Plenary session 2

Science and technology policy

Technology-policy gap and impact on application of animal biotechnology in sub-Saharan African countries

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Abstract
The livestock sector continues to play a major role in the economies of many sub-Saharan African countries. Predictions indicate that demand for livestock products will increase in the coming decades due to increasing human population and urbanisation. This calls for enhanced livestock production and productivity, which will require and will clearly involve increased intensification while also ensuring that the systems are resource efficient. Livestock diseases and the need for sustainable natural resource management are among the key challenges that need to be addressed. Although livestock research has over the years been directed at addressing these issues, little progress has been made in sub-Saharan Africa. Conversely, the application of biotechnology, for example in animal health, has significantly benefited developed countries more than African countries. This paper addresses the apparent gap between research and technology generation and adoption of the technologies on farms, especially by smallholders in sub-Saharan Africa. It is argued that science and technology policy if it exists, does not address the constraints faced by the farmers in a way that would facilitate adoption. The constraints include inadequate infrastructure, markets, capacity building, extension, credits, tenure system and institutions among other factors. Governments ought to address these issues at policy level as a way of accelerating widespread application of livestock biotechnologies particularly for increased productivity and profitability in the sub-sector. Moreover, concerted efforts from the national and international community in addressing issues of intellectual property rights, biosafety regulations and rules, fair trade, as well as effective and open communication between researchers, policymakers and technology users would be required.

Key words: biotechnology, research, science and technology policy, livestock sub-sector, smallholder farmer, sub-Saharan Africa

Introduction
Agriculture remains the most important economic sector in many African countries in terms of food and fibre supply, employment creation, income generation and foreign exchange earnings. Over 75% of Africa's population live in rural areas depending heavily on the production and use of natural resources for their livelihoods through agriculture. The agricultural sector accounts for 35% of the continent's gross domestic product (GDP), 40% of exports earnings and 70% of employment and it is expected that reliance on natural resources will remain high at least for the next generation (Dione 2002).

African smallholder farmers pursue a wide range of crop and livestock production enterprises, with considerable diversity across and within the major agro-ecological zones. The importance of the livestock sub-sector to their farming systems in the sub-region is reflected by its contribution to crop production, providing employment throughout the year and dispersing risks, providing funds for buying crop inputs and for financing farm investments through sales, forming a major capital reserve and enhancing the economic viability and sustainability of the farming systems

(Steinfeld and Mack 1995). It is estimated that 70% of the rural poor in sub-Saharan Africa own livestock. Of these, 200 million derive their incomes, nutrition and employment among other services directly from livestock (Sere 2004). It is estimated that in 1988, the livestock sector in Africa raised US$ 11.8 billion, constituting 8% of the total GDP and 25% of the agricultural domestic product (Lahlou-Kassi 1995), due mainly to the large animal population. Statistics indicate that Africa has over 230 million cattle, 246 million sheep and 175 million goats (Knight 2002) as well as 13 million camels (ILCA 1993), millions of poultry and other domestics such as horses, donkeys, pigs and mules.

Demand for livestock products in Africa is on the increase owing to the increasing human population growth, urbanisation, changing lifestyles and increasing incomes (FAO 2000). Currently, it is estimated that 145 million people reside in urban areas and 700 million people will be residing in towns and cities by 2025 (FAO 2000). This will translate into increased demand for nutrient rich and easy to prepare livestock products. Currently, most livestock related food products are obtained from smallholder and pastoral systems despite the production systems being characterised by low production as a result of climatic effects, lack of genetic merit on available livestock, inadequate feed supply and quality, poor animal health, livestock performing multiple functions in the livelihood systems, poor management and lack of credit facilities, especially among poor farm families (Smith and Hunter 1990). This implies that tremendous efforts in prudent structural and technological interventions will be needed to enhance production if demand by 2025 will have to be met (FAO 2000), failure to which massive importation of livestock products will be required (Table 1).

Table 1. Net trade in livestock products ('000 tonnes) in Africa.

Product	1970	1980	1990	2000	2015	2030
Beef	119	63	–32	52	–5	–109
Eggs	0	–3	–5	–17	–9	–22
Meat	142	50	–110	–80	–283	–744
Milk	–913	–2496	–1785	–1971	–3605	–5226
Mutton/goat	29	40	29	59	73	80
Pig meat	–4	–9	–21	–42	–71	–108
Poultry	–2	–43	–86	–149	–280	–606

NB. Negative figures indicate imports.

Source: Seré (2004).

The structural and technological interventions should be directed towards ensuring adequate resource allocation; introduction of new technologies to improve productivity; promoting suitable institutions for research, extension, marketing and credit; and putting in place appropriate policy, both national and at the sub-sector level. This will alleviate the current situation where there is hardly any success story of biotechnology application in developing countries as opposed to developed nations (Rege 1996). This paper highlights some of the bottlenecks relating to institutions and policy that ought to be addressed in order to facilitate effective application of livestock biotechnologies in sub-Saharan Africa.

Status and prospects of biotechnology application in animal agriculture in Africa

It has been argued that conventional technologies are no longer able to increase or provide sufficient levels of the ever-increasing needs for food, fibre and better agricultural environment and therefore the application of agri-biotechnology is vital. Agricultural biotechnologies have been developed as tools/techniques to boost productivity although due to their ownership by private corporations, their usage has mainly been in developed nations with most farmers in

Africa continuing to rely on conventional technologies associated with low productivity and production (Nkamleuet al. 2003).

Biotechnology refers to the scientific application of techniques that uses living organisms or substances from them to make/modify products or improve plants/animals, or to develop micro-organisms to serve specific purposes. The main components used in biotechnology are genomics, bioinformatics, transformation, molecular breeding, diagnostics and vaccine technology (Persley and Lantin 2000) and some of them involve the manipulation of the DNA components of organisms. Modern biotechnology techniques and processes are applied to improve the production potential of plants and animals (Bailey 2003). Cell and tissue cultures are the most commonly used techniques in Africa with genetic engineering being yet to gain profound utilisation due to regulations surrounding its application (Berg et al. 2003) although there have been efforts to produce animal vaccines using the technology both in Kenya and Zimbabwe (Chetsanga 2000).

