Public Attitudes towards Agricultural Biotechnology in South Africa

---

Final Report

A joint research project of

the Center for International Development (CID),
Harvard University, USA

and

the Southern Africa Labour and Development Research Unit (SALDRU),
University of Cape Town, South Africa

Philipp Aerni

Science, Technology and Innovation Program
Center for International Development
Harvard University, Cambridge, MA
E-mail: philipp_aerni@harvard.edu

April 5, 2002

TABLE OF CONTENTS

Illustrations

Tables

Abbreviations

ANC	African National Congress
ARC	Agricultural Research Council
BAC	Biotechnology Advisory Committee
CSIR	Council for Scientific and Industrial Research
DACST	Department of Arts, Culture, Science and Technology
DEAT	Department of Environmental Affairs and Tourism
GM	Genetically Modified
GMOs	Genetically Modified Organisms
IPR	Intellectual Property Rights
NDA	National Department of Agriculture
NGOs	Non-governmental Organizations
PP	Precautionary Principle
RICs	Regional Innovation Centers
SAGENE	South African Genetic Experimentation Committee
SALDRU	South African Labor and Development Research Unit
S&T	Science and Technology
TNCs	Transnational Corporations
TRIPS	WTO Agreement on Trade Related Issues of Intellectual Property Rights
UCT	University of Cape Town
WTO	World Trade Organizations

Introduction

South Africa approved the first field trials with genetically modified crops in 1992 and the first conditional commercial releases started in 1997. To date, South Africa continues to be the only African country that has approved transgenic crops for commercial purposes and is the leader in agricultural biotechnology research and development on the continent.
However, there are also vocal opponents to agricultural biotechnology[1] in South Africa and an ongoing national debate is held on the potential risks and benefits of this new technology for farmers, consumers and the environment.
The purpose of this study is to investigate the perceptions of the political stakeholders involved in the public debate on agricultural biotechnology and to interpret these perceptions in the cultural and political context of South Africa. During a survey in November 2000, 48 stakeholder representatives from 33 institutions completed a questionnaire on the potential risks and benefits of agricultural biotechnology, public trust in institutions, current biosafety and intellectual property rights regulations and influence of political stakeholders in South Africa.
The results of the survey show that the respondents generally expect agricultural biotechnology to have the potential to address agricultural, environmental and nutritional problems in South Africa. While most respondents do not consider genetically modified food as a health risk for consumers and expect agricultural biotechnology to make a contribution to future food security in Africa, they are concerned about the sustainability of Bt crops and the proper implementation of national biosafety regulations. Moreover, most respondents doubt that such crops would be appropriate for resource-poor farmers.
One reason for this latter perception might be related to the government's current science and technology policy. Though the policy recognizes the important role of agricultural biotechnology to stimulate national economic growth and increase global competitiveness, it lacks a political strategy that would give scientists incentives to improve not just cash crops but also the basic food crops in South Africa.

The following report is divided into 5 chapters: Chapter 1 gives a short overview of the current theories on public perceptions of new technologies in industrialized and developing countries. Chapter 2 describes the debate and policy regarding agricultural biotechnology in South Africa. Chapter 3 gives a short introduction to the methodology used to analyze public perceptions in developing countries, and Chapter 4 gives some background information about the survey in the South Africa and portrays the results of the study. Chapter 5 summarizes the findings and discusses political implications.

[1] Agricultural biotechnology comprises different techniques for the genetic improvement of crops. In this study, agricultural biotechnology is narrowly defined as genetic engineering in agriculture.

1. Public perception of new technologies in developing countries

Public perception of agricultural biotechnology has been thoroughly investigated in industrialized countries [1] [2]. However, not much is known about public attitudes in developing countries. This may be explained by the popular assumption that most people in these countries were hardly informed about the advent of biotechnology and probably more concerned about risks in everyday life rather than potential long-term hazards of new technologies.

Nevertheless, there are public interest groups in developing countries that oppose the introduction of agricultural biotechnology. Their protest events attract the attention of the mass media and build up public pressure on politicians to respond to these concerns [3]. It indicates that public opinion also matters in developing country democracies, though it is the opinion of academic, economic and traditional elites rather than the public at large that counts [4].

The question is why are there people opposing the introduction of new technologies in developing countries? After all these countries should have a strong desire to get access to these technologies in order to increase productivity, relieve the pressure on natural resources and stimulate economic growth?

A survey conducted in the early 80s by Renn and Swaton [5] on the perception of nuclear technology among technical students in Germany, the Philippines and Japan revealed that Filipino students have the most negative attitude towards this technology. A major reason for this rather counterintuitive result is seen in the fact that Filipinos regard nuclear technology as an imported Western technology with doubtful benefits and high potential risks, whereas students in Germany and Japan also associate it with cultural heritage and cheap energy supply that fuels economic growth. It indicates that a technology, which is perceived not just as an imported Western technology but also as a fruit of the country's own research and development, tends to be more accepted in developing countries. Thus, it is not just the perception of the risks and benefits that matters in regard to the introduction of high technologies in developing countries, but also national interests and nationalist feelings. A study on stakeholder perceptions towards agricultural biotechnology in the Philippines in 1997 and Mexico in 2000 tended to confirm the importance of nationalist aspects in the public debate on agricultural technology in these countries [6]. In conclusion, it is factual knowledge, stakeholder interests and public perception that shape political decisions on the adoption of high technologies in developing countries.

Nevertheless, the blending of nationalist feelings with anti-technology attitudes may easily turn out to be a trap in the fight against poverty, since it will most likely hamper public sector support for technology transfer and, consequently, increase the socioeconomic gap between the rich and Western-oriented elites who have access to technology and the deprived poor masses. Governments, NGOs and the business community should therefore recognize the importance of technology for the provision of

public goods[2] that are particularly under-provided in developing countries. The under-provision of national public goods in developing countries also affects the quality of public goods in industrialized countries and therefore, increasingly assume the character of global public goods. The sustainable management of technology as a global public good is essential to make technology work for human development and to prevent it from further increasing social inequality due to unequal access [8].
Risk is a social and cultural construction [9] and its meaning may differ significantly among societies with different political and economic circumstances. Many people in developing countries face a wide range of everyday risks that were to a large extent eliminated long ago in industrialized countries, and thus have disappeared from the perception radar screen of its people. Ironically, these risks were reduced in affluent societies through the use of modern technology. The unintended side effects caused by new technologies are certainly a serious matter of concern in the present and the future; but, particularly in developing countries, these potential side effects of technology must be weighed against the potential gains from the appropriate use of technology to reduce existing risks.

2. The situation in South Africa

South Africa is a republic consisting of a central government, nine provincial governments and local government. It has a bicameral parliament elected every five years and is under the executive leadership of the President who is elected by the National Assembly. The dominant party that also governs the country is the African National Congress (ANC). None of the remaining smaller parties is able to challenge the dominance of the ANC, which has almost a 2/3 majority of the Legislature. It is mostly the particular tribal, ethnic or ideological orientations that prevent the smaller parties from reaching a wider constituency.
The ANC managed during the 1990s to forge a new civic multiethnic South Africa after the end of the white Apartheid regime. A new civic nationalism replaced, to some extent, the previous multiple forms of nationalisms within the country: from white Afrikaner and British imperial nationalism to the various kinds of black nationalisms. Traditional leaders who played an ambiguous role during the Apartheid period are also rather reluctant to participate in the new democracy [10].

[2] The marketplace offers the most efficient way of producing private goods. But the market relies on a set of public goods that it cannot itself provide (such as property rights, public health, public education, safety etc.) because they are mostly non-rivalrous and non-excludable. The provision of these increasingly global public goods require collective action and cooperation between local, national and global governance [7].

Political stakeholders involved in the public debate on agricultural biotechnology

South Africa is a unique case in the developing world for its extreme cultural diversity, its substantial gaps between the rich and the poor, the formal and the informal sector, and the developed and developing areas. Its transition from a repressive apartheid regime to a united nation of South Africans under the leadership of Nelson Mandela has produced many challenges and new opportunities. This transition converted the ANC from one of the largest civil society movements in the world into the rulers of the new South Africa.

Civil Society

The shift of the ANC from an extraparliamentary movement to the ruling political party had certain negative impacts for the future of civil society in South Africa. Civil society in South Africa today is smaller, more fragmented, and less embedded in local structures [11]. At the same time it is reported that the number of NGOs significantly increased in the 1990s [12].

Environmental organizations represent one important part of the new civil society. They could be described as the watchdogs over South Africa's rich biological diversity and environmental justice. Earthlife Africa is a good example of an environmental organization that successfully manages to mobilize concerned but unorganized citizens to protest against scandals of environmental justice such as toxic waste dumps adjacent to black townships [13]. As such they manage to use the issue of environmental justice to organize popular resistance across party, class, religion, gender, race and ethnicity [14].

However, environmental consciousness emerged in South Africa during the Apartheid-era. White environmental consciousness in South Africa was deeply rooted in a eurocentric conservation ideology and Afrikaner nationalism. As a consequence it also led to racial discrimination in the application of conservation policies and forged anti-conservation attitudes among blacks. The reason for today's frequent absence of black South Africans in the South African environmental movement may well be related to their perception of white environmentalism as a disguised form of resource control. Poor black South Africans are ultimately motivated by the desire for access to resources, and in varied measures, react against perceived layers of structural powers [14].

The NGO coalition against genetic engineering in agriculture represents a mix of the earlier eurocentric conservation ideology and the fear of being subjected to a new form of colonialism by transnational corporations (TNCs). While reservations regarding the domestic expansion of TNCs are common among developing countries, the concern about the potential risks of GMOs to human health and biodiversity in combination with the outright discarding of any possible benefits for South African farmers seems to reflect a rather eurocentric attitude. In the context of environmental and social justice, the discussion should not just revolve about potential risks of agricultural biotechnology, but also the possibility for using this technology to reduce the existing risks to which poor South Africans are exposed to (such as malnutrition, food shortage, environmental degradation and unemployment). This would require a public policy that aims at

maximizing the social benefits while minimizing the socio-economic and environmental risks of agricultural biotechnology.
The current NGO campaign for mandatory labeling may be based on genuine consumer concerns but it is of no importance to the poor who are buying their food products in the informal sector[3].
On the legal and socio-economic side, anti-biotechnology activists criticize the government regulatory policy for being too responsive to the demands of TNCs. The current regulatory system is further criticized for not taking into account public participation and the precautionary principle in risk management decisions. The NGO coalition against genetic engineering, led by the NGO 'SafeAGe' would prefer a preventive approach in the regulation of agricultural biotechnology and calls for a five-year-moratorium on the planting of GM crops in South Africa.
Though these concerns are legitimate, an adaptive biosafety approach, which provides continuous monitoring, accommodates dynamic circumstances and emphasizes the importance of learning might be more effective in reducing uncertainty regarding potential long-term risks of genetic engineering than the rather inflexible preventive approach. Moreover, preventive regulation does not so much damage TNCs than threaten the emergence of small domestic biotechnology companies that do not have the same means to insure themselves against losses of returns due to huge delays in the regulatory process.

