy balance to achieve, and is one of the primary concerns of the biodiversity sector. Solutions range from the idealistic notion of sustainable consumptive utilisation, through non-consumptive use such as tourism and recreation, to a clear delineation between uncompromising preservation and aggressive commercial development. This last point implies that the intrinsic value of biodiversity needs to be acknowledged, and that today's generation has an obligation to future generations to ensure the protection of future options, including the quantification of the environmental services provided by strict preservation.

In making our recommendations, we have taken into account the fact that South Africa has generated a great deal of knowledge in the field of biodiversity. That knowledge is embodied in trained human capacity, in scientific publications, databases, and herbaria and museum collections, as well as in the traditional knowledge retained by the systems of oral history in many rural communities. These various forms of knowledge need to be conserved, developed, and applied to maximum benefit if the goal of sustainable development is to be achieved. We have, therefore, taken a strategic view, recognising that, although we have accumulated a large store of knowledge in various forms, much still remains unknown and there is

ample scope for further research. However, such research will have to be strategic and focused to maximise the derived benefits. The opportunities for contributing to socio-economic development of the country, for example, through job creation and the development of consumptive and non-consumptive products, will need to be optimised. There is significant scope for the incorporation of indigenous knowledge, but this needs validation and its utilisation needs to be promoted.

This chapter presents the Working Group's recommendations, based on the above analysis and principles. Some suggestions for the implementation of the recommendations are also made.

5.2 Recommendations

To gain maximum benefit from South Africa's remarkable biodiversity, society must invest in the development of scientific and human capacity. Our recommendations, arising from the Foresight process, are aimed first and foremost at promoting such development. The list of recommendations in this report is neither detailed nor comprehensive, but rather it encapsulates the most important areas where R&D can contribute to wealth creation and quality of life by promoting the development and use of biodiversity-based activities and products. We recognise that these recommendations will need to be developed further. Listed below are the activity areas of primary concern, which will require special attention from the research and technology sector in the coming decades.

5.2.1 Developing and maintaining a basic inventory

Although the need for inventory was not identified as a priority area in the survey, the Working Group members were nonetheless unanimous that these activities required priority investment. Without knowledge of the nature and distribution of biodiversity, no scientifically-based conservation, or development of its potential, will be possible. Inventory research should focus on the identification and distribution of (a) species with potential for commercialisation, especially where community-based opportunities exist; (b) species commonly used for subsistence and trading in the informal sector; and (c) bio-indicators.

These and the following recommendations are given weight by the identification of inventory and monitoring as important activities in the stated goals of the White Paper on the Conservation and Sustainable Use of South Africa's Biological Diversity.

Key technologies and techniques to address the concerns

- Rapid and accessible identification tools for poorly-known taxonomic groups;
- intelligent robotic devices (artificial autonomous systems) capable of collecting and classifying ecological data;

- automated identification systems (such as Description Language for Taxonomists, or DELTA systems) to describe and identify taxa;
- DNA techniques to enhance understanding of biodiversity patterns and processes;
- models to predict the distribution and dynamics of biodiversity;
- user-friendly information systems concerning biodiversity indices and patterns; and
- methods to rapidly assess the biodiversity status of habitats at different scales.

5.2.2 Monitoring global change and its impacts

The need for monitoring was also not identified as a priority area in the survey. The Working Group members were again of the opinion that these activities required investment. Monitoring should provide benchmarks for detecting the impacts of change, and should focus on (a) the effects of changing land-use and habitat destruction; (b) fragmentation and its effects; and (c) the effects of climate change. The use of techniques based on remote sensing will be especially important in this regard.

Key technologies and techniques to address the concerns

- Satellite data for large-scale habitat monitoring;
- electronic tracking for movement of animal populations;
- genetic tagging techniques to protect biodiversity (for example, monitoring of illegal trade in fauna and flora); and
- information technology to support predictive modelling of impacts on biodiversity by
 - climate change (altered rainfall patterns, rise in CO₂ level, sea-level rise);
 - changing land-use patterns and habitat fragmentation;
 - genetically modified organisms; and
 - invasive alien organisms.

5.2.3 Developing strategies for conservation and sustainable resource use

The conservation and sustainable use of biodiversity will have to be built on a working understanding of sustainable levels of utilisation, of acceptable harvesting methods, of methods of restoration in degraded ecosystems, and of the impacts of ecosystem management. The degree to which this is achieved and implemented will be constrained by funding levels and by society's ability to develop and maintain the necessary skills in a critical mass of scientists and trained ecosystem managers. We recommend, therefore, that adequate funding is made available to develop and maintain these skills through training at appropriate levels.

Key technologies and techniques to address the concerns

- Miniaturised monitoring devices (such as microbiosensors) for research and conservation;

- genetic-tagging techniques to protect biodiversity (for example monitoring of illegal trade in fauna and flora);
- models to simulate the effects of disturbance and management practices on ecosystem functions (for example fire, grazing, hydrology and fishing practices);
- restoration technologies to renew and renovate damaged ecosystems;
- off-reserve conservation techniques (such as tax incentives to retain rare species);
- techniques to predict the location and magnitude of threats to biodiversity;
- methods to estimate sustainable levels of direct and indirect resource utilisation, including harvesting of commonly used species;
- techniques to propagate recalcitrant plant species for ex situ conservation and use;
- techniques to facilitate or improve the breeding success of animals in ex situ situations;
- technologies for the ex situ storage of tropical and subtropical plants; and
- techniques to enable the use of DNA banks to complement gene banks.

5.2.4 Identifying and conserving biodiversity in a system of protected areas

It is essential that South Africa's biodiversity be adequately represented in a system of conservation areas that are effectively managed and defended. We recommend that investment be directed at the development of techniques to identify priority areas for conservation, and the development of models for financing the acquisition and management of the areas. Acceptable socio-cultural solutions are also important in this regard, and these need to be understood by conservation planners and communicated to policy-makers.

Key technologies and techniques to address the concerns

- Techniques (using spatial technologies such as GIS) to design a system of protected areas that will adequately represent biodiversity.

5.2.5 Developing nature-based tourism in South Africa

Nature-based tourism has the potential to contribute significantly to South Africa's GDP. Research here should focus on the development of innovative, theme-based packages, and on the development of community-controlled ventures that will, in turn, ensure that ecosystems retain a tangible value for the communities that live in them.

Key technologies and techniques to address the concerns:

- Information technology to support the development and production of —
 - portable electronic guides to fauna and flora;
 - theme-based ecotourism packages; and
 - community-controlled ecotourism ventures.

5.2.6 Valuation and value-addition

It is imperative that sound valuation techniques are developed to cover the contribution of components of biodiversity to the economic and environmental fabric of South Africa. Quantified assessments must inform decisions about the alternative uses of bioresources, such as land and water, to ensure, in turn, that ecosystems are optimally sustainable and productive with regard to the delivery of products and vital services. Investment should focus on both the development of valuation techniques and the communication of the results, in order to promote awareness and a common understanding of value. Unless policy-makers are aware of the benefits of biodiversity conservation and the options available to them, valuation techniques alone will bring no benefit. In addition, research should focus on the development of techniques to add economic value at local level to harvested and cultivated products, as well as on non-consumptive use.