Globally, the major breakthroughs of biotechnology in the livestock sub-sector have been in the generation of techniques for disease diagnosis and manipulation of selected germplasm for traits such as production, adaptation and improved feed digestibility (Lahlou-Kassi 1995). This has led to techniques such as artificial insemination and embryo transfer as integral part of animal husbandry for many years. Recent applications of DNA engineering techniques target the development of new improved methods of diagnostics and vaccine production, animal breeding and improved nutrition through modification of microbes to improve rumen functions, and in reproductive physiology. However, low annual rate of genetic progress, lack of ways to separate the desirable from undesirable traits of breeding, and the difficulties of transferring genetic information across species (Berg et al. 2003) has hindered some of the intended achievements. It is hoped that with advancing biotechnologies and novel molecular genetics tools, some of these challenges will be overcome.

In sub-Saharan Africa, the application of these technologies at farm level has not been realised. Studies on agricultural innovations show that effective adoption at the farmer and aggregate levels is influenced by several factors. These include: the educational process that extension practitioners use to equip individuals with the knowledge and skills necessary to use an innovation (King and Rollins 1995); supply (institutional process of technology generation and promotion) and demand (reasons for using a technology) of technological innovations (Rogers 1983); relative advantage and compatibility that determine the immediate and long-term economic benefits from using an innovation; access to credit and output prices (Hwang et al. 1994); complexity, trialability, and observability that indicate the ease with which the potential adopter will learn and use the innovation (King and Rollins 1995); nature of farming environment (agroclimatic conditions, nature of prevailing farming systems, degree of commercialisation and factor availability) (Morris et al. 1998); land tenure systems; farm sizes; farmer characteristics (ethnicity and culture); time lag required before getting returns/benefits from adopting the technology; management to maintain the technology working at farm level; initial capital investment; and social factors because farming systems are in some regions highly influenced by social networks (FAO 2001) among many others.

In sub-Saharan Africa, the rate of adoption is not only restricted by the aforesaid causes but also to policy and institutional frameworks at national, regional and international level. The following section highlights some of the areas that require policy interventions to address the challenges facing the application of livestock biotechnologies in smallholder farming systems.

Poverty

According to the World Bank (1996) between 45% and 50% of Africa's population is poor and live in abject poverty. The poor status is a result of limited employment opportunities, inadequate access to markets, low endowment of human capital, environmental degradation, decades of economic mismanagement, corruption, improper governance and conflicts. The GDP of sub-Saharan Africa remains lower than that of other regions of the world. Since multinational companies from the North that conduct biotechnology research are profit oriented, they do not focus their attention on technologies that are relevant to the poor populations in developing countries because these populations cannot afford them. In addition, poverty has driven most governments to accumulate huge external debts, resulting in loan repayment as a priority over investing in biotechnology. This denies the poor smallholder farmer the chance to access improved biotechnologies for increased production. Therefore, there should be efforts to avail cheap but effective technologies and to devise policies for wealth creation, human capacity development to match modern job market, democratic governance and conflict resolution as steps towards ensuring increased biotechnology application in Africa in the future.

Infrastructural development

Infrastructure denotes the materials, institutional, personal facilities and arrangements that facilitate production and movement of goods and services (Karugia et al. 2003). They include roads, storage facilities, research facilities and market centres. In Africa, both the communication and transport systems are skewed in favour of urban centres rather than rural areas. Infrastructural problems date back to the colonial times when the infrastructure favoured settler occupied areas and neglected African reserves. Post-independence governments continued to rely on the colonial infrastructure while expansion or maintenance has been minimal. As a result, transportation of inputs and outputs has become a nightmare in many regions. Poor communication channels and skewed networks that favour urban areas have hampered delivery of information about the latest technologies to farmers in remote rural areas. Although the status is blamed on population distribution patterns, there is need to devise policies for infrastructure improvement as a means of facilitating dissemination and adoption of research recommendations.

Africa also lacks effective research facilities that are compatible with progress in biotechnology, e.g. there are few specialised laboratories where research can be adapted to meet local conditions. In fact, it is argued that only the International Livestock Research Institute (ILRI) is able to undertake livestock biotechnology research in sub-Saharan Africa despite the fact that it cannot manage to address all problems facing the livestock sub-sector in the region. Facilities for procedures such as progeny testing are lacking in many countries. There is need to ensure favourable infrastructure, such as repositories of biotechnology resources, biotechnology information services and centres, biotechnology cooperation service, good roads and communication channels and a strengthened regional technical cooperation network.

Ineffective marketing systems

Agricultural markets in Africa have for a long time been under the control of central governments with limited involvement of private sector players. This meant supply of inputs, market information and marketing of produce by state managed and controlled cooperative societies. Central governments were also responsible for maintaining services that ensured effective delivery, e.g. transport services. However, after the implementation of structural adjustment programmes (SAPs) and liberalisation, government controls over input and output prices, as well as regulatory controls over input and output marketing were considerably reduced or eliminated. Public enterprises were restructured and involvement of marketing boards in agricultural pricing and distribution minimised to improve procurement and distribution channels of key commodities and increase market efficiency. However, the process introduced stiff competition in provision of services and marketing of agricultural products in many parts of sub-Saharan Africa. Rather than increasing efficiency in the marketing channels, malfunctioning input supply, output marketing systems and inadequate market information resulted due to lack of adequate infrastructure and government support. Costs of inputs increased while product prices went down due to the long chains of marketing transactions involved. As a result, smallholder farm activities were significantly affected by dwindling prices that were lower than could motivate farmers to produce.