AfricaBio, a South African NGO that promotes agricultural biotechnology on a private sector basis, plays an important role in fostering international partnerships in agricultural biotechnology research, improving university-industry linkages in the process of innovation, and promoting biotechnology investment in South Africa. These activities may lead to more, and especially smaller players in the South African biotechnology business. As a consequence, these smaller South African companies may gain more public attention in the mass media, which is currently focused mainly on the strong presence of a few dominant TNCs in the South African biotechnology business. However, AfricaBio seems to be equally detached from rural development concerns in South Africa. It advocates the use of agricultural biotechnology as a future source of sustainable economic growth but does not address in detail the burning issue of how the new tools of agricultural biotechnology can be employed to meet the needs of the poor in

[3] The only retailer who responded to the campaign for labeling was the supermarket store Woolworths which announced in December 1999 that it would remove GMO from its shelves and begin the process of sourcing its ingredients in order to identify and phase out all GMOs from its product lines. As a food retailer, Woolworths' caters to a mostly white and affluent customer base willing to pay higher premiums for non-GM or organic products. Only a mere seventh of the 42 million inhabitants of South Africa is supplied by the formal food retail sector at all. The wholesale suppliers who sell their food products to street vendors have taken no formal position on the sale of GM foodstuffs. But it can be assumed that the price is the only criteria that counts among the low- income consumers [15].

South Africa[4]. AfricaBio, which consists almost exclusively of natural scientists, has a rather simplistic view of risk communication. It explains the public opposition to agricultural biotechnology with a lack of understanding of science and believes better education in science is sufficient to overcome this. However, opposition to agricultural biotechnology is more complex. Various forms of risk communication in industrialized countries have failed, and, in some cases, even led to more polarization. Risk researchers are increasingly concluding that public opposition against high technologies is a matter of trust in institutions and world views, rather than a lack of understanding of science [16, 17]. Therefore, scientists need to acquire more social competence as much as the lay public may have to learn more about what science can or cannot do. Science is trusted as long as it is generally perceived to be a disinterested authority that seeks truth for the sake of truth. If science is perceived to be detached from the common interest and associated with private interests it runs the risk of losing public trust, even if excellent research continues to be produced. As a consequence, the public debates on agricultural biotechnology are increasingly characterized by emotional clashes of different worldviews rather than fact-based discussions on the risks and benefits of agricultural biotechnology. Risk debates have become either a rationale for actions taken on other grounds or a surrogate for social or ideological concerns [18].

Government and Academia

The ANC government started with many promising efforts to steer public resources towards the poor black population, however, there is considerable debate about its overall success in the fight against poverty and inequality. The ANC government is often accused of having lost touch with the local structures of the country, and of having sectoral policies, which are poorly connected due, in some degree, to the lack of an overall vision on how to tackle the problems of the country [21, 22].

Throughout the nineties, South Africa's development policy moved increasingly away from the role of technology as a crucial contribution in the fight against poverty and inequality, and, as a consequence, science and technology (S&T) policy was increasingly detached from the poverty alleviation policies.

S&T policy in South Africa has a strong focus on the improvement of university-industry linkages and the creation of an academic environment that encourages scientists to become innovators. South Africa suffered from a lack of incentives to use high-quality scientific knowledge gained at Universities and National Research Institutes for commercial purposes [23]. In this context the new policy may indeed improve South Africa's competitiveness as a modern knowledge economy. But at the same time it may leave behind the huge resource-poor rural population of South Africa. There is a risk of

[4] Though the adoption of Bt cotton in the Makathini Flats in Kwa Zulu Natal may have indeed benefited small-scale farmers too through higher yields and lower input costs [19] [20] it should not be treated as evidence that GM products developed in the private sector are sufficient to meet the needs of resource-poor farmers' in South Africa. The major problems of marginal farmers are often not pest-problems but problems related to uncertainty regarding drought, flood and lack of storage facilities.

over-emphasizing the role of technology generation in the private sector and thereby neglecting public research designed to address the country's problems in agriculture, environment, health and nutrition.
The white paper on science and technology [24], issued by the South African government in 1996, points out the importance of technology for enhancing the quality of life of all South Africans. However, there is no clear vision or strategy how this is supposed to be achieved. A strategy as to how to make use technology to manage essential public goods such as public health and the environment is lacking (apart from a short hint that research results need to be placed in the public domain). There is also a conspicuous absence of independent social science research in the area of S&T policy. Though the paper emphasizes the critical role of social scientists in providing critical analyses of national goals, choices and development policies, independent S&T policy research at Universities is almost absent, and social scientists are hardly involved in the public technology debates. The frequent absence of public participation in S&T policy is a symptom of the neglect of social science research: in the listing of the stakeholders that matter in South Africa's National System of Innovation in the White Paper [24], there is no mention of the role of local government, farmer organizations or consumer organizations. Social science research may be particularly important to find effective ways to improve communication with the public and facilitate a constructive public dialogue on S&T policy in South Africa. It may also help to convert the current top-down approach in S&T policy into a bottom-up approach that responds better to local needs and ideas and encourages personal initiative at different levels of technological development.

Agricultural Biotechnology in South Africa

Business

The first controlled field trials with GMOs in South Africa began in 1992 and resulted in the 1997 issuance of the first conditional commercial release permits by the Department of Agriculture. There are two genetically modified crops currently approved for planting and commercial release in South Africa, two varieties of yellow maize and one of cotton (all are pest-resistant Bt[5] varieties). In the 1999-2000 season, 163,000 hectares of GM yellow maize and 18,000 hectares of GM cotton were grown in South Africa. Genetically modified seed is the primary agricultural biotechnology import into South Africa, with imported herbicide-resistant soybean as the dominant preprocessed commercial GM product for consumption [15]. The major foreign biotechnology players in South Africa are currently Monsanto, Pioneer Hi-Bred International, Syngenta, and Aventis. They almost all have links to local South African companies and research institutions [15]. The major government institutions in South Africa that conduct and

[5] Bacillus thuringiensis (Bt) is a naturally-occurring soil bacterium that produces poisons which cause disease in insects. Bt is considered ideal for pest management because of its specificity to pests and because of its lack of toxicity to humans and the natural enemies of many crop pests.

promote public agricultural biotechnology research are the Agricultural Research Council (ARC) and the Council for Scientific and Industrial Research (CSIR).

Regulatory Issues

South Africa started to address issues related to genetic engineering as early as the late 1970s through the establishment of the South African Genetic Experimentation Committee (SAGENE) as the national advisory body on biotechnology research and development. Out of these initial efforts evolved a focused national biotechnology policy that identified strategic goals in biotechnology research. S&T policy during the apartheid period was mainly focused 'safety' as a public good, which essentially meant economic self-sufficiency and protection of the white population in the face of a hostile domestic and international environment. However, after the end of the apartheid regime, these early documents have not been taken up by the ministries of the new administration.

The old biotechnology regulation was therefore gradually replaced by a new regulatory system of which the GMO Act, passed in 1997 and implemented in December 1999 is the main piece of legislation dealing with trade, production and R&D of genetically modified organisms. The GMO Act is administered by the Registrar of the Act, located in National Department of Agriculture (NDA). The Registrar receives all applications for permits to conduct GMO trials or to release commercial products derived from GMOs [19]. After processing the applications, the Registrar hands them over to a Scientific Advisory Committee composed of ministerially-appointed academics who conduct safety reviews and risk assessments. If the GMO product successfully passes this scientific review, the application is forwarded to an Executive Council composed of representatives from the ministries of Agriculture, Environmental Affairs and Tourism, Trade and Industry, and Health. Ultimately, a successful application must be approved by the Minister of Agriculture. Final approval is usually delegated to the Registrar [19].

The regulatory system is praised for its scientific approach and its method of checks and balances between government departments, academia, and commercial producers as well as the concept of conditional approval, which obliges applicants to consider possibilities of technology transfer. Yet, it is also criticized for the lack of capacity to handle the numerous applications, the disregard of public participation in the decision-making process and the omission of the precautionary principle. The precautionary principle (PP) is an important but contentious legal concept in public risk management endorsed in the Cartagena Protocol on Biosafety adopted on 29 January 2000 and signed hitherto by 107 countries. The Protocol is a supplementary agreement to the UN Convention on Biological Diversity and coordinates trade, production and development of GMOs on an international level [25]. The essence of the principle is that once a risk has been identified the lack of scientific proof of cause and effect shall not be used as a reason for not taking action to protect the environment. Though the PP may serve as a useful, temporally restricted tool in risk decisions that involve great uncertainty, its broad definition allows for extreme interpretations that are frequently used to push a particular political agenda. South Africa is not a signatory country of the Cartagena Protocol on Biosafety.

The Department of Health is responsible for food safety in South Africa and as such also provides the standards for labeling of genetically modified products for human consumption. Its labeling regulations follow the U.S. example, omitting the labeling requirement for GM products when substantially equivalent to the conventional product.

The National Biotechnology Strategy

The government's national biotechnology strategy report [26] is an attempt by the Department of Arts, Culture, Science and Technology (DACST) to define the role biotechnology can play in the economic development of South Africa. It is a cross-cutting strategy that seeks to involve several government departments.
The national biotechnology strategy, as outlined in the first draft, has the following goals:

- to ensure it meets the national imperatives
- to focus on comparative advantage
- to harness existing scientific and technological competencies
- to address issues of biological safety and
- to review the strategy constantly in the light of national priorities and international trends

The report recommends new institutional arrangements and specific actions for government departments: It is proposed that a Biotechnology Advisory Committee (BAC), under the auspices of the Cabinet's Economic Cluster implements the new strategy by coordinating biotechnology R&D and aligning it with national priorities. Regional innovation centers (RICs) would act as active nodes for the growth of the biotechnology sector. RICs would facilitate funding and better university-business linkages in biotechnology research and as such essentially contribute to economic growth and employment through innovation.

The draft report also mentions in the executive summary that biotechnology can make an important contribution to South Africa's national priorities, particularly in the area of human health (including HIV/AIDS, malaria and tuberculosis), food security and environmental sustainability. But throughout the rest of the report there is no mention of the kind of public policy needed to manage biotechnology as a public good that can help address these problems of national priority. Cuba is quoted as a successful example of how to invest in biotechnology to solve such problems, but the report does not further elaborate to what extent a similar approach would be appropriate for South Africa's problems of poverty and inequality. South Africa has recently replaced Brazil as the most unequal country in the world [21] and technology is likely to increase this inequality unless it is also handled as a public good.