Key technologies and techniques to address the concerns

- Resource-economics techniques to assess the monetary and non-monetary value of South Africa's biodiversity and ecosystems services;
- biodiversity evaluation techniques to inform decisions about land use; and
- techniques to add economic value to harvested or cultivated products and develop appropriate markets.

5.2.7 Developing equity and access to biodiversity resources

Issues of access to biodiversity resources and the equitable distribution of the benefits derived from such resources must be addressed to ensure a broad-based acceptance of management regimes. Research and technology should focus on the development of models for the co-management of protected areas by authorities and local communities that are compatible with protection of the biological integrity of these areas. In addition, shared-benefit bioprospecting schemes will need to be developed to boost the economies of underdeveloped areas. The relationship between different land-tenure systems (communal, private or state ownership) and biodiversity conservation also needs careful and strategic consideration.

Key technologies and techniques to address the concerns

- User-friendly information and communication technologies (for example with interactive and multilingual voice recognition capabilities) that will increase access to biodiversity information;
- innovative co-management options for protected areas to improve and increase ecological sustainability and economic benefits;
- shared-benefit bioprospecting projects to improve economic conditions in underdeveloped areas; and
- information systems to control access to sensitive areas, for example containing rare species or traditional knowledge.

5.2.8 Reducing the impact of development on biodiversity

Ways of incorporating biodiversity considerations into development planning and environmental impact assessments need to be developed in order to reduce the impact of development. Such considerations should not be simplistic, such as conserving one or two rare species, but should rather be aimed at protecting healthy ecosystems and the services they provide. In addition, the use of alternative resources to reduce pressure on biodiversity in poor areas needs to be developed. In all of these developments it is imperative that solutions acceptable to rural communities be found. The findings of research in these fields will also have to be incorporated into relevant legislation and regulations. This implies that the communication of research results to policy-makers is vitally important.

Key technologies and techniques to address the concerns

- Procedures and methods to incorporate biodiversity considerations in development-planning procedures and environmental-impact assessments;
- models for alternative bioresource use in poor rural communities to reduce the impact on biodiversity; and
- resource-economic models to develop an understanding of the effects of improved living standards among lower-income groups on biodiversity (for example, the effect of electrification on firewood use in rural communities, the influence of access to clinics on the muti trade in threatened plant species in the wild, etc.).

5.2.9 Developing capacity for managing biodiversity

The ability of society to conserve biodiversity and to develop the potential for wealth creation and quality of life that these resources offer in South Africa will depend on the development of adequate human capacity. This implies a need to maintain and strengthen training institutions, and to provide opportunities for research funds to be utilised for building human capacity. It is important that this capacity should be capable of integrating all levels of biodiversity (from molecular to biosphere), effectively a trans-disciplinary approach. In order to do this, institutions that can facilitate this type multifaceted interaction of knowledge and expertise need to be maintained and developed at a national level.

Key technologies and techniques to address the concerns

- Cooperative interdisciplinary research programmes to rapidly quantify and predict ecosystem structure and functioning;
- trans-disciplinary research programmes, linking natural and social sciences, which will enable biodiversity researchers and managers to cope with the changing, complex and dynamic environment;
- dynamic ecological-economic models to estimate the socio-economic value of ecosystem services;
- techniques to design and apply ecosystem restoration and rehabilitation; and

- education software (especially interactive software), for use in natural history and science museums or classrooms, to foster scientific skills in children.

5.2.10 Integration of indigenous knowledge systems

A considerable body of knowledge exists in the form of indigenous knowledge systems, and this needs to be harnessed in order to derive benefit for biodiversity and to broaden buy-in and benefits from biodiversity. Although this was not identified as important in the survey, the Working Group members have included these issues here, as there was a strong feeling in the group that the issues were very important, and that this importance may not have been fully appreciated by the survey respondents. As a first step, South Africa needs to develop its own definition of 'indigenous knowledge systems' — there is much room for the development of a common understanding of this issue among the country's diverse population groups. The incorporation of indigenous knowledge systems into biodiversity management projects needs to be encouraged, as does the inclusion of indigenous knowledge systems into the curricula of formal learning institutions.

Key technologies and techniques to address the concerns

- A validation system incorporating both indigenous and 'Western' approaches, providing standards for indigenous products, services, knowledge and technologies; and
- techniques for the commercialisation of products and processes traditionally used by South Africa's indigenous communities.

5.2.11 Developing biotechnology products

South Africa's unique and substantial biodiversity offers the potential for the development of a number of products, using modern techniques to build on a considerable resource base. This, too, was not identified as being among the top priorities by the survey respondents, possibly because of a lack of expertise and experience in these fields amongst the survey group. Once again, the members of the Working Group felt that these approaches had merit and needed further investigation. One of the major challenges in this regard will be to ensure the means for thorough testing of GMOs and their possible impact on biodiversity resources, as well as to facilitate a full public understanding of the process by consumers to permit constructive debate of relevant issues.

Key technologies and techniques to address the concerns

- Biomapping systems to combat pollution, based on local microbial biodiversity;
- Gene-modification techniques to improve the commercial viability of indigenous fauna and flora;
- Bioprocessing techniques to produce chemical products on a commercial scale;

- tissue-culture technologies to mass produce commercially important indigenous flora species; and
- effective monitoring and assessment techniques to ensure the biosafety of GMOs.

5.3 Next steps

The Working Group agreed that in order to take the recommendations further, a few key actions should be identified. For sustainable development to be achieved, careful conservation and development of biodiversity-based resources will be critical. At present, the responsibilities for biodiversity-related issues are divided among several government departments, resulting in inefficiencies and anomalies in ecosystem management that South Africa can ill afford. The challenge is to overcome these in innovative ways by building on a sound base of scientific and cultural knowledge, and seeking collaboration to achieve mutual benefit. Careful attention to a clear understanding of the status quo echoes recommendations of the White Paper on Biodiversity. The following discrete steps outline the path that the Working Group envisages for implementation of its recommendations:

STEP 1. The DACST Biodiversity Foresight initiative has established a diverse and well-qualified Working Group. The knowledge and skills and the familiarity of this group with current problems should not be lost to the process, but should instead be drawn upon as a reference base of biodiversity issues in future, and should receive support from government agencies to retain this advisory function until such time as a politically effective decision-making body can be established. The Biodiversity Reference Group could coordinate implementation of the recommendations and ensure cross-sectoral synergies (for example, between tourism, agriculture, forestry and the environment). The reference group that was brought together to conduct the Foresight exercise could form the basis for such a reference group.