Moreover, African countries continue to face external influences from the developed world in terms of trade policies and barriers that negatively affect access to technologies, production and markets for products. First, the global market for biotechnologies is under the control of a few private-sector investors due to mergers and acquisitions. For commercial reasons, these few biotechnology investors target the rich farmer as the main market while giving less consideration to the poor small-scale farmer. Secondly, the subsidisation policies in developed nations (for production and exporting) offsets the real market prices making products from unsubsidised smallholder farms more expensive and unprofitable (Johnson et al. 2003). Thirdly, most products from the region are sold as bulk raw materials with minimal or no value addition. Moreover, any value addition subjects them to escalating tariffs in developed countries (Johnson et al. 2003) which discourages costly and intensive production that relies on advanced innovations. Addressing the plight of farmers in access to inputs, value addition, market information and fair marketing systems, and acting as a cohesive group to negotiate for favourable international trade agreements would be required to promote intensive livestock production through increased biotechnology application.

Research priorities

Due to weak economies, most African states emphasise short- and medium-term research to meet the immediate needs of their populations and industry, such as food security and raw materials. Owing to the fact that biotechnology requires long-term research to allow time for concrete solutions to biosafety and trade issues and is capital intensive, many nations have not developed/ initiated effective biotechnology research programmes. This works against the timely availability of biotechnologies to farmers. There is need for sub-Saharan African countries to commit resources and orient towards long-term research to effectively encompass biotechnology research in their programmes as a measure of accelerating the availability of livestock biotechnologies to smallholder farmers in the region.

Extension systems

Extension services are meant to offer advice, help farmers analyse problems, develop opportunities, share information, support formation of groups and facilitate collective action. Extension also allows demonstrations that inform farmers on the best levels of inputs and practices to adopt, especially in the initial stages of technology introduction (Akele et al. 2000) and provides specialists and researchers with valuable information on farmers' needs and efficiency of developed technologies (Damalas 2003). Many African countries and research institutions have traditionally relied on agricultural extension systems to advance their finding to farmers. However, the extension services are no longer effective because most agricultural extension services have virtually collapsed in much of Africa or have been debilitated by structural adjustments and policy reforms. They have experienced operational lapses and lack of follow-up because of low budgetary allocation by national governments. Moreover, most extension systems emphasise crop production and cater less for livestock development. Both the policy makers and researchers have ignored the independence of livestock extension services (Morton and Wilson 2000). Coupled with the effects of the HIV/AIDS pandemic, the system has been further weakened to the extent that it is not possible to disseminate current research findings to intended beneficiaries (Jones 2004). Hence, research findings and recommendations remain on shelves in research stations where they are inaccessible to potential users.

Access to credit services

The SAPs implemented in many African countries reduced government support for the agricultural sector. Agricultural credit systems were destabilised as privatisation took place, exposing farmers to liquidity problems. The resultant private sector was constrained by inadequate legislation governing commercial relationships or the existence of obsolete legislations that made normal commercial activities technically illegal, thereby undermining the confidence of private institutions in providing credit. The commercial and agricultural development banks, however, have remained uninterested in providing credit to small-scale farmers because of the risk of default, lack of collateral and high transaction costs. With missing or malfunctioning credit markets and liquidity constraints, households surrounded by such a multitude of risks tend to have high discount rates and being risk averse in investment even in current agricultural innovations. There is need for great intervention among African governments to make credit services available to farmers at rates they can afford if agricultural innovations are to find root in farmers' fields. This can be by supporting upcoming farmer cooperatives or providing enabling environment for micro-finance institutions and commercial banks to aid livestock keeping.

Patents and intellectual property rights

Most agricultural biotechnologies are developed by multinational corporations and international research institutions in developed nations (Taylor and Cayford 2003). To recover the cost of research, they seek intellectual property rights (IPR) or patent rights over a certain period of time (Pardey et al. 2003). The implication of this is that IPR and patents limit researchers from developing countries from accessing state of the art technologies for dissemination to farmers (Cruz 2000). Sometimes, the CGIAR (Consultative Group on International Agricultural Research) system and some international research organisations may be allowed to access such knowledge without authorisation to promote agricultural research in the South but this has not been sufficient due to budgetary limitations and diversity of production systems in Africa. Providing an enabling environment for public-private partnerships between research institutions of developed and developing nations where local scientists and national research institutions can access innovations for adaptation would help alleviate the problem. This would enable local research institutions harness their meagre resources to meet local needs rather that strive to conduct research whose results already exist. Moreover, public-private partnerships would avail extra resources for research in local research institutions.

Biosafety regulations and policies and the fear of losing export markets

Given food safety concerns in developed nations, especially in the European Union, biosafety policies and regulations continue to be enacted, inhibiting importation of transgenic products (USDA FAS 2003). Certification and labelling has become common in Europe and Australia although most Africa countries have not adopted such policies. Because biosafety regulations and policies tend to restrict trade in biotechnology-based products, most farmers in developing countries who target developed countries in Europe for their market shy from producing biotechnology related goods for fear of losing profitable foreign markets (Wafula and Sikoyo 2005). This discourages the use of technologies based on genetic modification. For instance, in Namibia, Uganda, Zambia and Zimbabwe there have been cases reported where genetically modified products were denied entry into the countries for fear of contaminating local varieties used for producing export products for the European market (Wafula and Sikoyo 2005). This implies that the growing concern for food safety and the need to produce for markets will limit faster application of livestock biotechnologies in smallholder farms, especially if it is perceived to pose threat to the international trade.

In other instances, African states lack the regulatory and scientific assessment structures that are necessary to make decisive steps on biosafety application of biotechnology leading to guidelines and policies that are contradictory, thereby hindering the flow of biotechnologies across borders. This calls for harmonisation of policies and procedures for standard testing and enforcement, risk assessment, information and documentation among other issues on safety issues of biotechnology.