Agricultural and Environmental Policy

The potential importance of biotechnology in addressing socioe-conomic and environmental problems in South Africa is also neglected in South Africa's agricultural and environmental policies. The Department of Environmental Affairs and Tourism

(DEAT) refers to biotechnology only with regard to issues of biosafety but not with regard to its potential to contribute to the solution of environmental problems. As the host of the World Summit on Sustainable Development (Rio +10) in Johannesburg in 2002, it is hoped that South Africa will emphasize the important role of technology in efforts to achieve sustainable development in developing countries. However, judging from statements by DEAT officials regarding the World Summit, South Africa's attitude remains unclear [27]. South Africa certainly does not stand alone in neglecting the role of science and technology in sustainable development. Many countries throughout the 1990s, numerous international donors as well as the United Nations largely dropped support for science and technology in the development agenda [28]. It appears as if science and technology has become mainly associated with negative side effects rather than its potential to solve problems and reduce uncertainty. Biotechnology is only seen as a threat to biodiversity though it also has the potential to contribute to the conservation of biodiversity by making agriculture more productive in already existing cultivation areas and preventing further encroachment on fragile ecosystems. It is the tragedy of technology that its benefits are taken for granted while its potential risks have become increasingly unacceptable, though, statistically they are in no way comparable to the real risks caused by the lack of access to technology (e.g. disease, malnutrition, hunger, environmental degradation). The insistence of many corporations in the 1990s on an uncompromising strong enforcement of intellectual property rights in developing countries, and the general hostility towards technology of many NGOs active in development work may have contributed to the divide of S&T and development policy.

The white paper on agriculture issued by the National Department of Agriculture (NDA) [29] emphasizes the importance of making extensions services, technologies and training accessible to the poor, and recognizes the important role of government to supply `public goods' such as basic agricultural research, market information, appropriate legal regulation and environmental protection. The discussion document on agricultural policy [30] states that the government will intervene where a public good can be achieved by its actions, which would otherwise not be achieved by decisions taken by the private sector and individual farmers. Unfortunately, the National Biotechnology Strategy does not pick up on this in the case of biotechnology.

The NDA policy paper also recognizes the wealth of knowledge of indigenous communities. Farmers use local varieties of seeds and adapt their practices to local conditions, and this knowledge can be as important a source of technological innovation as biotechnology. But the document merely mentions that researchers should be more sensitive towards the concerns of indigenous communities and give due credit to the source of information. No mention is made of how benefit-sharing agreements between indigenous communities, researchers and companies might be structured in the light of the very weak negotiating power of indigenous communities.

Poor farmers are often forced to develop a capacity to innovate because their natural and material constraints encourage them to become inventive in the development of practical, low-cost technologies. The White Paper on Science and Technology emphasizes the role

of the government in the promotion of innovation on the high-technology end but does not give any recommendation of how innovation can be encouraged on the low-technology side, which would be essential for rural development. The objective of the Indian Honeybee network led by Professor Anil Gupta is to search for innovative solutions created by poor farmers in India. Farmers are to be encouraged to make use of their capacities as innovators by being offered the resources necessary to produce their low-tech solutions for other farmers[6]. If poor farmers become aware of their own innovative abilities, they become more confident and more motivated to be innovative and this provides eventually more local technical solutions for local problems. Such an approach may also be useful to South African farmers. High-tech and low-tech solutions must not exclude each other but go hand in hand, if managed properly. Biotechnology is a high technology that can easily be adapted to local circumstances, and its research costs are constantly falling.

It is estimated that 72 % of the poor people in South Africa live in rural areas, and that about 70 % of rural people are poor. While there is a food surplus at the national level, some 30 % to 50 % of the population has insufficient food intake, or is exposed to an imbalanced diet, as a result of low incomes [21]. Food shortage is mostly a local problem and must therefore be addressed locally by improving infrastructure, access to technology and market conditions. It cannot be addressed simply by increasing the overall national production of food produced mostly by white large-scale farmers.

3. Methodology used to assess public attitudes

Theoretical Aspects

An individual's perception of the risks and benefits of a new technology is determined by personally selected sources of information, values, interests, and individual experience [31]. In the case of agricultural biotechnology, most people cannot count on their own experience. Instead, they have to rely on information distributed through the mass media by representatives from industry, government, public interest groups and academia. Based on socially communicated values, social status, and professional affiliation, a person regards particular sources of information to be more trustworthy than others. The selection of the sources of information is also strongly influenced by his or her personal worldview and interests. [32].

A Stakeholder-Based Approach

The investigation of public perception in a particular country can be conducted either by means of a representative sample survey of a county's population [2] or by means of a stakeholder-based survey approach [33], which focuses on those political actors who

[6] More information on this approach can be found on the following website: www.sristi.org/honeybee.

form public opinion and claim to represent certain public and private interests. This study uses the stakeholder-based approach to investigate public perception. Though there is a risk that even the most well-meaning organizations can view the interests of their members in a simplistic manner, or distort them unwittingly [34], this potential problem applies to all stakeholders equally. Moreover, it is assumed that those political actors who are actively involved in the biotechnology debate are also well-informed. This allows a survey on public risk perception to be conducted in a country with generally low awareness of agricultural biotechnology. It also allows going beyond simple questions designed for citizens who are hardly familiar with agricultural biotechnology and its environmental, health and socioeconomic risks and benefits. Surveys in which respondents are randomly chosen and asked about their perception presuppose that most of them have already formed an opinion about the issue. However, this is hardly the case in ex-ante studies about genetically modified food. The response rather reflects the latest news they received from their preferred source of information. And often they are not at all familiar with the subject but nevertheless respond in order to avoid a feeling of embarrassment for not having an opinion. These aspects may contribute to a significant distortion and a very transient character of representative public perception surveys. Though these distortions may also occur in a stakeholder-based perception survey, it is nevertheless more appropriate to focus directly on those political stakeholders whose opinion or information serves as a relevant source of information for the public at large. In addition, an analysis of the political strategies and interests of these stakeholders may also provide interesting information about the long-term development of the public debate.

In particular in developing countries with characteristics of an elite democracy and with a general public that is less informed than in developed countries, it is definitely more useful to concentrate on the participants in the public debate on agricultural biotechnology. It can be assumed that they are well-informed and have a significant influence on those citizens who are not or are hardly informed about the technology. It is correct to assume that it would be helpful too to know more about the actual perceptions of farmers who ultimately grow transgenic crops and of the consumers who ultimately eat GM food in developing countries. These perceptions could then be compared with the perception of the stakeholders that claim to represent their interests. However, such surveys are of a different nature and rather costly; nevertheless, they will become particularly important in the near future when producers and consumers in developing countries may eventually become more aware and have more personal experience with food and crops derived from genetic engineering.

The first step of a stakeholder-based perception survey is to select the stakeholder representatives that matter in the public debate on agricultural biotechnology. For this study, they were selected with the help of local key informants who were familiar with the participants of the public debate. Moreover, members of different committees related to agricultural biotechnology, and personalities often mentioned in media coverage on biotechnology were also considered.

The Questionnaire

The selected stakeholder representatives were asked to complete a semi-standardized questionnaire, which consisted of four parts. The first part was about their perception of the problems in agriculture and the potential of genetic engineering for solving these problems. The second part contained positively and negatively worded statements regarding the potential risks and benefits of agricultural biotechnology. The third part was about trust in institutions, new approaches in risk reduction and legislation. The various statements had to be assessed in a scale from one (completely disagree) to five (completely agree).
The last part of the questionnaire consisted of a policy network table in which 70 organizations of relevance to the public debate were listed. Those who participated in the survey mostly represented one of these listed stakeholders. Thus, they had to assess one another with regard to their respective attitudes towards agricultural biotechnology, and their influence on public opinion, political decision-making and the biotechnology debate. Moreover, they had to indicate whether they associated a particular personality with the respective organization, and whether they cooperate with this organization.
The data analysis consists of a descriptive analysis of the general perception, a cluster analysis, which presents an evaluation of different perception patterns, and a visual representation of the principal component analysis (biplot), which portrays the perception of each single respondent in a two-dimensional scale. Finally, the data of the policy network table is analyzed by means of a simplified policy network analysis that reveals the influential stakeholders in the debate and the different forms of cooperation among them.

4. Survey results

Background Information

The survey on public attitudes towards agricultural biotechnology in South Africa was conducted in co-operation with the South African Labor and Development Research Unit (SALDRU) at the University of Cape Town (UCT) in November 2001. The study was funded by grants of the Swiss National Science Foundation and the Hochstrasser Stiftung, a Foundation that supports small research projects of Swiss researchers.
48 respondents from 33 organizations completed the questionnaire. The response rate was 55%.
The respondents can be categorized into representatives from the following institutional groups:

- Academia: 12 respondents from the fields of agronomy, biotechnology, natural and social sciences

- NGOs: 13 respondents (Pro-/anti-biotechnology, large environmental organizations, consumer organizations, churches)
- Government: 8 respondents from Research Councils, the Advisory Committee, and government agencies related to Health, Agriculture and Education
- Business: 7 respondents from the biotech, food, and retail industries
- Other stakeholders: producer organizations (4 respondents), attorneys (2 respondents), international donors (1 respondent), legislature (1 respondent)

Compared to the two previous surveys in Mexico and the Philippines [6], the response rate in South Africa was rather low. It indicates that there was a very modest response rate from representatives of government institutions and political parties, and no response from the mass media representatives in the South African debate at that time. Officially, nobody refused to participate in the survey for reasons of distrust but many complained about the length and the complexity of the questionnaire. One response from a media representative approached by telephone was they do not know much about the risks and benefits of agricultural biotechnology and would be very interested in sources of objective information. Many politicians mentioned that they are rather unfamiliar with the subject. As a consequence, most participants in the survey are either scientists from Universities (including social science divisions), corporations or government research institutes, or they represent public interest groups.

Descriptive Analysis

The first part of the questionnaire started with the question: *Which of the following problems in agriculture do you consider most important in your country and how do you assess the potential of genetic engineering for solving these problems?*
In this context, the respondent had to assess 20 problems on a scale from 1 to 5 whereas 1 meant 'not important/no potential at all' and 5 meant 'very important problem and very high potential of genetic engineering for solving the problem'.
Figure 1 shows the average perception of the respondents in South Africa regarding the importance of the problems and the potential of genetic engineering for solving these problems.
The y-axis represents the rating scale from 1 to 5 and the x-axis lists the problems starting from the one perceived to be most important and ending with the one perceived to be least important.