STEP 2. In South Africa today, biodiversity-related research does touch on a number of the areas in which we have recommended that future research priorities should lie, but no clear and readily accessible picture of the scope, depth and adequacy of current research is available. As a first step, an audit of current activities in the country in respect of our recommendations should be conducted. Such an audit will be very useful to determine the adequacy of current biodiversity research, the identification of priorities for research funding, the impact of biodiversity loss on the quality of human life in South Africa, and the human capacity that needs to be developed for the effective management of biodiversity

STEP 3. The recommendations of the Working Group should be developed as funding priorities in all institutions that support biodiversity-related research. Examples of such institutions include the Departments of Environmental Affairs and Tourism, Water Affairs and Forestry, and Land Affairs and Agriculture, as well as the Agricultural Research

Council, the CSIR, the Water Research Commission, Universities, Technikons, and Museums.

STEP 4. A funding mechanism should be established, based perhaps on the old Co-operative Scientific Programmes model of the CSIR in the 1980s, and getting contributions from a range of stakeholder organisations (such as the Departments of Environmental Affairs and Tourism, Water Affairs and Forestry, and Land Affairs and Agriculture, as well as the Water Research Commission), in order to encourage trans-disciplinary and integrative biodiversity research. At present, the National Research Foundation would appear to be the ideal institution to manage such a funding mechanism, since it now includes social scientists.

STEP 5. Explicit efforts need to be made to identify gaps in terms of human capacity for the establishment of resource economics as a strategic tool in the management of biodiversity resources, and then to address these systematically. This may involve the creation of capacity where it does not exist (for example the creation of a Chair in Resource Economics at one or more universities), or the development of postgraduate training courses by harnessing existing expertise, e.g. the postgraduate courses in conservation biology and management at the Universities of Cape Town and the Witwatersrand.

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Appendix 1: Biodiversity Working Group Members

Ms Khungeka Njobe (Sector Coordinator). Department of Arts, Culture, Science and Technology— Biodiversity Sector Coordinator. Her areas of interest and expertise include biodiversity and science and technology policy and technical issues. She provided secretarial and research support for the working group, and helped to design and facilitate the workshop processes.

Prof. Richard Cowling (Sector Chair). University of Cape Town's Institute for Plant Conservation. His main area of expertise and interest is research, focusing on the development of predictive understanding of plant biodiversity patterns and processes and the use of this knowledge for conservation and sustainable use of flora and vegetation. In addition to being the Chair of the Working Group, he was also on the Working Subgroup on Ecological Sustainability and on the Editorial Committee. He helped to design and facilitate the workshop processes.

Dr Rob Anderson. Seaweed Research Unit of the Sea Fisheries Research Institute. His areas of expertise and interest are seaweed research, biology, ecology of biodiversity, and management of marine resources. He served on the Working Subgroup on Ecological Sustainability and on the Editorial Committee.

Dr Harry Biggs. South African National Parks Board. His areas of interest include application of research and monitoring results using strategic adaptive management, management of scientific programmes, and quantitative systems ecology. He served on the Working Subgroup on Applications of Information and Communications Technology.

Prof. Mike Bruton. Formerly of the Two Oceans Aquarium in Cape Town, now CEO of the MTN Science Park.

Dr Cobus Coetsee. Agricultural Research Council— Fynbos Unit. His areas of expertise and interest include commercialisation of indigenous plants, plant breeders' rights, farmers' rights, patent rights regulation, and indigenous knowledge systems. He served on the Working Subgroup on Applications of Biotechnology.

Dr George Davis. National Botanical Institute. Formerly leader of the Stress Ecology Research Programme, he is now involved primarily in project development and donor liaison within the NBI. Within the Foresight project he served on the Working Subgroup on Implications of the Political Trends and Policy, was the Editor of the Biodiversity Foresight Newsletter (a communication to the sector stakeholders), and general editor of the final sector report.

Dr Chris Dickens. Umgeni Water. His areas of expertise and interest are management and use of river and lake systems and general limnology. He served on the Working Subgroup on Ecological Sustainability.

Dr Roger Ellis. Agriculture Research Council — Plant Genetic Resources Unit. His areas of interest and expertise cover plant genetic resources, ex situ conservation, biodiversity utilisation and biosystematics. He served on the Working Subgroup on Application and Issues on Indigenous Knowledge as well as on the Survey Subcommittee.

Mr Saliem Fakir. IUCN — South Africa. He also served on the Working Subgroup on Implications of Political Trends and Policy.

Dr Dai Herbert. Natal Museum. His areas of interest and expertise include conservation of invertebrate animals, biodiversity data banks, environmental education and science and technology issues. He served on the Working Subgroup on Economic Opportunities.

Dr Marthinus Horak. Council for Scientific and Industrial Research — Foodtek. His areas of interest and expertise are the study of biologically active chemicals in plants and micro-organisms, bioprospecting and value-addition to indigenous plants and indigenous knowledge. He served on the Working Subgroup on Applications of Information and Communication Technologies, and the Survey Subcommittee, and represented the Biodiversity Working Group on the Cross-cutter Working Group on Beneficiation.

Ms Mpho Litha. Department of Public Works. She served on the Working Subgroup on Applications of and Issues in Indigenous Knowledge.

Mr Edward Mabogo. University of Venda — Department of Botany. He served on the Working Subgroup on Applications of and Issues in Indigenous Knowledge.

Mr Isaac Mayeng. Traditional Medicine System Organisation and Department of Health. His areas of interest and expertise include traditional medicines, intellectual property rights, indigenous knowledge, conservation and development of medicinal plants. He also served on the Working Subgroup on Applications of and Issues in Indigenous Knowledge.

Ms Maria Mbengashe. Eastern Cape Provincial Government — Department of Economic Affairs, Environment and Tourism. She served on the Working Subgroup on Poverty (and Biodiversity) and represented the Biodiversity Sector on the Cross-cutter Working Group on Human Resource Development, Education and Skills Development.

Ms Dolana Msimang. Council for Scientific and Industrial Research — Technology for Development. She served on the Working Subgroup on Economic Opportunities and represented the Biodiversity Sector on the Business Development Cross-cutter Working Group.

Mr Myles Mander. Institute for Natural Resources. He served on the Working Subgroup on Economic Opportunities.

Ms Nonjabulo Nduli. National Department of Agriculture. Her areas of interest and expertise include initiatives to improve sustainable natural resources, economic and social development, poverty and environmental degradation, institutional analysis, development, and evaluation and adoption of a legislative and policy framework to support biodiversity. She also served on the Working Subgroup on Poverty (and Biodiversity).

Mr Clifford Nxomani. Foundation for Research Development. His areas of interest are biotechnology, biodiversity and conservation. He served on the Working Subgroup on Applications of Biotechnology.