Lack of effective communication/dialogue between research, official policy makers, civil society organisations, consumers and farmers

In most cases, researchers generate information and pass it to farmers for adoption with less attention to requirements or needs of farmers. Traditionally, the process of developing technologies has had minimal or no interaction with stakeholders, including policy makers, on what the repercussions of such developments would be in society and on environment. As a result, some of the technologies in the market contravene the policy frameworks on public and environmental safety while farmers and consumers view other technologies with mistrust and lack of confidence. To avoid such situations and develop technologies that are readily acceptable in the market, stakeholders must participate in making decisions about the research and technologies being developed. The decision making process should be based on scientifically accurate information to promote awareness and understanding, transparency, consensus, trust and confidence building rather than being driven by recommendations from the supply side that may be unfavourable or less understood/accepted by policy makers and farmers.

Effect of national food sufficiency policies

Most of the African population depend on agriculture for livelihoods and this makes the agricultural sector quite important in many economies. Hence, agriculture is viewed as the backbone for food sufficiency. However, the aspect of food sufficiency has traditionally been viewed from the point of crop production (especially grains/cereals) while neglecting the contribution of the livestock sub-sector. This has led to policies that emphasise intensive cereal crop production through intensive or irrigation schemes in many arable pockets of marginal areas traditionally used for livestock production resulting in land degradation due to unsustainable use and shrinkage of grazing resources. Consequently, livestock production has been confined to poorer zones where it is not economically viable to apply modern animal biotechnologies. There is need to reconsider the contribution of the livestock sub-sector towards national economies and at household level to integrate it within the national policy frameworks for food self sufficiency.

Lack of policies that emphasis commercial small-scale farming

Most farming systems in sub-Saharan Africa are subsistence oriented and produce for livelihoods with little for markets. In trying to survive in their harsh and difficult environments, smallholder farmers have over time learned how to adapt and tailor their agricultural technologies and systems to work in their unique circumstances and environments. They tend to adapt what works best for them under conditions of limited resources. Africa governments have failed to enact policies that help transform smallholder farming to commercial farming as a means of benefiting from economies of scale (Herbert 2004). This has been reflected by past scientific research that rarely addressed the socio-economic nature of subsistence farming. As a result, most innovations generated through research tend to have relatively limited application under the small-scale conditions found in much of sub-Saharan Africa.

Improper land tenure and property rights systems

Mutema (2003) notes that production efficiency, investment and the adoption of new technologies is highly related to ownership of land rights because it enables users claim ownership and access facilities such as credit for investment. This contradicts many cases in sub-Saharan Africa where land tenure systems are still based on the colonial systems. Through the colonial land policies, small-scale farmers were pushed to poor lands, a situation that was never corrected after independence. The high potential zones where property rights are defined are used for large-scale production of coffee, tea and dairy ranching while most subsistence farmers continue to exploit the poor areas with insecure property rights. Lack of effective property rights is not only a result of traditional land tenure systems but also of contradictions between official land laws and traditional entitlements. However, research over the years has emphasised production in high potential areas while neglecting the needs of a large proportion of small-scale farmers who exploit areas characterised by insecure property rights. Considering the case of Kenya, for instance, marginal lands constitute 80% of the country and carry over half the livestock population. Nevertheless, property rights in most of these areas are mostly held under open access or common property. Farmers lack the incentive to intensify their production or ensure sustainable utilisation. Where land rights are defined based on individual property rights, there is the tendency to use land for more lucrative ventures other than livestock keeping.

Land tenure systems and property rights also determine the natural resource management systems put in place, which has been a major constraint to livestock production. Moreover, land tenure systems determine how various communities claim ownership to the natural resource base. Insecure tenure, multiple ownership, common property and lack of clearly defined and secure property rights result in the overexploitation, underinvestment and general mismanagement of resources due to inappropriate institutions to govern their use. This consequently determines the species and breeds of livestock raised and technologies applied. Traditionally, societies have placed emphasis on breeds of animals that are adaptable to prevailing conditions even though they might not be the best in terms of production. This implies the need for understanding how land tenure systems and resource management policies affect resource use and the consequent effects on application of livestock biotechnologies.

Training and research policies

Having a sustainable livestock production sector requires a variety of skills, which include animal nutritionists, breeders, forage/range agronomists, veterinarians, sociologists, economists and animal physiologists. However, in many countries across Africa, there is a shortage of skilled capacity in many disciplines to engage in research, support extension and ensure economically viable relationships with technology developers for the benefit of smallholder farmers. Under such a scenario, biotechnology production is left in the hands of private firms from the West that mainly produce for profit. In other situations there is lack of adequate funds to support research and establish and/or maintain the necessary research facilities. Effective training-research linkages should be enhanced to ensure the needs of farmers are well matched with research development. Therefore, strengthened linkages between training and research institutions, and with extension systems will be required for the knowledge generated to be of any relevance to smallholder farmers.

Domestic policies

In most African countries, domestic policies such as undervaluation of currencies in order to promote exports have contributed to the squeeze on agricultural prices. Unfavourable prices do not give proper incentives to farmers despite the existence of improved technologies that they can use in production. In other instances, domestic policies on export taxation to raise state revenue leaves lower profit margins for the small-scale farmers. Coupled with attempts to appease urban populations by lowering food prices or facilitating importation of cheap products, it becomes expensive to produce under small-scale conditions because of limited profitability. As a result, farmers continue to rely on rudimentary technologies rather than investing in improved technologies with limited promise for profits. This calls for formulation of domestic policies that are favourable to small-scale production while rectifying those that undermine it.

Conclusion and the way forward

Although Africa can derive numerous benefits from adopting livestock biotechnologies to increase production, lower disease challenge and meet the deficit in livestock products, there are various areas that require effective policy intervention or review of existing policy frameworks in order to create an enabling environment for the adoption of existing modern biotechnologies. Considerable effort should also be directed at ensuring existence of effective institutions and policy frameworks relating to appropriate markets and marketing systems, infrastructure, training, extension, credit systems, biosafety regulations and land rights among others as a way of promoting biotechnology application at smallholder level for increased productivity and profitability. Globally, addressing issues of intellectual property rights, biosafety regulations and rules, fair trade, and effective and open communication between researchers, policy makers and technology users would be required.