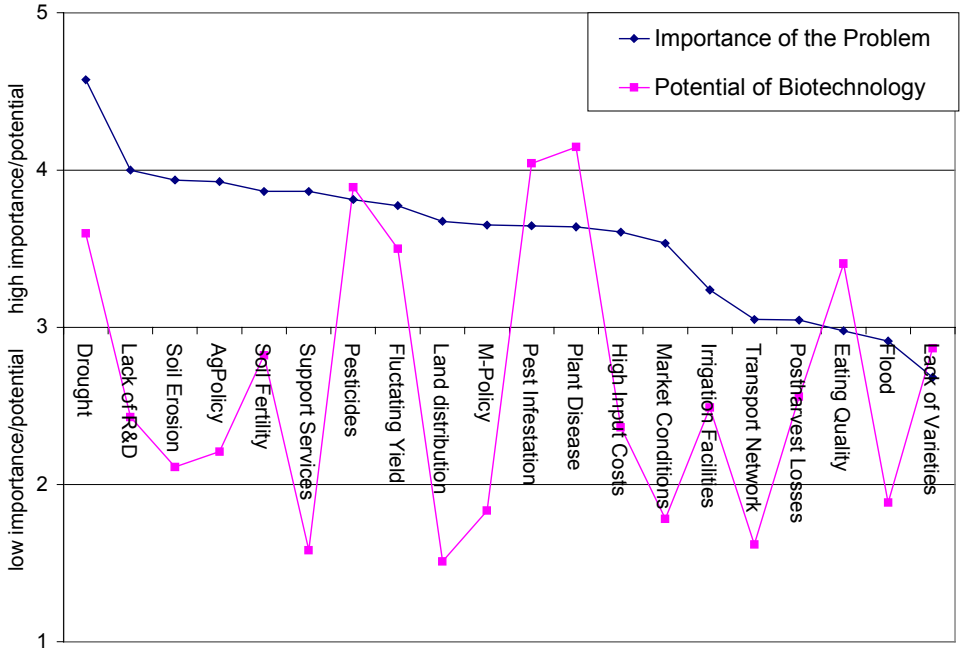

Figure 1: Stakeholder perception of the importance of domestic problems in agriculture and the potential of genetic engineering for solving them in the South Africa

A first observation is that *drought* is considered to be by far the most important problem in agriculture and biotechnology is perceived to have a potential for solving it. *Lack of R&D* is considered to be the second most important problem. This largely reflects the priorities of the national biotechnology strategy, which asks for significantly more funding of R&D activities in South Africa to promote technological innovation in the country. Agronomic problems such as *soil erosion*, *reduced soil fertility*, *high use of pesticides*, *pest infestation* and *plant disease*, as well as an inadequate agricultural (*AgPolicy*) and macroeconomic (*M-policy*) policy are seen as important problems in agriculture. Biotechnology is seen as having a great potential to solve agronomic problems. Surprisingly, marketing and infrastructure problems (*Market conditions*, lack of *irrigation facilities*, inadequate *transport network*, and *postharvest losses)* are not considered to be very important problems, considering that these are largely the problems small-scale farmers are struggling with in South Africa. It shows that those involved in the agricultural biotechnology debate are mainly concerned with the problems of mostly white large-scale farmers.

One respondent added the important comment that the dual agriculture system in South Africa should be considered in this question too. The dual structure of agriculture in South Africa was considered in the second question of part one of the questionnaire where respondents were asked to assess the economic impact of six different biotechnology products on large-scale and small-scale farmers. Figure 2 presents the average assessments again in a scale from 1 to 5.

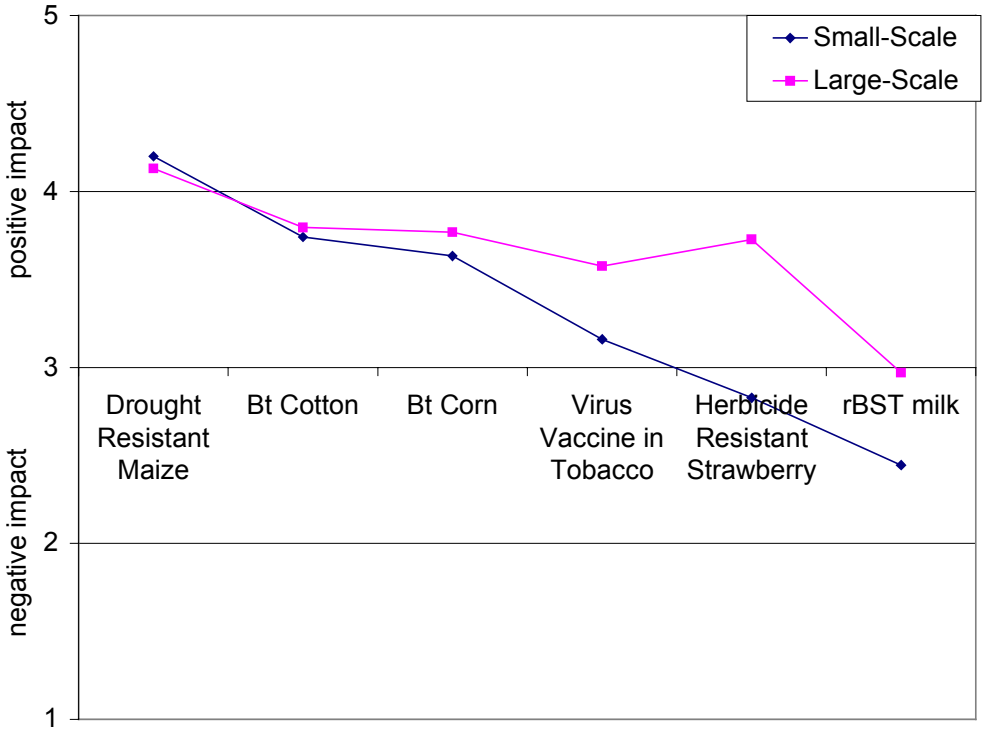

Figure 2: The Impact of GM crops on Small and Large Scale Farmers

Everybody seems to agree that *drought resistant maize* could have a positive impact for small-scale and large-scale farmers, and the same applies to Bt (pest-resistant) cotton. Bt corn is also considered to have a positive impact, particularly for large-scale farmers.
The three remaining crops are mainly considered to be beneficial for large-scale or capital-intensive farms. In case of an HIV or Tuberculosis vaccine grown in Tobacco the true beneficiary would be the population in general. Herbicide-resistant strawberry is seen mainly as an export business for capital-intensive farms and increased milk production is not even considered to have a positive impact on large-scale farmers.

Part 2 of the questionnaire consisted of 7 positively and 7 negatively worded statements regarding genetic engineering in agriculture. Figure 3 shows how these statements were evaluated by the respondents of the survey.
The positively worded statement that agricultural biotechnology is just a new tool that helps to solve problems that cannot be solved by conventional breeding received highest agreement among the respondents. This was followed by the negatively worded statement that Organic Farming/Integrated Pest Management (Org. Farming/IPM) is a better solution for resource-poor farmers to ensure their own food-security.

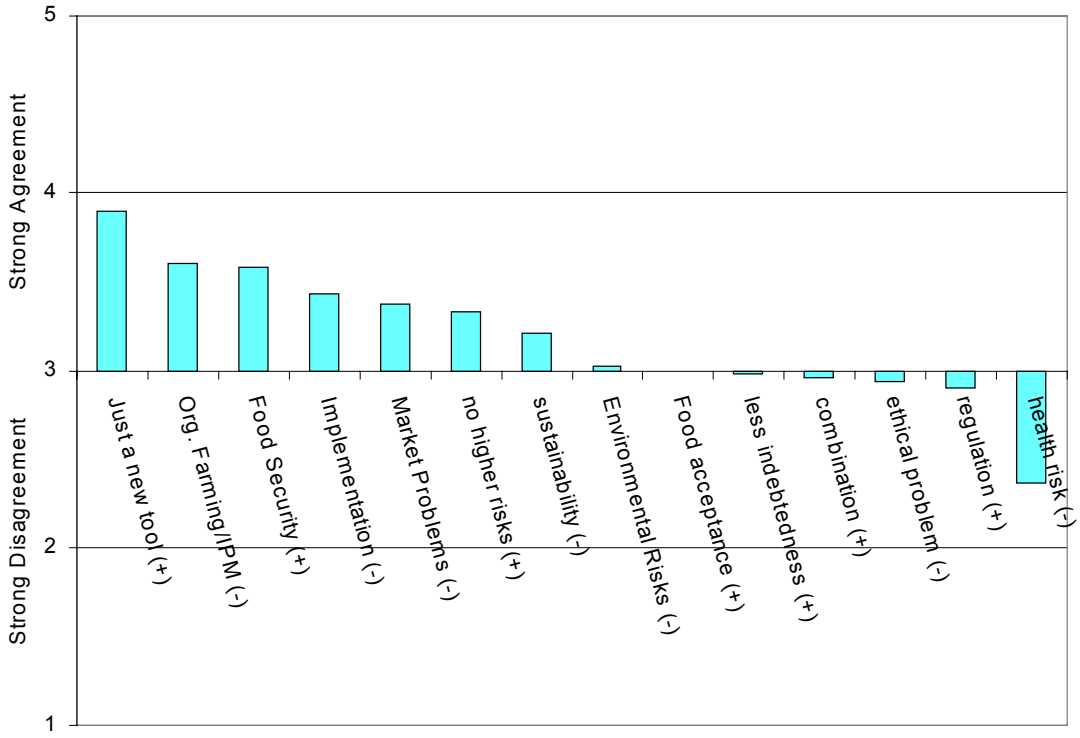

Figure 3: Positive and Negative Statements regarding GMOs

This judgment somehow contradicts the third most agreed statement namely that genetically modified corn can contribute to future *food security* in Africa. Obviously many respondents believe that genetically modified crops would be adopted mainly by large-scale farmers. These farmers could then increase production and this would ultimately lead to lower food prices. The lower prices would then make this food more accessible to the poor and therefore be a contribution to food security. A further confirmation for this assumption is the rejection of the statement that a *combination* of organic farming and agricultural biotechnology might particularly benefit the poor. Moreover, the disagreement with the statement that the expected lower input costs of GM crops would lead to a lower risk of indebtedness (*less indebtedness*) of resource-poor farmers, indicates that additional royalty payments for GM crops are expected to keep input costs high. This also shows that the country lacks a public policy that would give incentives to public research institutes to work with marginal farmers in order to improve basic food crops that could later be distributed without royalty free.

It appears to be a rather Western view to think future food security can be provided by the cheap surplus production of large-scale farmers because sometimes, prices of food crops can be high in one region, even though the neighboring region had a bumper harvest [35]. Lack of purchasing power and high transactions costs may be important reasons that prevent farmers from one region to provide their surplus to consumers who suffer from a food shortage in another region. Therefore, a sustainable food security strategy must have a strong focus on local food self-sufficiency.

While there is a doubt about the *sustainability* of pest-resistant Bt crops in the view of pests that may become Bt resistant, the *environmental risks* are perceived to be rather moderate. The statement that genetically modified crops pose a serious *health risk* to consumers is the most rejected statement. This appears to be a common perception in all the three case studies in the Philippines, Mexico and South Africa [6]. A majority of the respondents also reject the statement that *regulation* is strict and will prevent abuse of agricultural biotechnology and they agree that there is a risk that biosafety guidelines cannot be properly implemented (*implementation*) in South Africa. This indicates that the ongoing discussion on appropriate regulation and its implementation continues to be an issue.
Respondents also strongly agree that because of an inefficient marketing system, producers of transgenic crops won't profit from genetic engineering through higher revenues nor will consumers profit from lower prices (*market problems*). This somehow contradicts the earlier perception in part one where market conditions are not considered to be very important in South Africa's agriculture.