Mr Trevor Sandwith. KwaZulu-Natal Nature Conservation Service. His areas of interest and expertise are primarily policy and institutional development in nature conservation. He has focused on the integration of conservation and community development, and especially the harnessing of biodiversity value through economic development. Current initiatives include the development of statutory local boards for protected areas and cross-border conservation initiatives. He served on the Working Subgroup on Economic Opportunities.

Prof. Wouter van Hoven. University of Pretoria— Centre for Wildlife Management.

Prof. Albert van Jaarsveld. University of Pretoria— Centre for Environmental Studies. His areas of interests and expertise cover research into appropriate procedures for conservation planning, biology of fragmented populations, principles of sustainable development, integration of regional conservation objectives and options for land use. He served on the Working Subgroup on Applications of Information and Communications Technology and the Survey Subcommittee and regularly represented the Biodiversity Sector at the Foresight Chair's Meetings.

Dr Brian van Wilgen. CSIR Division of Water, Environment and Forestry Technology. His interests lie in the conservation and sustainable utilisation of terrestrial ecosystems, and he is an expert in fire ecology, the ecology and management of alien invasive organisms and integrated catchment management. He served on the Working Subcommittee on Ecological Sustainability and the Editorial Committee.

Dr Allan Whitfield. JLB Smith Institute of Ichthyology. He served on the Working Subgroup on Ecological Sustainability.

Dr Gert Willemse. Department of Environmental Affairs and Tourism. He served on the Working Subgroup on Implications of the Political Trends and Policy.

Ms Rachel Wynberg. Graduate School of Environmental Studies, University of Strathclyde — Biowatch South Africa. Her areas of interest and expertise include the commercialisation of biodiversity, environmental policy development and analysis, intellectual property rights and traditional knowledge, access to genetic resources and benefit-sharing, land reform and environment, protected area use and management, global environmental policy. She also served on the Editorial Committee and on the Working Group on Political Trends and Policy.

Dr Philemon Mjwara. DACST — National Research and Technology Foresight Project Director

Appendix 2: Terms of Reference for the Working Group

The sector working groups will investigate future socio-economic challenges facing the sector and identify the impact these will have on the sector. The sector will be analysed within the South African context while recognising its contribution to the global and regional economy. The sector working groups will then be expected to identify market opportunities as well as research and technology requirements, which will assist the sector in enhancing its performance and also address social issues. The responsibilities of the sector working groups will be to —

1. agree on proposed sector foci;
2. analyse the current status of the sector;
3. identify future research and technology challenges and market opportunities over the next 10-20 years;
4. make recommendations on the identified cross-cutting issues/areas;
5. compile a prioritised list of research and technology topics for each sector;
6. make recommendations on implementation strategies;
7. compile the Foresight sector report; and
8. assist in identifying research and technology themes towards the designing of appropriate research programmes.

In achieving the above, recommended foresight methodologies and tasks are included.

Recommended methodologies and tasks

The Foresight Project Management Team recommends that the following Foresight methodologies and tasks be carried out by sector working groups in conjunction with the designated sector coordinator, who will be responsible for giving research and analytical support to the sector activities:

1. It is recommended that the sector working groups review the proposed sector foci and agree on foci for the sector.
2. Analysis of the sector will be achieved by synthesising the information provided in the —
 - a) International study — A study examining current technological, market, policy and strategic trends of the sector internationally.
 - b) Local study — A review of the current status of the sector in South Africa.

On the basis of the above information, it is recommended that a SWOT analysis be done and major STEEP drivers and constraints within the sector be identified.

3. In addition to sector challenges and opportunities identified by the sector working groups, it is recommended that the sector working groups —
 - a) survey the needs of communities.
 - b) source opinions of knowledgeable people in the sector on various issues via a questionnaire-based survey.
 - c) workshop the progress of the sector with sector stakeholders at agreed milestones of the Foresight process.

Specifically, the sector working group will then be responsible for —

- agreeing on a process to be followed when surveying needs of communities and for synthesis of those inputs;
- identifying issues to be surveyed (see 3b) and developing questions;
- designing the survey questionnaire;
- managing the survey process;
- analysing and synthesising survey results;
- agreeing on issues to be workshopped;
- identifying participants in sector progress workshops; and
- reporting the progress of the sector to stakeholders.

Given that the benefits from the outputs of the NRTF project will only be realised in the long term (ten to 20 years), it is recommended that sector-specific scenarios be developed and analysed. The sector working group's role will therefore be to —

- contextualise for the sector the macroscenarios that are being developed for S&T in South Africa; and
- develop and analyse sector-specific scenarios.

4. Two cross-cutting areas/issues, namely education/human resource development/skills development and business development, have been identified. It is recommended that sector working groups examine these issues in relation to the sectors and give recommendations on how to address them.
5. Sector-specific prioritised research and technology topics are one of the major outputs of the NRTF project. This output will be achieved by using all the information gathered as outlined in previous points. The sector working group role will be to—
 - agree on sector research and technology topics;
 - agree on prioritisation criteria; and
 - prioritise the sector research and technology topics.
6. The success of a foresight exercise lies in its outputs being implementable. As there are practitioners in various sectors, it has been suggested that sector working groups advise on implementation strategies.

7. A sector report will be produced. Together with the sector coordinator, Sector Working Groups will be responsible for this.

8. A composite Foresight report will be compiled on the basis of inputs from various sectors. A major component of this report will be a listing of research and technology themes/areas which will be an input when designing research programmes. The role of sector working groups in this regard is to help identify the research and technology themes.

Appendix 3: Biodiversity Sector Scope

The main focus of the Biodiversity Sector will be the identification of research areas and technologies (existing, emerging and to be developed, including indigenous technologies) underpinning —

- knowledge generation and understanding of the country's biodiversity;
- conservation and sustainable use of biodiversity; and
- novel market opportunities (products, services etc.) based on biological diversity.

Since the goal of the Foresight Biodiversity Sector is to make biodiversity socially and economically attractive, about 50% of its efforts will be towards the identification of novel market opportunities.

The sector will consider all fauna and flora, including marine organisms, plant, animals, fungi and micro-organisms. All levels of biodiversity, namely genetic, species, and ecosystem, will be considered. The focus will be not only on indigenous species but also on domesticated plants and animals and on the impact of introduced species (exotic) and genetically modified organisms (GMOs) on biodiversity.

The Foresight Biodiversity Working Group proposes that the sector be categorised according to the model presented in Figure 1.

Improving knowledge and public understanding of biodiversity

This category encompasses composition, structure, function and services provided by biodiversity. Specific areas to be considered include the following:

- An inventory of biodiversity.
Systematics, taxonomy (formal and parataxonomy), collection management and databases are tools that facilitate this. There is a need to move away from a 'flat lists only' approach towards integrated predictive understanding.
Spatial distribution of biodiversity should also form part of this component. This will include development of GIS-based databases for collection records (e.g. bird atlas, précis, protea atlas).
- Systems functioning, to give an overall view and to aid decision-making. Modelling is an important tool in this area.
- Productivity, which is essential for sustainable use of biodiversity.