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The role of biotechnology in animal agriculture to address poverty in Africa: The need for appropriate policies

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Abstract

Livestock production currently accounts for about 30% of the gross value of agricultural production in Africa. Seventy per cent of the rural poor in Africa own livestock, including pastoralists living in arid and semi-arid zones. Of these, over 200 million rely on their livestock for income (sales of milk, meat and skins) and manure for growing crop. The livestock sector in Africa, characterised by low productivity, is struggling to keep up with the demand for food from animal sources by the expanding human population. Conventional methods of livestock improvement and agricultural research and development have in the past served the purpose of increasing livestock productivity. However, these options can no longer sustain production hence new intensive techniques including biotechnology are now required to augment productivity.

Modern biotechnology has the potential to provide new opportunities for achieving enhanced livestock productivity in a way that alleviates poverty, improves food security and nutrition and promotes sustainable use of natural resources. While modern biotechnology is and will not be a panacea for solving all the problems of food insecurity and poverty, it could provide a critical component to the solution if it is guided by appropriate policies. This proposition forms the basis of this paper.

Introduction

The challenge facing sub-Saharan Africa today is providing food and alleviating poverty in the ever-growing population without downgrading the environment or affecting the future productivity of natural resources. During the 1990s, the population of Africa constituted 13% of the world population and had the fastest growth rate (Nyira 1995). The population expansion, which puts a burden on economic growth, also decreases food security and environmental sustainability. Poverty is mainly a rural phenomenon in Africa where the rural resource-poor farmers and their families make up more than 75% of the population. Between 55% and 60% of the rural people in sub-Saharan Africa are absolutely poor, subsisting on less than US$ 1 per day (Ndiritu 2000). More than 200 million people suffer chronic malnutrition (Ndiritu 2000). Per capita food production has been declining and today production is less than 70% of the average for the 1960s, when most of African countries attained their independence (Edroma 1992). African countries that were self-sufficient in food 10 to 20 years ago are now importing food through purchases and/or food aid to satisfy demand. Livestock production currently accounts for about 30% of the gross value of agricultural production in Africa. Seventy per cent of the rural poor own livestock; this includes pastoralists living in arid and semi-arid zones. Of these, over 200 million rely on their livestock for income (sales of milk, meat and skins) and manure for crop growing (Seré 2004). However, there are a number of limitations to greater productivity and production of livestock in Africa which include but are not limited to the small size of farms, lack of water resources, poor livestock breeds, diseases and insect pests, poor livestock feeds, lack of rural infrastructure and equipment, and financial constraints.

The low productivity of animal agriculture on the continent will need to be substantially increased to satisfy increasing consumer demand, to more efficiently utilise scarce resources and to generate income for a growing rural population. To increase livestock productivity, we must modernise the rural farming communities through improved breeds, reduce risks such as livestock diseases and insect pests, and improve pastures and forages. This goal can be achieved through innovative and modern agricultural technologies that may include both conventional and modern biotechnology.

Potential uses of modern biotechnology in animal agriculture

Modern biotechnology has the potential to provide new opportunities for achieving enhanced livestock productivity in many countries in Africa in a way that alleviates poverty, improves food security and nutrition and promotes sustainable use of natural resources. In livestock development, modern biotechnology can be utilised to produce cheaper and safer vaccines for animal diseases, prevalent in a given region. It is also possible to produce disease diagnostic kits, and immune boosters for livestock. Recent developments in molecular genetics also allow the identification of livestock with superior traits such as resistance to parasites or diseases and manipulation of rapid animal reproduction using multiple ovulation and embryo transfer (MOET). Applications of biotechnology to animal agriculture include improving milk production and composition; increasing growth rate of beef/meat animals; improving production efficiency, or gain-to-feed ratios, and carcass composition; increasing disease resistance; enhancing reproductive performance; increasing prolificacy; and altering cell and tissue characteristics for biomedical research and manufacturing. Continued development of new biotechnologies also will allow farm animals to serve as sources of both biopharmaceuticals for human medicine and organs for transplantation (NRC 2002).

One of the most prominent developments of modern biotechnology has been the creation of transgenic animal strains and cloning. In the 1980s it became possible to develop a transgenic animal—a mouse (Gordon and Ruddle 1981); the technology has since been applied during the 1990s to some mammals, including cattle, pigs and sheep (Hammer et al. 1985). The creation and use of transgenic animals in research continues to increase. For example, in Great Britain, there were 581,740 procedures in which transgenic animals were used or bred during 2000. Around 99% of these procedures involved mice (Anonymous 2002). A number of applications of genetic modification to farm animals may be possible. As it is with fish, it may be possible, for example, to use genetic modification to create faster growing livestock or produce leaner meat. For example, cloned transgenic cows have been developed that produce milk with a marked increase in â-casein and *k*-casein (Brophy et al. 2003). Transgenic pigs have been produced that over-express the bGH gene, which is associated with a dramatic reduction in carcass fat (85% reduction) and constituent fatty acid classes (Solomon et al. 1994). Genetic modification to change levels of selected nutrients in plants and animals has been, and is, an important objective of genetic engineering strategies to create designer foods (CAST 2003; Falk et al. 2002). From the perspective of modifying the nutrient profile of foods, this has been done to increase beneficial nutrients or to decrease nutrients associated with adverse health effects, such as saturated fatty acids.

Other applications would include engineering resistance to specific infectious diseases within the animal population. An example is Marek's disease in poultry, a virus-induced lymphatic cancer, which is clearly detrimental to the birds' welfare and costs the UK poultry industry alone some £ 100 million a year (Anonymous 2002). It might be possible to make animals resistant to infectious diseases that are also human health risks such as *Salmonella* in poultry or to produce bovine spongiform encephalitis (BSE)-resistant cows or scrapie-resistant sheep. It is further claimed that genetic modification could be used to improve farm animal welfare by correcting physiological problems which have arisen as a result of conventional selective breeding. Increased knowledge of animal genome sequences has the potential to allow some of the same effects to be achieved by identifying effective genetic maps that will improve marker-assisted breeding techniques.