Part 3 of the questionnaire was about trust and legislation in the agricultural biotechnology debate. Figure 4 shows how the respondents perceive the trustworthiness of the different stakeholders. In a range from 1 (very low confidence) to 5 (very high confidence) academia reaches an average of almost 4 and ranks number one in terms of public confidence, followed by the religious organizations, and public interest groups such as consumer organizations, NGOs and farmer organizations. International organizations are found slightly above the average of 3 whereas traditional leaders are located below 3, which means that they are not considered to be very trustworthy along with business, the mass media, legislature and trade unions. According to our respondents the military and the government are trusted least. This picture brings back the assumption of Lipset and Schneider [4] that institutions, which are perceived to act in the public interest are considered more trustworthy than those who are perceived to be driven by self-interest. As it was also the case in the Mexican survey in 2000, respondents in South Africa may also perceive the government to act more out of self-interest than public interest[7]. The unions are still perceived to be affiliated with the government in spite of the fact that the strong alliance between unions and the ANC weakened considerably throughout the 1990s.
It is very promising that academia ranks so high in public confidence. It is a sign that its work is still considered to be detached from immediate private interests. Academia could use this social capital to improve the dialogue on agricultural biotechnology, but this would also require the participation of social scientists as mediators in the public debate and the funding of more research about the potential socioeconomic impact of biotechnology.

[7] This result must however be influenced by the composition of the sample of the survey that included relatively few government officials.

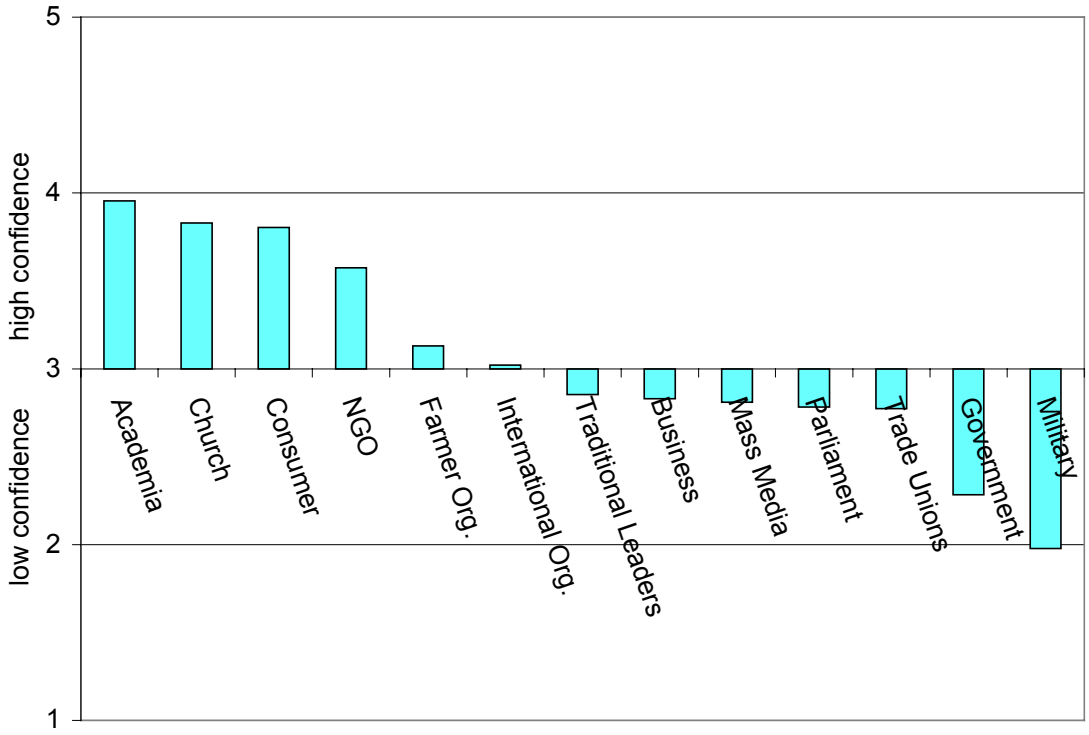

Figure 4: Trust in Institutions

The second section of part 3 was about the debate on mandatory labeling. According to Figure 5, the statement that received most agreement, was that mandatory labeling is necessary (*choice*) in a democracy where consumers are supposed to have the right to choose the products they prefer. This statement however, did not refer to all threshold problems related to mandatory labeling. The concern that mandatory labeling would cause additional costs and consequently raise consumer prices of these food products and make them less accessible to those with low purchasing power (*access*) also received support from a majority of the respondents. In fact, it appears to be questionable whether the wholesale sector, which provides the street cash and carry markets would be willing or able to label its GM products.

In turn, a majority disagrees with the statement that mandatory labeling is misleading (*Mislead*) since it would give consumers the impression that genetically modified products are unsafe compared to conventional products. While there is little polarization (according to numbers of standard deviation) among respondents regarding the '*choice*' statement, there is increasing polarization regarding the remaining statements. The large standard deviation of the '*mislead*' statement shows how far opinions diverge with respect to this argument.

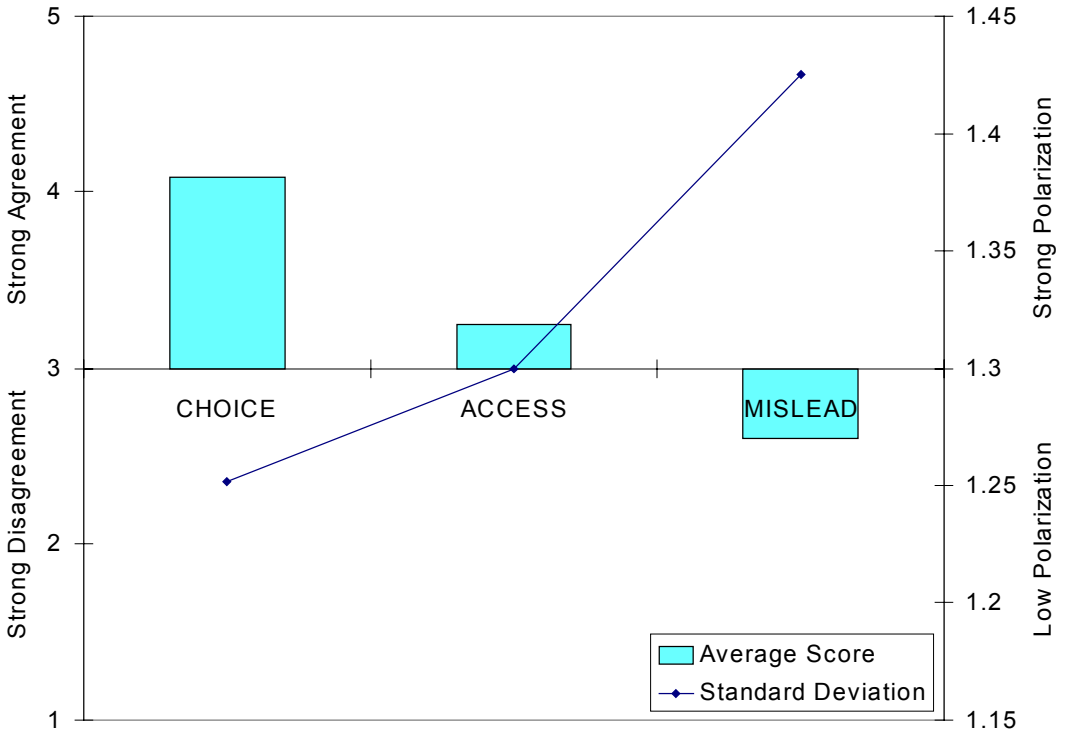

Figure 5: Mandatory Labelling of GMOs

Section three of Part 3 was about the advantages and disadvantages of the WTO Trade Related Aspects on Intellectual Property Rights (TRIPS) agreement and adequate forms of technology transfer. South Africa has a relatively strong framework for intellectual property protection. Although there was some concern over South Africa's proposal to import generic AIDS antiretrovirals in violation of U.S. patents, the legal actions of multinational pharmaceutical companies against South Africa have been halted[8], and no generic drug imports have occurred. To date, it appears that no patent for a biotechnology product has been violated in South Africa.

Figure 6 shows the respondents' opinions with regard to the statements related to intellectual property rights and technology transfer.

The statement that the government should promote fair and independent research partnerships between foreign companies and domestic private and public research institutions received most support from the respondents (*joint venture*). The risk that the interests of *indigenous groups won't be heard* in the design of a sui generis system on intellectual property rights due to their limited negotiation power also received approval by a considerable majority. The number of respondents which judged this statement at all is however rather low. The risks and benefits of the TRIPS agreement (*TRIPS benefits,*

[8] The lawsuit involved a challenge to legislation which would have allowed parallel importation, compulsary licensing , etc., and not only for HIV/AIDS treatments

TRIPS risk) are equally recognized by the respondents though considering the different response rates, the risks may be discussed more frequently than the benefits.
The statement about the design of a *sui generis system* to protect indigenous knowledge, natural resources and ensure access to important drugs and crops in case of emergency also received modest approval. The high number of respondents shows that the design of sui-generis system seems to be a matter of concern for many stakeholders but not everybody seems to strongly agree as regards the useful of such a system for South Africa.

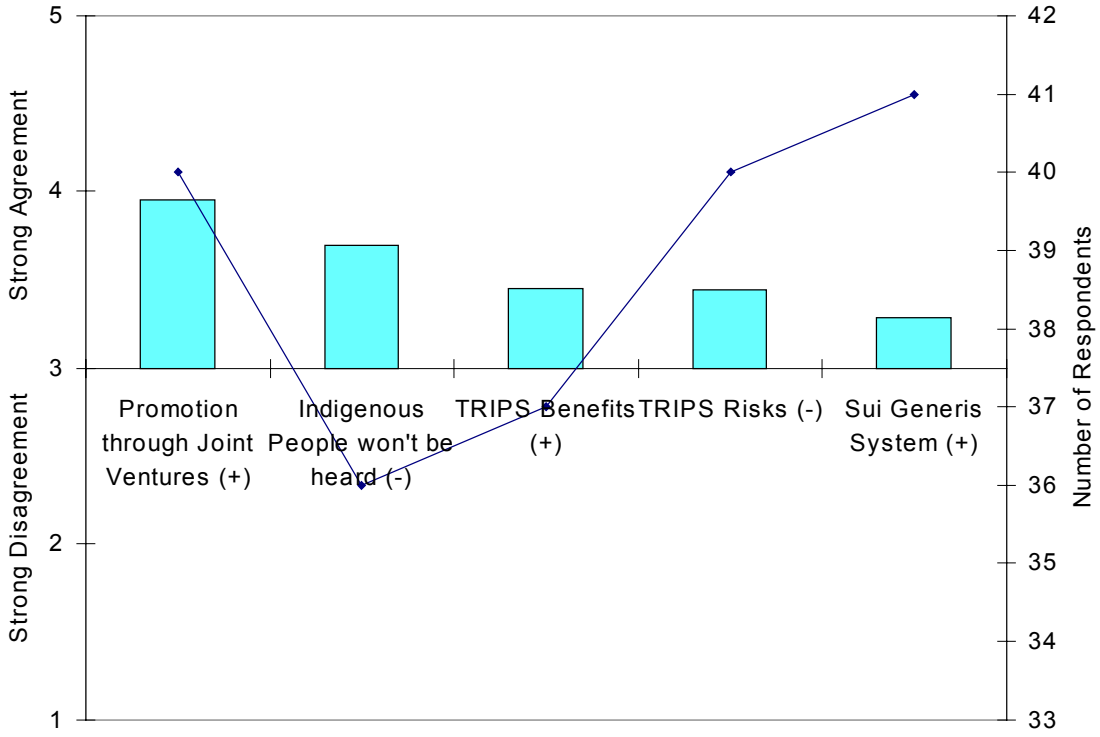

Figure 6: Biotechnology and Intellectual Property Rights

Perception Patterns

This part of the analysis aims at the identification of different clusters that represent perception patterns among the respondents of the survey. Perception patterns regarding genetic engineering are evaluated considering the answers given in the first two parts of the questionnaire on the potential of genetic engineering in agriculture, the potential economic impact of some transgenic products, and the perceived risks and benefits of agricultural biotechnology in general.