- Services derived from biodiversity. Services, in this instance, encompass direct use or consumptive use, indirect use or non-consumptive use (for example tourism, recreation), options for use, and existence value.

Management of biodiversity: its conservation and sustainable use

This component is concerned with conservation and promoting sustainable use of biodiversity at genetic, species (which includes sustainable yield/production, e.g. cropping one or a few of selected species), and ecosystem (e.g. tourism, pastoralism, game and fish management) levels. Conservation issues to be covered include the following:

- In-situ conservation
Specific issues related to reserve networks, number of species captured in these, and distribution of natural (undisturbed) habitats outside of formal conservation areas should be considered in this component.
- Priorities for conservation
This covers identification of threatened species, habitats and ecosystems, and prioritisation of these in terms of need for conservation action.
- Threats: factors contributing to biodiversity loss
This covers threats to biodiversity, their severity and spatial distribution. Examples include habitat destruction or conversion, invasion by alien organisms, pollution, and over-utilisation.
This issue will also look at ways in which negative impacts on biodiversity could be reduced or reversed. Research directed towards searching for alternatives to negative activities is needed. Techniques or tools needed to rehabilitate or restore degraded habitats need to be developed.
- Identification of effective conservation practices or techniques.
These include indigenous and traditional practices. Examples of where lessons could be drawn from include those of well-managed reserves, farms and forestry estates, and indigenous sustainable harvesting practices.
- Monitoring of biodiversity
There is a need to develop systems to monitor trends in habitat loss, the spread of alien species, and changes in the distribution and status of species, as well as in environmental factors that affect them. A bird atlas is a good example of such a system. We also need to establish and maintain a series of long-term ecological research sites to detect trends and to serve as benchmarks. This is especially important in view of predictions of climate change, increased levels of CO₂ and so on.

Issues pertaining to sustainable utilisation include the following:

- **Survey of current use of biodiversity**
There is a need to survey the degree to which populations of naturally occurring organisms are being harvested and utilised. Such utilisation could include both direct utilisation (e.g. fishing, hunting, harvesting of plant products, etc.) and indirect utilisation (for example organisms that maintain soil fertility, that decompose waste), non-consumptive utilisation such as tourism, birdwatching, photography and so on. How much of this utilisation is for local use, and how much for export?
- **Promoting sustainable use**
How can biodiversity be used in future, and be sustainable to benefit the maximum number of people? There are undoubtedly many opportunities to utilise our biodiversity. We need to develop these so that future utilisation is developed on a sustainable basis.

There is a need for use of traditional and non-traditional technologies to manage utilisation, and to enhance knowledge of how different ways of utilisation impact on biodiversity conservation and management of strategies that we pursue.

- **Valuation of biodiversity**
There is a need to address the issue of proper valuation of biodiversity, both through direct utilisation, and through the ecosystem services that it provides. Science and technology policy should have the explicit aim of developing methods to enable these values to be included in the national balance sheet. This is the field of natural resource accounting. The national balance sheet should include our natural assets (species populations, soil, air and water) and the value they contribute to the economy.
- **Identification of novel opportunities (products, services etc.) based on biodiversity**
The Biodiversity Sector probably acts as the most important primary screening filter (based on knowledge of the above categories) for generating new suggestions or possibilities arising from nature, or suggesting novel alterations to existing practices e.g. in agriculture/fisheries). Interlinking with the respective 'client' sectors in order to understand their problems and needs (see Figure 1) may also guide us in generating candidate solutions. Opportunities identified in category should include socio-economic considerations.

Cross-cutting issues

The following issues are important in realising the Sector's goals

1. Business development
2. Beneficiation
3. Education, especially environmental education

4. Information technology (IT)
5. Policy framework
6. Technology transfer
7. Public awareness
8. Institutional framework
10. Intellectual and material property rights
11. Integration and multidisciplinary approaches
12. Development of capacity.

Appendix 4: Scenario Development and Analysis for the Biodiversity Sector

Key Aspects of the Biodiversity Scenarios

Key aspects of the different scenarios are summarised under socio-political characteristics, economic characteristics, science and technology characteristics and environmental management. The narratives of the four scenarios are presented in Boxes 5.2 - 5.5.

Scenario 1: 'Our Way is THE Way'

- Politically, there is a clear vision and strong commitment towards biodiversity issues. Biodiversity is seen as playing a positive role.
- There is a strong conservation ethic which is based on the economic value of biological resources.
- Access to resources is initially controlled in the interests of the environment. Intellectual property is initially well protected although there is limited international investment.
- High value is placed on biodiversity because of unique features, economic opportunities and national pride.
- There is a high level of economic sophistication. Value-addition or beneficiation is emphasised.
- Regional (South-South) cooperative economic opportunities based on biodiversity exploitation are created.
- Appropriateness of technology is emphasised.
- Technologies developed in South Africa are incompatible with international technologies.
- There is high S&T investment.
- In terms of management of global change issues (e.g. climate change, invasive species, desertification) there is selective focus on issues that will have an impact on South Africa. South Africa links up with southern bloc countries for mutual benefit and cooperative research. Southern bloc countries unite against exploitation by the North.
- When disasters (such as floods, oil spills, etc.) occur, these are managed well. There is capacity to predict, assess risk and mitigate disasters. Contingency planning includes the poor. However, local disasters are better handled than international disasters.

Scenario 2: 'Innovation Hub'

- Politically, vision and commitment to biodiversity management are weak. Biodiversity is not seen as playing a major role.
- The conservation ethic, education and awareness are linked to innovation and economic value.
- Access to resources is for those who are innovative players.
- Economic value of biodiversity overrides social and environmental value.
- Politically, there is a high level of economic sophistication. Value-addition and beneficiation are promoted.
- Southern African regional economic opportunities based on biodiversity exploitation are created.
- There is appropriate investment in research and technology.
- In terms of management of global change issues (climate change, invasive species and desertification) there is selective focus on regional issues. Regional collaboration and linkages are emphasised. There is focus on long-term effects of change.
- A regional capacity to manage (i.e. predict, assess risk, mitigate) disasters is developed. Contingency planning is developed for the region.

Scenario 3: 'Global Home'

- Politically, biodiversity has a minor but material role.
- The conservation ethic, education and awareness are influenced by global trends.
- Access to resources is determined by global norms and favours multinationals. Private ownership model dominates.
- The value of biodiversity is determined by what is seen to be valuable globally.
- There is minimal focus on beneficiation or value-adding. There are cells of value-added products (e.g. ecotourism, nature-based products, etc.), but the major focus is on 'mining' raw materials for export.
- There is high investment in S&T.
- There is selective focus on those global change issues (i.e. climate change, invasive species, desertification) that will have a large impact on South Africa. Links with other global role players are created.
- In terms of management of disasters (e.g. floods, oil spills) there is reliance on external intervention. The country has a better capacity to cope with global disasters than local disasters.
- Sustainability is not a priority. The practice is, 'If you can sell it, use it'.