Transplantation of tissue and organs between different species, and in particular transplantation of animal tissue into humans (xenotransplantation), is foreseen as possible in the near future. There is also a potential for a shortage of human organ donors and some animals, particularly pigs, are being examined as a potential source of suitable organs or cells, genetically modified to reduce the chance of rejection by humans. The recent successful production of cloned pigs is a further step towards efficient genetic modification of pigs and as such is aimed at bringing xenotransplantation closer (Anonymous 2002). There is debate about whether other necessary progress will have been made to allow successful transplants from genetically modified (GM) animals in the next 5 to 10 years. As the general public has become aware of the impact of these discourses, concerns over the use and safety of modern biotechnology have also been on the increase. Besides organ rejection, there remain serious concerns about the possible transfer of animal viruses to humans that will have to be addressed before the technology could be applied; and there are also concerns about physiological compatibility, let alone cultural concerns.

Challenges for biotechnology application

Whereas the developments in biotechnology reviewed above offer potential solutions to most of the problems facing livestock productivity and production, the application of modern biotechnology to research for development systems in Africa requires new investments, changes in resource allocation and new responsibilities for policy makers, research managers and scientists. The new responsibilities include, among other things, deciding how biotechnology is embraced in the national research agendas, setting appropriate policies, determining the benefits and risks of biotechnology applications and use of products thereof and services, ensuring that productivity constraints of the resource-poor farmers are addressed and developing the necessary regulatory capacities (Cohen 2001).

The general policy framework for biotechnology development in Africa should therefore encompass the various stages of transfer of technology and how it relates to decision making. The decision making process should take into account what products and services are needed and how these can be obtained through biotechnology. It is also necessary to identify technologies available and, where such technologies exist, to determine how they can be obtained, whether national expertise is available to source, access, assess, adapt and apply the technologies and to determine what kind of infrastructure is needed for research for development and whether trained manpower is available for the sustainable application of the technologies acquired. The strategy of using modern biotechnology as a component for an overall policy to foster sustainable development in the livestock sector and improve the livelihoods and well-being of the poor will require good political will and governance and leadership of a high order.

The policy framework

Appropriate biotechnologies can improve livestock production on farms of all sizes through improved animal health, reproduction and nutrition. However, to determine if modern biotechnology can benefit the resource-poor farmers in Africa, policy makers at the national, regional and international levels need to analyse the problems that are impeding livestock productivity in the region. Indeed, modern biotechnology is and will not be a panacea to solve all the problems of food insecurity and poverty. But it could provide a critical component to the solution if it is being guided by appropriate policies. These policies should guide (i) priority setting and capacity building in R&D and desired outcomes; (ii) safe application of biotechnology and use of products and services; (iii) intellectual property management; (iv) financing and incentives for public sector R&D; (v) public-private partnerships; (vi) promotion of regional and international collaborations; and (vii) education and public awareness on balanced, authentic and non-polarised information about biotechnology and biosafety.

Priority setting and capacity building in R&D and desired outcomes

Priority setting must be governed by the need to enhance livestock productivity in a way that improves food security and nutrition, alleviates poverty and promotes sustainable use of natural resources. Governments deciding whether or not to invest in agricultural biotechnology need to identify the most pressing needs and priorities to be addressed and if biotechnology can meet those needs and fit those priorities, and ensure that those priorities are consistent with the government's efforts to improve the livelihoods of the resource-poor people in both rural and urban areas. The key step here is to identify the constraints to agricultural production that conventional research has not been able to overcome and the recent scientific advances that offer new solutions. In recognition of the meagre human and financial resources available priority must be given to those R&D programmes that lead to develop: (1) new breeds of high-productivity, high-quality and disease/insect tolerant/resistant livestock; (2) new medicines, vaccines and diagnostic kits; and (3) biochemical engineering to open up new ways of production in food processing and storage, pharmaceutical industry and agriculture. In determining priorities and assessing the relative benefits and risks of using various technologies a participatory-interactive bottom-up approach involving all stakeholders is highly recommended. This ensures the participation of resource-poor farmers in all stages from priority setting to project development and implementation. The continuous involvement of all stakeholders including the urban and rural poor in R&D ensures development of biotechnology products that are demand driven, thus expecting high adoption rate.

Safe application of biotechnology and of products and services

The term 'biosafety' in the context of biotechnology describes a set of measures used to assess and manage any risks associated with genetically modified organisms (GMOs). Effective and efficient national biosafety systems should be in place before modern biotechnology is streamlined into a country's agriculture. The key components of an effective biosafety system include: (1) guidelines that clearly define the structure of the system, the roles and responsibilities of those involved and the review process; (2) the regulatory mechanism comprised of well trained personnel, confident about decision making; (3) an efficient information system that enables the biosafety evaluation process to be based on up-to-date and relevant scientific information; and (4) feedback mechanisms for incorporating new information and revising the regulatory framework as needed. A science-based assessment of risks on a case-by-case basis and identification of any concerns expressed by stakeholders, enable regulators to find out what risks may be associated with a particular product and to make appropriate recommendations.

In most countries with regulatory regimes, existing institutional arrangements have been adjusted to accommodate biosafety needs. Many developing counties in Africa are now in the process of developing their biosafety frameworks through the support of the UNEP/GEF (Mwinjaka 2004). As a reflection of the need to regulate potential risks posed by transnational transfers of GMOs, efforts are ongoing to negotiate a legally binding biosafety protocol under the Convention on Biological Diversity (CBD). The centrepiece of the Cartagena Protocol is an Advance Informed Agreement (AIA) procedure to be followed before the transboundary transfer of GMOs called living modified organisms or LMOs in the Protocol. While the Biosafety Protocol encompasses

GM semen, ova and animal embryos, animal cloning does not fall within the scope of the Protocol. Under the Biosafety Protocol, any country exporting GM animals for release into the environment will be required to give advance notice to the importing country (www.biodiv.org/biosafety/protocol.asp).