The pre-structured answers and statements in part 1 and 2 of the questionnaire were grouped into variables based on the criteria of problem, respectively statement similarity.

Briefly, the following seven new variables were created:

(1)POTENA = The potential of genetic engineering for solving agronomic problems (pest infestation, plant disease etc.)

(2)POTENM = The potential of genetic engineering for solving marketing and infrastructure problems (irrigation facilities, market conditions etc)

(3)POTENN = The potential of genetic engineering for solving problems related to natural catastrophes (drought, flood)

(4)POTENR = The potential of genetic engineering for solving policy and long-term problems (M-Policy, land distribution, soil erosion etc)

(5)POTENTL = The assessment of the economic impact of six different genetically engineered food products for small-scale and large-scale farmers.

(6)POSITIVE = Positive statements regarding risks and benefits of genetic engineering in agriculture

(7)NEGATIVE = Negative statements regarding risks and benefits of genetic engineering in agriculture

These variables were used to perform a cluster analysis using the WARD clustering procedure. The clustering of the respondents was done in 2 steps. The first step was to form preliminary clusters. The second step was to choose the final number of clusters. An arbitrary number of clusters was assigned until a reasonable number was selected. The selection was done using cubic clustering criterion and other related parameters.
The 48 respondents were allocated according to their institutional membership. Thus, the following 10 institutional groups were formed:

A = Academia
B = Business
C = Consumer organizations
CH = Churches
IO = International organizations
GA = Government (Dept.&Agencies)
IO = International Organizations
L = Legislature
N = Non-governmental Organizations
P = Producer Organizations

The following table (Table 1) shows the three perception groups obtained with the WARD procedure[9]:

Ward's minimum variance analysis

	A	B	C	CH	GA	IO	L	N	P	Total
Cluster 1	1	3	0	1	1	0	1	8	0	15
Cluster 2	9	5	1	1	4	1	0	1	3	25
Cluster 3	2	1	1	0	3	0	0	0	1	8
	12	9	2	2	8	1	1	9	4	48

Table 1: Clusters obtained through the WARD procedures

Cluster 1 contains 15 respondents, mainly from NGOs. Cluster 2 is the largest group with 25 respondents and contains mainly scientists in academic, government and private research institutions and representatives of producer organizations. Cluster 3 is the smallest group with only eight respondents from different respondent categories.

The so-called Biplot[10] enables the visualization of the clusters in an unclustered presentation, and the detection of each individual perception (letters) by its location in relation to the different variables (vectors).

Figure 7 portrays the Biplot of the stakeholder perceptions in South Africa and the three clusters, which highlight the three dominating perception patterns obtained in the cluster analysis (indicated by the circles added).

Cluster 1 comprises a range of perceptions towards agricultural biotechnology from slightly critical to extremely negative. The 15 respondents (2 are missing[11]) in this cluster mostly disagree with the positively worded statements (POSITIVE) and agree with the negatively worded statements (NEGATIVE) and, generally do not see any significant potential of agricultural biotechnology to solve problems in South African agriculture (POTENM-,N-,A). NGOs (N) are mostly concentrated in the area with a very negative perception, whereas the other critical stakeholders from academia (A) (listed in the cluster table but not shown in the Biplot), business (B), the legislature (L), and government (G) are found more in the less negative part. The critical business actors represent an agrochemical company, a supermarket chain and a law firm. The respondent from the legislature represents an opposition party and the government agency represents an agency in charge of food control.

[9] The table shows that three clusters were formed. The expected R-Square of these clusters is equal to 0.67, which basically means that 67% of the proportion of variance is accounted for by the clusters.
A supplementary analysis to the cluster analysis is the canonical discriminant analysis, which further evaluates the differences between the clusters. The multivariate test (using Wilk's lambda statistic) for differences among the clusters turned out to be highly significant ($p < 0.001$).

[10] The Biplot graph is based on a principal component analysis and provides a two-dimensional, unclustered picture of the variables (vectors) and observations (letters) [36].

[11] Missing values are the result of incomplete questionnaires. If certain statements were not rated, certain variables did not yield useful results, and as a consequence, the respondents could not be located properly in the two-dimensional landscape.

Cluster 2 is the largest group with 25 respondents (3 are missing) and mainly consists of representatives from Government (G), Academia (A), Business (B) and Producer organizations (P). Moreover, single representatives from a consumer organization (C), a pro-biotechnology NGO (N) and an international organization (IO) are also found in this cluster. Their attitude is generally favorable towards agricultural biotechnology. Respondents in this cluster agree with the positively worded statements (POSITIVE). One part of the cluster tends to see the potential of genetic engineering mainly with regard to agronomic problems (POTENA) and the economic impact of the different GM crops (POTENTL). The other part sees the potential more regarding problems related natural stress exposure (POTENN), as well as long-term (POTENR) and marketing and infrastructure (POTENM) problems.

Cluster 3 consists of merely 8 respondents (2 are missing). They also have a positive attitude towards agricultural biotechnology and particularly emphasize biotechnology's potential regarding problems such as natural stress exposure (POTENN) and long-term problems (POTENR). The respondents represent government (G), academia (A), business (B), consumer (C) and producer organizations (P).

In the context, the positive attitude of representatives from consumer organizations (C), which are found in cluster 2 and cluster 3, is rather surprising.

As for religious groups (CH), the representative of the Protestant church expressed a positive attitude whereas the representative of the Muslim community (Halaal) was rather critical. Unfortunately, both representatives belong to the missing values in the Biplot but are listed in the table.

Though most respondents are found in the center and tend to have a positive attitude, there seems to be a very strong polarization between environmental NGOs and the academic and government establishment. Academia, which includes three representatives from the social sciences, has a very positive attitude apart from one exception (see table 1). Unlike environmental NGOs, producer organizations are generally strongly in favor of agricultural biotechnology. However, those who responded represented only white farmers. There are only few black farmer organizations and their concern mainly focuses on agrarian questions. Though we invited black farmer organizations to participate they did not respond.

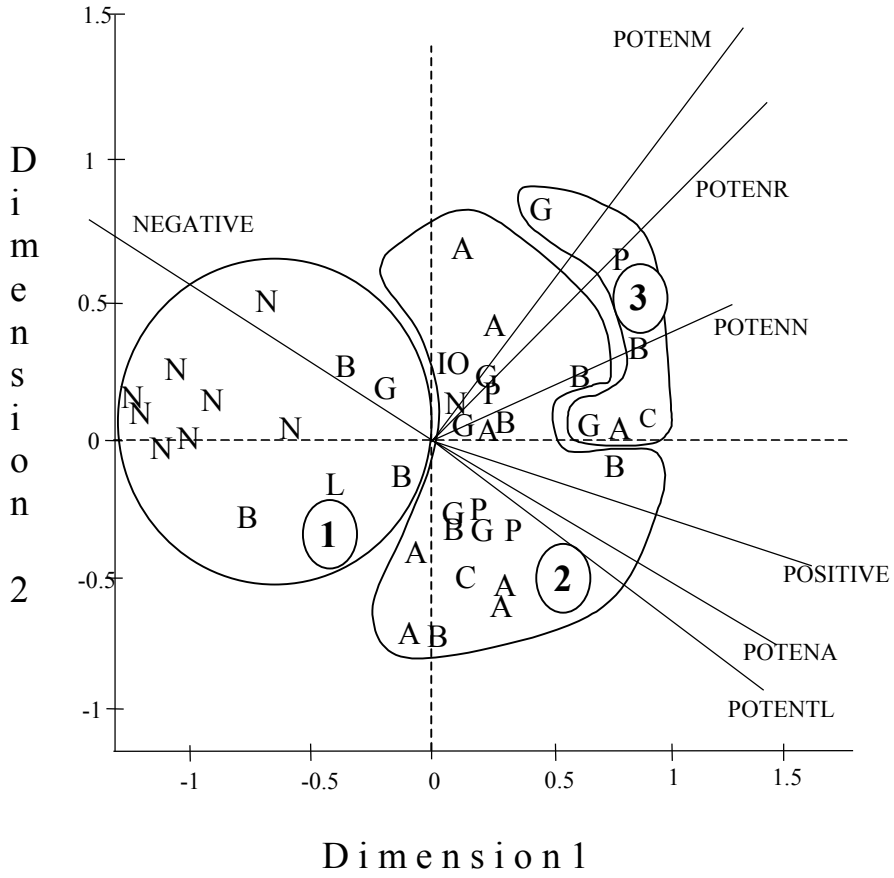

Figure 7: Biplot of the stakeholder perceptions[12] (7 observations missing)

Stakeholder influence

A stakeholder-based approach used to analyze public attitudes towards agricultural biotechnology also includes an evaluation of the stakeholders' political influence. The data necessary for this evaluation was obtained in part 4 of the questionnaire. This part part includes a table with a list of 70 organizations. Many of these organizations were represented by a respondent in the survey.

The respondents were asked to answer 5 questions with respect to each of the organizations listed. The possible pre-structured answers were labeled as numbers or letters, which then had to be inserted into the respective cell in the table.

Figure 8 shows how respondents assessed one another with regard to influence on political decision-making processes, public opinion, the public debate on agricultural biotechnology and the public debate on biotechnology in general.

[12] The length of a vector represents the 'Eigenvalue' (explanatory power) of the variable, while the angle between the vectors represents the correlation between them.