Scenario 4: 'Frozen Revolution'

- Politically, the role of biodiversity is inconsistent. Government vision is confused, unclear. There is a short-term commitment to biodiversity, but this slowly deteriorates over time.

- Some have a conservation ethic, education and awareness (most don't) but overall they are in decline.
- There is inequitable, opportunistic access to resources. Utilisation is ad hoc and unsustainable.
- The country is unable to attach value to biodiversity. Lack of protocols, standards etc result in attrition of biodiversity.
- There is some 'mining' of raw materials, and the value-adding drive is inefficient as there are no incentives.
- There is little local investment in S&T.
- Management of global change issues is left to other countries to deal with. Ineffective use of technologies related to management of global change issues. No integration of information and management systems.
- No capacity for management of disasters, only for emergency services and focus is on crisis management. Problems are addressed on an ad hoc basis.
- Sustainability is a priority on paper but lack of action results in environmental decline.

Biodiversity Scenario Narratives

1. Our way is the way

In 1994, after years of isolation, South Africa faced enormous social and economic challenges. The world — particularly the then G7 countries — had made progress and was becoming a global village. International conventions, agreements and protocols were setting standards in many areas — from trade to protection of the environment. However, not everyone was pleased with the globalisation trend. A feeling of dissent from the poorer southern countries was brewing and many in South Africa shared the sentiment. In 1999, a government advocating that South Africa participate in the global village on its own terms, was voted into power by an overwhelming majority.

From the outset, the new government made it clear that it was going to focus on uplifting the many poor people in the country. In the 'Road to Recovery' plan — a ten-year plan for development published in 2002— sustainable utilisation of biodiversity was cited as one of the key strategies to alleviate poverty and develop the economy. Ivory, for example, was specifically mentioned as one of the commodities that could generate significant revenues for the country. This, of course, invited criticism from international organisations, especially animal welfare organisations.

In 2006, Environment-SA, the government department responsible for biodiversity issues, together with Economic Affairs-SA, developed an action plan for the development of natural products such as herbal teas, natural food products and medicines. Three years earlier, the Task Team on Economic Development of the South-South Countries Alliance had identified natural product development as

an area with promising market potential. Along with the action plan, guidelines for sustainable harvesting of biological diversity were also issued.

Earlier in 2006, the Secretary-General of the Global Village for the Betterment of the World (GVBW), an alliance of the wealthiest countries in the world, issued a strong warning that South Africa would be further isolated if it continued to violate the Trade-Related Intellectual Property Aspects of International Trade Protocol. This warning was prompted by the promulgation of the Access to Genetic Resources Act, No. 47 of 2005, which stated clearly that South Africa would not honour Intellectual Property Rights on the country's genetic resources registered outside South African borders. The State President dismissed the warning and reiterated South Africa's intentions in this regard by citing the success when law enforcers clamped down on biopiracy activities carried on in the country by foreigners.

In 2011, South Africa experienced one of many hardships it had to endure in its pursuit of 'Our Way is THE Way'. A millet pest, an insect whose origins were traced to the South American region, destroyed the annual harvest. Millet was by then a popular staple thanks to the government's Promoting Indigenous Products Programme. As a result, the country suffered severe food shortages. However, it could not get assistance from the GVBW countries as in 2005 it had been unanimously agreed that South Africa should be isolated until it complied with the international agreements it had violated for years. Now the country had to look at alternative foods — mainly mealie-rice donated by South American countries. Most people, however, disliked it ... but what choice did they have?

'South Africa shall never see a disaster similar to the one in 2011 again,' declared the Minister responsible for Research and Appropriate Technology at the recent launch of the neem-based biopesticide developed jointly with the South American Union and South East Asian Cooperation Body. The Minister also remarked in his speech that South Africa had made significant strides in developing appropriate technologies. 'Cooperation with those countries with similar problems has led to this success,' he said. He also joked that South Africa would continue to access information from any source and by any means possible to aid development of the country.

Indeed, twenty years on and following a long and winding road, the quality of life for many has improved. Many more are literate and have jobs and access to services such as electricity, telecommunications and water. However, the 'Information Age,' which took the world by storm and which contributed to the phenomenal economic growth of the GVBW, taking it to unprecedented heights, has passed South Africa by. South Africa is now contemplating joining the information society — if one has to go by the now popular People's Party election manifesto.

2. Innovation Hub

Former President Sekgonyela has lived to see a hundred years. One could be tempted to think that his wife Nobandla's charm and love were responsible, were the rapid strides in technology and medicine not so obvious. Is it the Mhlonyane syrup that he now gets packaged in a biodegradable bottle with directions for use printed on strictly recycled paper? Or is it the convenience of life-extending homeopathic creations that have bridged the gap between Sifozonke and the techno-magic potions of the post-millennium? This betrays a South Africa that is at home in the world's technological jungle while carving unique niches to create little nests of gold. At home. About home. From home.

Innovation is the primary and non-negotiable standard in dealing with all things created or transformed. In policies defined and imagined, in governance and operation, from making clay bowls to assembling BMWs and Volksies for export. The prima-donna status of social reconstruction is undercut by the effectiveness (read profitability) of collective productivity. Innovative approaches radically disembowel accepted notions of black and white and expose them both for the fact that neither of them is a real colour.

Access to international markets and technology and responsible investment in science and technology has made much progress and change possible. From a birth-control vaccine for elephants in the Kruger Park to tuskless elephants with favourable bioconversion rates that minimise the biodestruction for which they were once infamous. These innovations, however, come at a price. Those who dreamed them demand generous reward and those who want to enjoy them give generously of income creatively earned. Yet many can only wait patiently for the sun to shine their way. Perhaps one day they will be able to catch a glimpse of the reddish-brown silhouettes of lions taking their last sip of the day.

Contradictions abound, between the petty charades of the comfortable and the fundamental needs of those who possess little. As the 'Save the stalkborer coalition' clashes with Free State farmers demanding insect and drought-resistant maize, historically disadvantaged farmers are growing transgenic maize in the Karoo. Here the word biodiversity has more relevance to the variety of dollars one is likely to get from growing Gemini virus-free maize on land cleared of fynbos, than the variety of species likely to lose their habitat through such action. Through access by licence to cutting-edge know-how, the Southern African National Park stretching from Botswana to Mozambique through South Africa is poacher free and a haven for biodiversity from creatures that fly to those that swim. It is patrolled by miniature planes and inhabited by electronically and genetically tagged organisms whose movements are monitored through GIS-based technologies.

In this way, South Africa represents a microcosm of affluence to some and limited access to wealth for others. The contradictions of progress and limited sharing govern many social and economic undertakings. The country can acquire all the technology it needs, but is prevented from harnessing these opportunities for overall social upliftment. The reason is that even though the notions may be noble,

the dollar still wins the day. Biodiversity and sustainability mean something only when accompanied by the rustle of notes. However, in all the confusion and contradiction, infrastructural development makes unexpected gains. It looks like one big, confusing maze, but there is direction and movement.