Intellectual property management

Intellectual property rights (IPRs) is a broad term for the various rights granted by law for the protection of economic creation in a creative effort. The main categories of intellectual property relevant to agricultural research and development are patents, plant variety rights or Plant Variety Protection (PVP, also known as Plant Breeders' Rights) governed by an international agreement and organisation, UPOV (French acronym for International Union for the Protection of New Varieties of Plants), trade marks and trade secrets.

The purpose of intellectual property management is to protect local inventions and enable access to technologies developed elsewhere. The Trade Related Intellectual Property Rights (TRIPs) agreement, negotiated as part of the Uruguay Round, requires all members to make patents available in all fields of technology. Under the TRIPs agreement, Article 27 (3b) ['Members shall provide for the protection of plant varieties either by patents or by an effective *sui generis* system or by any combination thereof']. In this sense, it is possible to patent a gene, which typically involves legal claims over the isolated gene and DNA sequences, over the genetic engineering tools that use those sequences, and over plants that have been transformed with such tools. The rights of the patent holder do not extend to plants in which the genes occur naturally. Not surprisingly, the moves by developed countries to protect products of biotechnology have led developing countries to seek to protect their genetic resources. Under the CBD agreement it is clear that nations could enact legislation prohibiting the export of genetic resources unless arrangements were made to share the benefits of financial returns from the exported resources.

The increasing use in research for development of proprietary materials and technologies which are owned by private-sector companies also means greater reliance on licenses, material transfer agreements and other legal agreements. Both national and international public research institutes therefore require suitable institutional and legal frameworks for managing intellectual property. With such legal expertise, research institutions can protect their inventions when necessary and use them to negotiate access to and use of proprietary technologies owned by others.

Financing and incentives for public sector R&D

Creating an enabling policy environment that would allow the application of biotechnology to thrive in national R&D institutions or in the commercial and industrial systems is of critical importance. The issue of financial resources is fundamental to creating this positive policy environment. Policy makers and decision makers need to be informed about the need for and potential of biotechnology so that they are convinced to invest the necessary resources to acquire and develop the necessary capabilities.

In many countries in Africa, R&D institutions and the science and technology (S&T) activities are public financed. Governments are unable to meet their many obligations; consequently, the R&D and S&T activities suffer most. Although governments attach sufficient importance to R&D and S&T functions as integral components of the development strategy, they still stammer when it comes to investments in these areas. This is reflected in the actual budget allocations for R&D and S&T activities. Political support can be built for public sector funding by documenting and publicising research impacts, developing strong and articulate client organisations that have political influence, building closer relations between research managers, scientists and policy makers, and broadening the funding base to include sustainable management of natural resources.

Decision makers and policy makers must establish both short- and long-term policies that will provide incentives for investments in biotechnology to enhance the impact of biotechnology on levels of food security, in the alleviation of poverty and in commerce and trade.

The role of donors including international agencies towards R&D and S&T activities remains crucial in keeping the technological advancement of the society. Their role varies from outright financial input to participation in joint research projects and the supply of equipments and manpower training.

Public–private partnership and private sector investment

Strategic alliances between public and private sector entities must be established to expand the financial resources for R&D in biotechnology. First, and probably most important, private sector research has radically increased, driven in part by the possibility of profits supported by intellectual property rights.

Governments of developing countries could provide incentives to public institutions, non-governmental organisations and local private companies to acquire appropriate biotechnology applications from external sources. These technologies could be used to meet the needs of both the larger commercial farmers and the resource-poor farmers. Several technology transfer organisations and development agencies already have facilitated donations of proprietary products by multinational companies to increase the productivity of subsistence crops and livestock. Much more is possible. Equitable joint ventures between public and/or private sector entities from developing countries and private sector entities in developed countries should be assigned high priority. These ventures can accelerate the adoption of tested technologies by farmers. Developing countries typically will contribute adapted germplasm and the external private sector will provide the proprietary gene that enhances the product. Building trust between parties to ensure equity remains the key challenge. Independent, honest-broker institutions and organisations such as Heifer International, FarmAfrica, African Agricultural Technology Foundation (AATF) and the International Service for the Acquisition of Agri-biotech Applications (ISAAA) can help build trust to achieve the mutual objectives of both the developing countries and the private sector. Both parties can make in-kind contributions to initiate projects and they can agree on their respective returns after the economic value of the enhanced product has been evaluated in the field. Similar strategic alliances could also apply to research carried out by international agricultural research centres.

Joint ventures with multinational agri-biotechnology companies also have great potential for both the public institutions and local private companies in developing countries. They are particularly attractive to private companies, which normally lack the R&D and capital investments to develop their own technology. Joint ventures offer the opportunity to license the technology and gain experience with its use and distribution. The latter activity is one of the weakest links in the chain of crop and livestock production in developing countries. Development agencies should also consider participating in more joint-venture pilot projects.

Officials making decisions about publicly funded agricultural research must first consider whether to modify research foci in order to complement the work carried on in the private sector. The private sector will probably do well at adapting livestock (cattle, sheep, pigs and poultry for example) that middle-income farmers will use in middle-income nations. Private industry probably also will do well at research on livestock exported to the developed world. Conversely, the private sector will pay little attention to the needs of the poorest farmers and it may not be as environmentally sensitive as publicly funded institutions. The public sector, therefore, has an important role to play in areas that complement private-sector activity. Moreover, if mergers reach the point where competition within the private sector is weak, the public sector should ensure that good public varieties could compete with private varieties so that farmers face reasonable choices. Such choices should be made available even if there are objections that public-sector activity is cutting into private-sector profits. The development of institutional mechanisms, such as competitive funds, could also promote public-private interaction (Kameri-Mbote and Wafula 2000). Promotion of mechanisms that do not require new institutions, such as joint ventures, collaborative research, research levies, and contract research may also be encouraged.