The angular circle shows the average influence rating that was attributed to the various organizations within their respective institutional groups (0 in the center means no influence, 4 in the outer circle means highly influential). The institutional groups are found in the angles. The calculation of the average rating per institutional group was performed by adding the number of ratings (from 1 to 4) for each organization within an institutional group and then dividing it by the number of organizations within the institutional group. This may lead to some distortions in case the respective institutional group contains only one organization or group, which again was rated only by one respondent. This was the case with 'Traditional leaders' and 'Unions', therefore the gaps in the lines.

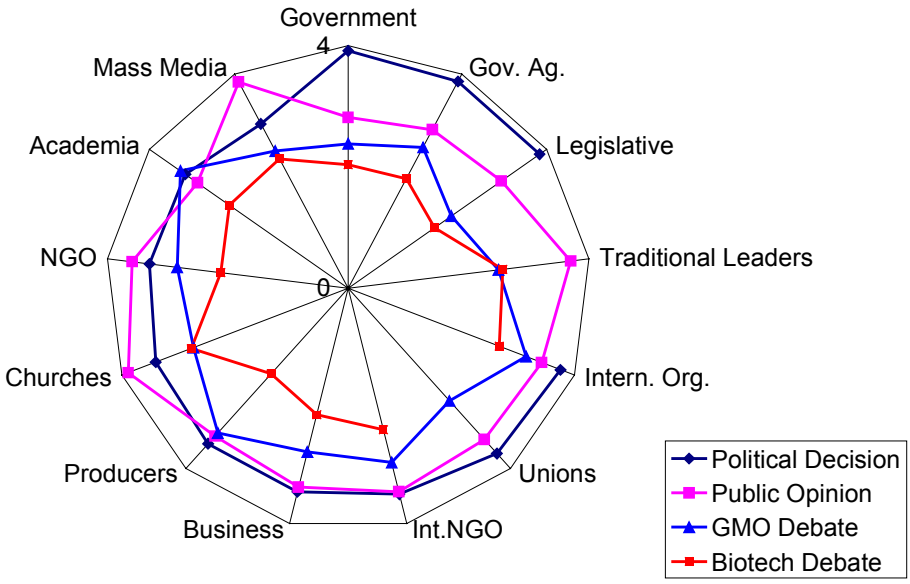

Figure 8: Stakeholder Influence

The ranking starts at the 12 o'clock site with the government, which was considered to be the most influential stakeholder in terms of *political decisions*. Other government agencies, the legislature and international organizations follow as influential political stakeholders. But also all the different public and private interest groups such as Unions, NGOs, Business, Producer Organizations and Churches seem to have a significant influence on the political decision-making process. Whereas academia and the mass media are perceived to play a rather low key direct role in political decision-making processes.

The mass media, which is considered to have the lowest influence on political decisions appears to have the highest influence on *public opinion*, followed by the religious organizations, traditional leaders and domestic NGOs.

Academia is clearly the most influential player in the agricultural biotechnology debate (*GMO debate*) followed by producer organizations, international organizations and non-government organizations.
In the general biotechnology debate (*Biotech-Debate*), the churches, traditional leaders, and the mass media appear to play a bigger stake than those stakeholders, which are central to the agricultural biotechnology debate.

Figure 9 shows the response to the question on whether the respondent would associate the listed organizations with certain personalities. The figure portrays the 6 most mentioned personalities by their institutional affiliation.

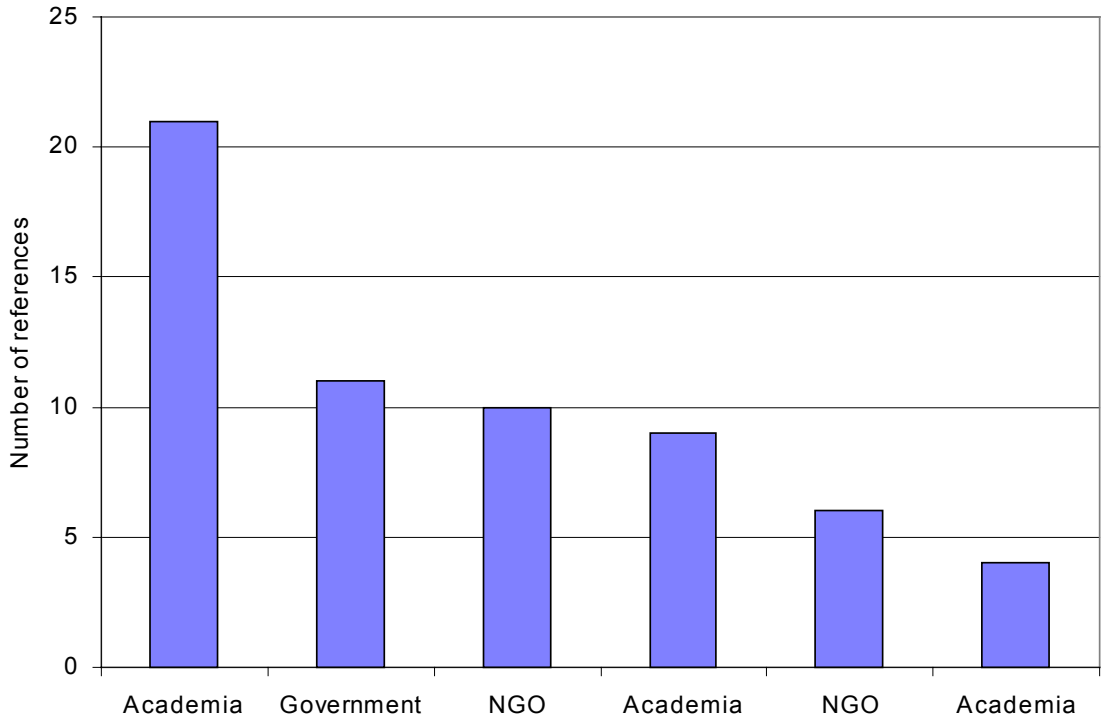

Figure 9: The six most mentioned personalities according to their institutional affiliation

There is one personality from academia, which was mentioned more than 21 times and seems to be the most central figure in the debate. The other personalities represent another two known scientists in academia, one representative from a pro-biotechnology NGO and one from an anti-biotechnology NGO, and only one personality from the government. This is somehow typical for the public debate in South Africa, which was dominated by the scientists as the main proponents and, to a minor degree, NGO activists as the main opponents rather than government officials. It was an indication of a lack of public leadership in the debate at the time the survey was conducted.

Figure 10 shows the network of cooperation among the different stakeholders in the agricultural biotechnology debate. N1, a pro-biotechnology NGO seems to be most involved within the network of cooperation. N1's connections include government department (GD) and agencies (GA), international (IO) and academic institutions (A) and producer organizations (P) but not other NGOs. NI1, a South African anti-biotechnology NGO with international influence, appears to be the second most connected organization and its relations appear to be linked mostly to other public interest groups (N), the legislature (L), the mass media (M) and the churches (CH). It is conspicuous that producer (P) and consumer (C) organizations, government (GD, GA) and academic institutions (A), and private companies (B) are mostly grouped on the left side while NGOs, Churches, the Legislature, the Mass Media, Artists (AR) and Traditional Leaders (TL) are found on the right side of the Figure. It appears to show, that consumer and producer organizations are not really part of the NGO network in South Africa. GD2, the Department of Environmental Affairs and Tourism seems to be the only government institution that has close cooperation with several NGOs.

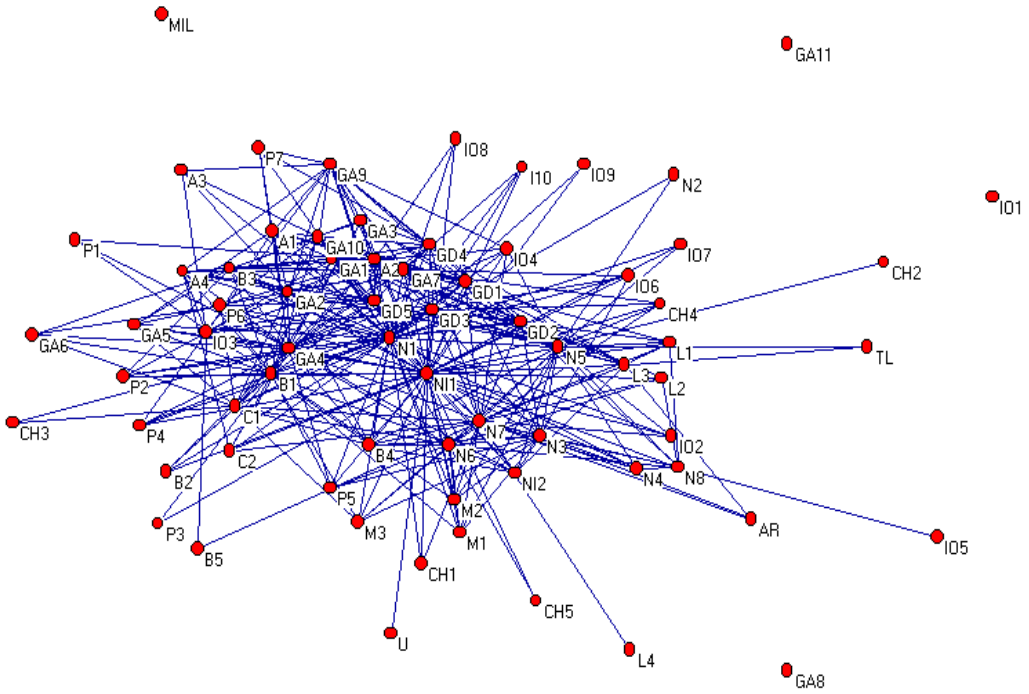

Figure 10: Cooperation Network

GA 11, the government's subcommittee on sustainable development, appears to be completely disconnected in the cooperation network. This observation indicates once more that technology is not adequately linked to sustainable development in South Africa.

5. Conclusions

The objective of this study was to assess public attitudes towards agricultural biotechnology in South Africa.
The results of the survey show that respondents recognize biotechnology as having a significant potential to solve the problem of drought, and other important agronomic problems such as pest infestation, plant disease, fluctuating yields and high use of pesticides. Moreover, transgenic crops already under cultivation in South Africa, such as pest-resistant Bt cotton and Bt corn, and transgenic crops under development, such as drought-tolerant corn, are considered to have a positive economic impact for small-scale and large-scale farmers.
Most respondents agree that biotechnology is a new tool that helps to solve problems that cannot be solved by conventional breeding, and they strongly disagree with the statement that genetically modified food poses a serious health risk to consumers.
On the other hand, respondents have considerable reservations regarding the current biosafety regulation and its implementation and they have doubts regarding the sustainability of Bt crops because of the possibility of pests becoming Bt-resistant.
There is strong support for labeling of genetically modified food to be mandatory because respondents feel that consumers must have the right to choose between GM and non-GM food. But at the same time, respondents are also aware of the additional costs of labeling that will be reflected in high consumer prices and less access for the poor. Moreover, only a seventh of the South African population is supplied by companies that operate in formal food market and would have the resources to implement labeling.