3. Global Home

It is 2020. The South African government has for two decades been committed to international competitiveness in a fully liberalised world economy, and has cultivated the most appropriate possible response from the private sector. This has attracted much international investment, and the country flexes its lean and fit musculature to run every available race according to global rules. At home, all is not well for those who are not lucky or ambitious enough to find a niche in this aggressive environment, and the state's social responsibilities cannot make up properly for this. However, South Africa is a force felt in the world economy, with certain niches being dominated by products in which they have played a pivotal role. The national identity is blurred by the stronger international feel, and indigenous knowledge has all but been forgotten in the formal system.

Biodiversity research and development issues are seen as important because of international compliance or opportunity. Agreements to which South Africa is party are closely adhered to, environmental awareness being in line with international trends. The international 'fat cat' companies are consistently given favourable positioning within South Africa, the expected result being proportionally good rewards for the country, though these are usually channelled directly to participants and not redistributed. Overall there is a very high investment in science and technology, again directly in harmony with international norms and requirements. There are some foci of excellence for value-addition to South African biodiversity products, but all too often raw products are 'mined' for direct export.

Technology flows in and out of South Africa freely and effectively, the country being fully wired in all respects to the global science and technology scene. As part of this, many inappropriate and some risky trends arrive in the country, but dangers are usually kept in control by international safeguards.

Those environmental changes seen by the world as alarming, get due attention from South Africa, and South Africa's global participation in these issues is strong. Certain locally important disasters in South Africa, which the world can do little about, are not responded to very successfully by South Africa. It becomes a joke among citizens that the country seems to regard other countries' disasters as more important than its own. Although sustainability is often regulated to some extent by world market trends, another cynical line is 'if someone wants it, sell it; too bad if there's none left'.

With all these contradictions and limitations, South Africa seems to have mastered the ability to survive internationally, albeit without everything in the social

and environmental areas being perfect. Good levels of biodiversity R&D have persisted through all this, but the focus has remained mainly international. Individuals and companies wanting or prepared to exploit science and technology opportunities in these particular fields have flourished.

4. Frozen Revolution

The year is 2020. The 'new' South Africa is more than a quarter of a century old. After four terms in office, with diminishing support, the African National Congress was finally forced into forming a minority government after the 2014 elections, a position it maintained and repeated during the 2019 elections. Its closest ally, the Populist Reformed Workers' Party, is increasingly influential in the development of inward looking policy in nearly all spheres. President Thembu Hlubi-Van der Merwe has indicated that this will be her last term of office.

Since the virtual collapse of the rand in 2011, when it fell to an all-time low of R104,55 to the US\$, South Africa's economy has been in a state of stagnation. The country does, however, benefit from its membership of the Southern and East African Economic Union, which is dominated by the booming economies of Uganda and Tanzania. Trade with Europe, Asia and the Americas is restricted to the export of small quantities of specialist wines, fruit and wildflowers produced on farms owned predominantly by Nigerian interest groups. Marine resources are almost entirely depleted, and local fishing communities in many coastal areas have turned to foreign-owned strip-mining operations for employment, from the steel and bauxite mines of the west to the titanium operations on the east coast.

Poor settlements both in rural and in peri-urban areas are multiplying and growing. Many of the people in these communities are unskilled — the world-renowned education policies of twenty years ago did not see implementation. Some hold low-level jobs in the service industry, earning salaries well below the living wage. Some rely on selling curios to the tourists who frequent exclusive resorts. Many are jobless. Generally their lot has no hope of ever being improved.

Tourism in the country has remained stable for the past 15 years, although facilities are becoming increasingly concentrated in the hands of expatriate owners, from the hotels and private beaches of the Western Cape to the former national parks network. Very little of the foreign income generated by tourism reaches local people directly, although the huge tourism taxes imposed by government on foreign operators manages to assist in maintaining some of the more desperately needed social upliftment programmes, such as those in the rural regions of the former Eastern Cape, now the South-eastern Territory administered by central government's Department of Environmental Crisis Management (DECM).

Following the promulgation of the Environmental Crisis Act, No. 45 of 2013 — at which time the former Department of Environmental Affairs and Tourism was dissolved to form the Department of Environmental Crisis Management, and tourism

functions were transferred to the Department of Trade and Industry — South Africa withdrew from all international environmental agreements and protocols. The momentum that had been made in gaining recognition of Intellectual Property Rights for components of biodiversity was lost, and the country once again became a target for opportunistic bioprospecting. Some of the protective legislation developed before that time, however, remained in place, and local communities managed to retain sufficient hold over local biodiversity resources for a discernible contribution to the alleviation of dire rural poverty in some regions. This was enhanced by the partially implemented agreements on benefit-sharing that prevailed in the first decade of the 21st century, which was the heyday of bioprospecting and biobeneficiation. It is generally agreed that that boom period was a result of the rapidly expanding nano-electronics industry which, among many other applications, allowed instant analysis of the biochemical characteristics of living biological material.

Ownership of the patent for that application of nano-electronics was the last major technological innovation from South Africa. Then the patent for it was sold to a Ugandan consortium. Constraints on government spending prevented intervention by the state to retain the rights for the product, which is now playing a major role in the global genetic biodiversity survey, in which participation was obligatory for signatories of the United Nations Convention on Biological Diversity.

Conclusion

The four macroscenarios and their biodiversity sector counterparts provided the possible backdrops against which South African scientists and technologists might need to review the value of biodiversity in the year 2020. These images allowed the working group to consider whether or not science and technology could have contributed to the development and conservation South African biodiversity as a resource. Guided by the consideration of an imagined future environment in terms of political, social, economic and science and technology factors, the biodiversity working group was required to consider outcomes of alternative plans of action in preparing for those futures.

Articulation of a scenario is a particularly valuable exercise for the consistency that it demands in consideration of the future. It demands consideration of the context of any envisaged situation, and prompts careful assessment of attendant factors. Use of this device, by way of the four scenarios outlined above, facilitated focus on biodiversity in several different lights. It highlighted the need to guard quite carefully the nation's right to benefit from the wealth of biological species through local product development, but not to ignore the role of the competition in the international arena; to value the integrity of natural ecosystems in the provision of environmental services, but to invest enough in research to know the useful limits of rigorous conservation. Working through the different hypothetical scenarios brought into better focus the questions that

needed to be answered in the Delphi survey, and assisted workshop participants in formulating and prioritising the statements that framed those questions.

Appendix 5: Biodiversity Sector Survey Statements

Making inventories

1. Development of rapid, accessible identification tools for poorly known taxonomic groups.
2. Practical use of intelligent robotic devices (i.e. artificial autonomous systems) capable of collecting and classifying ecological data.
3. Widespread use of automated identification systems (such as the Description Language for Taxonomists or DELTA system) to describe taxa.
4. Widespread use of DNA techniques to enhance understanding of biodiversity patterns and processes in South Africa.
5. Development of capacity to model and predict the distribution of biodiversity to fill gaps in current knowledge.
6. Development of user-friendly information systems concerning biodiversity indices and patterns in South Africa.
7. Development of methods to assess biodiversity status of habitats at different scales rapidly.
8. Practical use of satellite data for large-scale (area) habitat monitoring, e.g. for desertification studies.

Conservation and sustainable use

9. Development of miniaturised monitoring devices (e.g. biosensors) for research and conservation.
10. Practical use of genetic tagging techniques to protect South Africa's biodiversity (e.g. for monitoring illegal trade in fauna and flora).
11. Development of methods to model the effects of disturbances and management practices on ecosystem functions (e.g. fire, grazing, water flow, fishing practices, etc.).
12. Practical use of methods to rehabilitate and restore ecosystems that have been damaged.
13. Development of off-reserve conservation techniques (e.g. tax incentives to retain rare species).
14. Development of techniques to predict the location and magnitude of threats to SA's biodiversity.
15. Development of a system of protected areas that represent all of South Africa's biodiversity.

16. Elucidation of sustainable levels of direct and indirect resource utilisation in South African ecosystems (e.g. carrying capacities in fishing, ecotourism and rangeland-based animal production).
17. Elucidation of techniques to sustainably harvest useful species (e.g. medicinal plants).
18. Development of techniques to propagate plants (particularly recalcitrant species) or animals for ex situ conservation and use.
19. Development of techniques for storing species, gametes, and embryos for ex situ conservation and use.
20. Development of techniques for the re-establishment of viable populations of plants and animals into suitable habitats.

Valuation

21. Development of techniques to assess the monetary and non-monetary value of biodiversity and the ecosystem services it provides.
22. Widespread use of biodiversity valuation techniques to inform all decisions about land use.
23. Development of techniques to add economic value at the local level to harvested or cultivated products (e.g. medicinal or food plants).

Impacts

24. Elucidation of the effects on biodiversity of improved living standards among lower-income South Africans (e.g. the effects of electrification on wood/fuel use in rural areas)
25. Elucidation of alternative resources in poor/rural communities to minimise impacts on biodiversity.
26. Substantial progress towards dematerialising the economy leads to reduced resource consumption and lesser impact on the environment.
27. Widespread use of biodiversity considerations in all development planning procedures and environmental impact assessments

Global environmental change

28. Elucidation of the effects of climate change (e.g. altered rainfall patterns, rise in CO₂ levels, sea-level rise) on South Africa's biodiversity.
29. Elucidation of the effects of changing land-use practices and habitat fragmentation on South Africa's biodiversity.
30. Elucidation of the effects of genetically modified organisms (GMOs) on South Africa's biodiversity.
31. Elucidation of effects of invasive species on South Africa's biodiversity.

Indigenous knowledge systems

32. Development of South Africa's own definition of 'indigenous knowledge systems'.
33. Development of validation techniques for South Africa's indigenous knowledge systems, which incorporate both indigenous and western approaches.
34. Widespread application of South Africa's indigenous knowledge and technologies in biodiversity management projects
35. Indigenous knowledge is included in curricula at all formal learning institutions (i.e. from primary schools up to tertiary institutions).
36. Widespread use of indigenous knowledge, technologies, products and services by all sectors of South Africa's population.
37. Widespread commercialisation of products and processes traditionally used in indigenous communities (e.g. morogo being available at all food retail stores).

Equity and access to biodiversity

38. Development of user-friendly information and communication technologies lead to increased access to biodiversity information in South Africa.
39. Elucidation of options for innovative co-management of protected areas leads to improved ecological sustainability and increased economic benefits.
40. Shared-benefit bioprospecting projects improve economic conditions in the least-developed parts of South Africa.
41. Elucidation of the relationship between different tenure systems (e.g. communal, private or state ownership) and biodiversity conservation.
42. Development of a system to ensure that benefits from use and development of South Africa's biodiversity serve the national interest.
43. Development of information systems to control access to sensitive elements of South Africa's biodiversity (e.g. location of rare organisms or traditional knowledge).

Biotechnology products

44. Practical use of local microbial diversity as 'biomopping ' systems for pollution.
45. Practical use of gene modification of indigenous flora and fauna to improve commercial viability.
46. Practical use of bioprocessing techniques in indigenous microbial, plant and animal cells to produce chemical products on a commercial scale (such as pharmaceuticals).
47. Development of biotechnology for mass production of selected indigenous flora and fauna (e.g. mass propagation of indigenous plants through tissue culture).
48. Widespread acceptance by consumers of genetically engineered products (e.g. food, medicines and beverages).

Natural products

49. Increased international demand for local natural products (e.g. rooibos, aloe ferox) makes South Africa a leader in natural product development.
50. 25% of South Africa's population prefer products produced in a biodiversity-friendly manner

Tourism

51. Contribution of nature-based tourism to South Africa's gross domestic product doubles.
52. Design of tourist attractions and ventures ensures that ecological sustainability and cultural integrity are not compromised.
53. Development of a portable, computer-based guide to South Africa's fauna and flora for tourists.
54. Novel and innovative packaging of South Africa's unique biodiversity increases the scope and variety of opportunities for tourism.

Other services

55. Practical use of South Africa's flora as bio-indicators of environmental quality (e.g. fungi as bio-indicators of the extent of air pollution).
56. Practical use in business management strategies of ecological and evolutionary concepts such as competition, succession, facilitation, mutualism and niche differentiation.

Capacity development

57. Development of cooperative and interdisciplinary programmes to rapidly quantify and predict ecosystem structure and functioning.
58. Implementation of research programmes linking biological and social sciences to cope with the changing, complex and dynamic environment facing biodiversity practitioners.
59. Development of expertise in dynamic ecological-economic modelling to provide estimate of the socio-economic value of ecosystem services.
60. Development of expertise in the design and application of ecosystem restoration and rehabilitation techniques.
61. Development of expertise for socio-economic valuation of biodiversity resources and ecosystem services appropriate to South Africa.
62. Enhancement of Southern African regional capacity to manage biotechnology at all levels of sophistication.
63. Research and development investment in biodiversity doubles.
64. Widespread use in natural history and science museums of the latest information technologies (e.g. interactive, multimedia and voice-recognition features) fosters scientific skills of children.

65. Establishment of a national biodiversity facility to coordinate research and to facilitate collaboration among biodiversity researchers and users.

Intellectual property rights

66. Understanding of the implications of patenting life forms is applied in the best interests of South Africa's biodiversity and people.
67. Implementation of appropriate mechanisms to protect the intellectual property of indigenous communities.
68. Implementation of an information technology/intellectual property rights framework that balances data liberalisation trends with intellectual property rights protection.