The perception pattern analysis revealed three different perception groups.
The first perception group comprises stakeholder representatives with a negative attitude towards agricultural biotechnology. It consists of 15 respondents generally representing environmental NGOs, a few other public interest groups and companies (representing a supermarket chain, a law firm and an agrochemical company).
The second perception group consists of respondents with a rather positive attitude towards agricultural biotechnology. They believe biotechnology offers potential to help solve important problems in South African agriculture. The group consists of 25 representatives from government, academia, business and producer organizations.
The third perception group includes only 8 respondents from almost all the different stakeholder groups (except environmental NGOs). They have a very positive attitude and consider the potential of agricultural biotechnology to solve problems in agriculture to be very high.
In general, the strongest opponents are representatives of environmental NGOs and the strongest proponents are representatives from scientists representing public and private research institutions. They are found at opposite sides of the spectrum and explain the apparent polarization in the public debate. The low participation of government

institutions, the legislature and the mass media may be interpreted as a sign of caution in a rather controversial debate but can also be regarded as a lack of public leadership at the time the survey was conducted.

Academia is considered to be the most central and most trustworthy stakeholder in the public debate on agricultural biotechnology. This was also the case in previous surveys in Mexico and the Philippines [6] and is a major difference to Europe where academia is increasingly associated with business interests [2] .

Respondents in the South African survey consider integrated pest management/organic farming to be a better strategy for resource-poor farmers to ensure their own food security, and seem to be undecided about the combination of biotechnology and organic farming as an appropriate strategy to meet the needs of small-scale farmers. This contradicts the relatively high approval rate of the statement that transgenic crops will contribute to future food security in Africa. This perception may find an explanation in the fact that the public debate in South Africa is dominated by scientists who are mainly interested in the commercial use of R&D activities, large export-oriented producer organizations, and non-governmental organizations with a skeptical attitude towards agricultural biotechnology. All these stakeholders have either no incentive to make the technology broadly accessible and useful to poor small-scale farmers, or think that these technologies are not appropriate for these farmers in the first place. This is exacerbated by the absence of organizations that represent small-scale farmers in the public debate. It may also explain why respondents to the survey perceive the typical small-scale farmer problems (such as postharvest losses, lack of irrigation facilities, bad transport network, and inadequate market conditions) as not being very important in South African agriculture.

It would be the role of government to come up with a strategy that outlines how resource-poor farmers could benefit from the advances in biotechnology and how researchers could be motivated to co-operate more actively with the country's small-scale farmers. The August 2001 draft document of the National Biotechnology Strategy of South Africa is a first positive step toward strong public leadership in the national biotechnology debate. However, the strategy should elaborate in more detail on a public policy that would provide economic incentives for the national research institutes and universities to do more research on the improvement of food crops that are of essential importance to food security and nutrition in South Africa. It should be more embedded in existing strategies for rural development and emphasize the importance of dialogue and cooperation with local organizations that represent small-scale farmers. These challenges however would require a more active involvement of interdisciplinary-oriented social scientists that investigate the potential of science and technology to address basic local problems. Since respondents perceive academia to be the most trustworthy stakeholder, social scientists may also play and important role as mediators between the different interest groups.

The survey showed that stakeholder representatives are rather undecided about the usefulness a sui-generis system, suggested by the WTO/TRIPS Agreement, that would allow developing countries to tailor an intellectual property rights system that reflects the particular environmental, nutritional, socio-economic and cultural needs without stifling technology transfer and innovative activity. A reason for the hesitant attitude regarding the possibilities of a sui-generis system may be the relatively low integration of science and technology, environmental, agricultural and development policy in South Africa. Sectors seem to develop their own strategies without being led by a common vision.
The evaluation of the cooperation network among the different political stakeholders showed that the sub-committee on sustainable development is completely disconnected from those stakeholders involved in the biotechnology debate. The continuous exclusion of science and technology from strategies of sustainable development is a worldwide phenomenon [37]. It is to be hoped that World Summit on Sustainable Development (Rio +10) in Johannesburg in 2002 will help to reconsider the role of science and technology policy in the concept of sustainable development in South Africa.

Acknowledgements

This work was made possible by the funding of the Swiss National Science Foundation and the Hochstrasser Foundation, and the academic support of Calestous Juma from the Kennedy School of Government, Harvard University. The author also would like to thank Rosemary Wolson, Francis Wilson, Jennifer Thomson, Lynn Woolfrey, Alison Siljeur and Cynthia Best from the University of Cape Town for their very valuable local academic and administrative support, Glen Ashton for sharing with me his views and insights regarding the South African debate, and Florabelle Gagalac for helping me with the statistical data analysis.

References

1 Shanahan, J., D. Scheufele and E. Lee. 2001. “Trends: Attitudes about Agricultural Biotechnology and Genetically Modified Organisms*”. Public Opinion Quarterly* 65 (2): 267-81.

2 Gaskell, G., N. Allum, M. Bauer, J. Durant, A. Allansdottir, H. Bonfadelli, D. Boy, S. de Cheveigne, B. Fjaestad, J. M. Gutteling, J. Hampel, E. Jelsoe, J. C. Jesuino, M. Kohring, N. Kronberger, C. Midden, T. H. Nielsen, A. Przestalski, T. Rusanen, G. Sakellaris, H. Torgersen, T. Twardowski, and W. Wagner. 2000. “Biotechnology and the European public”. *Nature Biotechnology*, 18(9): 935-938.

3 Schuurman, F.J. .1992. “Social Movements and NGOs in Latin America”. Nijmegen Studies in Development and Cultural Change. Saarbruecken, Germany: Verlag Breitenbach Publishers.

4 Aerni, P.1999. “Public Acceptance of Transgenic Rice and its Potential Impact on Future Rice Markets in Southeast Asia”. Ph.D. Dissertation. Zurich: Swiss Federal Institute of Technology.

5 Renn, O. and E. Swaton. 1984. “Attitude Towards Nuclear Power: A Comparison between Three Nations”. Vienna, Austria: International Atomic Energy Agency.

6 Aerni, P. 2001. “Public Attitudes towards Agricultural Biotechnology in Developing Countries: A Comparison between Mexico and the Philippines”. Science, Technology and Innovation Discussion Paper No. 10. Cambridge, MA, USA: Center for International Development, Harvard University. http://www2.cid.harvard.edu/cidbiotech/dp/discussion_aerni.pdf

7 Kaul, I., I. Grunberg and M. A. Stern (Eds.) .1999. “Global Public Goods, International Cooperation in the 21st Century”. United Nations Development Programme. New York: Oxford University Press.

8 United Nations Development Program (UNDP). 2001. “Human Development Report: Making new technologies work for human development”. New York: Oxford University Press.

9 Johnson, B. B. & V. T. Covello. 1987. “The social and cultural construction of risk”. Dodrecht: Reidel.

10 Barber, J. 1999. “South Africa in the twentieth century”. Malden, MA: Blackwell Publishers.

11 Emdon C. 1998. “Civil Society and the Media”. In: J. Duncan and M. Seleoane. *Media and Democracy in South Africa*. Pretoria : HSRC and FXI.

12 Pile, J. 2001. “NGOs mushroom to fill gap in social service provision”. Financial Mail, November 9, 2001.

13 Earthlife Africa, Toxics Group. 1996. Meeting, Brixton, Johannesburg, South Africa, July 15, 1996.

14 Mittelman, J. H. 2000. “The Globalization Syndrome. Transformation and Resistance”. Princeton, NJ: Princeton University Press.

15 Robinson, H. 2001. “Biotechnology in South Africa”. US State Department. Washington D.C.

16 Nelkin, D. 1996. “Selling Science”. Revised Edition. New York: W.H. Freeman and Company.

17 Slovic, P. 2000. “The perception of risk”. London: Earthscan Publications Ltd.

18 Winterfeldt von, D. and W. Edwards .1984. “Patterns of conflict about risk technologies”. Risk Analysis 4: 55-68.

19 Tulsi, P. R. 2000. “The Potential Market Implications and Impact of Genetically Modified Organisms (GMOs) to the Maize Industry. Technical Report. Johannesburg: Faculty of Management, University of Witwatersrand.

20 Sulcas, A. 2000. “Profits, yields grow apace after a little tinkering with the genes”. Sunday Independent, January 9, 2000.

21 Husy, D. (2000) “Growth, Poverty and Inequality. South Africa Report. Social Watch Organization. http://www.socwatch.org.uy/2000/eng/pdf2000countries/southaf_eng-p65.pdf

22 The Economist (2001) “Aids in South Africa: Heads in the sand”. International Section. September 29th 2001 issue: 51-52.

23 Kaplan, D. 1997. “The State of Science and Technology Policy in South Africa. New Priorities, New Policies”. Working Paper 1. Cape Town: Development Policy Research Unit, University of Cape Town.

24 Department of Arts, Culture, Science and Technology. 1996. “White Paper on Science and Technology”. http://www.dacst.gov.za/science_technology/stwp.htm

25 Gupta, A. 2000. “Creating a global biosafety regime”. International Journal of Biotechnology Vol. 2(1/2/3): 205-231.

26 Department of Arts, Culture, Science and Technology. 2001. “The National Strategy on Biotechnology”. Draft. http://www.dacst.gov.za/default_science_technology.htm

27 Mabudafhasi, R.. 2001. “Africa's priorities for making the people of our planet prosper to eradicate poverty”. Speech delivered at the Globe Conference in preparation for the World Summit, Cape Town. http://www.environment.gov.za/index.html

28 Juma, C. 2001. “Science, Technology and Sustainability in the United Nations System: Prospects for the World Summit on Sustainable Development”. CID Research Seminar at Harvard University. Cambridge, MA. http://www.cid.harvard.edu/cidbiotech/events/juma.htm

29 National Department of Agriculture.1995. “White Paper on Agriculture”. http://www.nda.agric.za/

30 National Department of Agriculture. 2000. “Discussion Document on Agricultural Policy”. http://www.nda.agric.za/

31 Peltu, M. 1985. “The Role of Communications Media”. In: H. Ottway and M. Peltu (eds.) Regulating Industrial Risks. New York: Cambridge University Press.

32 Lipset, S. M. and W. Schneider. 1983. “The Confidence Gap: Business, Labor and Government in the Public Mind”. New York: The Free Press.

33 Laumann, E. O. and D. Knoke .1987. “The organizational state. Social choice in national policy domains”. Madison: the Unversity of Wisconsin Press.

34 Sagar, A., A. Daemmrich and M. Ashiya. 2000. “The Tragedy of the Commoners: Biotechnology and its Publics”. Commentary. Nature Biotechnology, 18: 1-3.

35 Sen, A. (1981) Poverty and Famines. Oxford: Clarendon Press.

36 Gabriel, K. R. 1981. “Biplot display of multivariate matrices for inspection of data and diagnosis”. In: Interpreting Multivariate Data, ed. V. Barnett. London: John Wiley & Sons.

37 Juma, C. 2002. “The Global Sustainability Challenge: From Agreement to Action”. Int. J. Global Environmental Issues 2, 1/2 : 1-14.