Promotion of regional and international collaborations

Successful biotechnology transfer and application will depend on access to information, positive national policies and most importantly, the recognition by the government of the central importance of S&T in national economic and social development. Biotechnology development has taken new dimensions from traditional technologies to international initiatives. The major investors on biotechnology are international companies, international laboratories and centres of excellence based in developed countries. Policy makers and decision makers must provide a conducive environment and setting to support international and regional initiatives in biotechnology R&D, and promote the creation of partnerships, both public-private and public-foreign investment firms which may also serve to reduce the potential risks in biotechnology developments. Governments must improve climate for creation of private biotechnological enterprises.

Governments must become actively involved in the coordination of the transfer of foreign technology with the development of domestic technological capabilities. Effective technology transfer requires human, scientific, technological, organisational and institutional and resource capabilities. To make technology appropriate for local circumstances, indigenous contribution to technological development is crucial, and this depends on indigenous technological capability. International collaboration and funding are essential, as many of the poor countries in Africa cannot develop successful biotechnology programmes by themselves. Both bilateral and multilateral collaborations are necessary. Regional collaboration and funding can be enhanced through existing organisations such as the African Union (AU), Southern Africa Development Community (SADC), East African Community (EAC), Economic Commission of West African States (ECOWAS) and sub-regional bodies such as Southern African Centre for Cooperation in Agricultural Research and Training (SACCAR), Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA) etc.

Education and public awareness on biotechnology and biosafety

Public awareness and understanding of biotechnology has great implication not only in successful application of biotechnology in research for development, but also on the acceptance of products of biotechnology. It has been observed that stakeholders including policy makers and decision makers, research managers and scientists in many developing countries have inadequate knowledge about biotechnology, its impacts and its potential for socio-economic development (Juma et al. 1995).

Recent advances in modern biotechnology and the rapid commercialisation of products, GM crops (James 2005), have led to many questions, deep disquiet and intensive debate. Sharply polarised debates in Europe, have underscored the importance of public participation in decision making on GMOs. GM proponents and GM opponents are continuing to differ on some issues, e.g. the impact of agro-biotechnology on the environment, health of human and animals (biosafety), the ownership and control of genetic resources (IPRs), and the livelihoods and socio-economic futures of the resource-poor farmers in both rural and sub-urban areas. The rapid pace of technological change and the wide-ranging nature of the perceived effects of biotechnology necessitate much greater public participation in policy making. A number of industrialised countries have launched programmes aimed at including the public in technology assessment and decisions involving the use of biotechnology in agriculture. The issue is not simply one of providing balanced scientific information to the public, but rather of building trust between science and society. Intermediary programmes and institutions concerned with the social aspects of biotechnology could be established to build such trust.

Conclusions

Modern biotechnology has the potential to alleviate poverty and improve food security in Africa, only if it focuses on the problems and opportunities poor people face and only if appropriate policies accompany it. Food insecurity stems from the combined effects of a number of factors; the challenge lies in strategies that tackle all problems comprehensively. Policies must ensure the development of a friendly environment and that biotechnology is oriented toward the needs of the poor, particularly resource-poor smallholders in rural and sub-urban areas. Modern biotechnology is not a silver bullet, but it may be a powerful tool in the fight against poverty and should be made available to poor farmers and consumers.

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Intellectual property rights and public agricultural biotechnology research for the poor: strange bedfellows or partners in crime?

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Introduction

Intellectual property (IP) refers to intangible property resulting from human ingenuity. It describes a wide variety of property including inventions, literary and artistic works, and symbols, names, images, and designs used in commerce, created by musicians, authors, artists, inventors etc. Intellectual property rights (IPR) introduces the concept of legal ownership of intellectual property. Ownership and use of creative works is regulated by IP laws, which recognise legal entitlement to IPR. Intellectual property is divided into two categories: industrial property, which includes patents, and copyright. In general, the holder of the legal entitlement is entitled to exercise various exclusive rights in relation to the subject matter of the IP. IPRs are granted by national authorities, generally for a specified period of time. The two terms, intellectual property and intellectual property rights, are often used interchangeably. In this paper, the term intellectual property is used to mean intellectual property or intellectual property rights as indicated by context.

The basic rationale for protection of IP is that it fosters innovativeness by encouraging authors and inventors to disclose their works in the public domain in exchange for exclusive rights to use of the work for a limited period of time. Thus other innovators can build on the information to develop more innovations. The inventor or author benefits in that he or she has exclusive rights to use or exploit the innovation, oftentimes for a fee, and/or to prohibit non-permitted use.

Changes in intellectual property landscape

A few decades ago, IP was a term that was the preserve for a few lawyers, individual inventors and private enterprises. Intellectual property rights were not considered to be a barrier in public agricultural research whose research products are taken to be public goods. In the recent past, however, the research environment has become more restricted because of protection of research products including basic research tools. National governments are also laying claim to genetic resources found within their bounders and regulating access to those resources. In the past genetic resources were generally considered a common heritage of humankind and were freely distributed and exchanged. Thus, public research institutions have to increasingly take into consideration IP related issues in conducting their research.

The restricted research environment is as a result a combination of factors that have caused tremendous changes in the IP arena. First, there is the dramatic shift from public to private research in the agricultural sector in the developed countries. Historically, agricultural research was a preserve of publicly funded research institutions. In the United States, for example, the Department of Agriculture and the land grant universities were the source of new innovations in agricultural technology. Today, however, the private sector spends more on agricultural research than do public research institutions (Keith and David 2000). In addition, the private sector commits more money into agricultural research than does the public sector. Entry of the private sector into agricultural research has been fuelled to a large extent by the advances made in molecular biology and in biotechnological research. After Mendel’s work on genetic inheritance was recognised as important in 1900, there was steady progress in understanding the genetic makeup of living organisms. This started with the discovery of radiation induced mutation in the 1920s, discovery of the chromosome and gene manipulation in the 1930s and 1940s, and the discovery of the double helix structure of DNA in the 1950s. The quantum leaps, however, are much more recent, notably in development of recombinant DNA technologies and the rapid development in DNA sequencing technology (Serageldin and Persely 2000). The developments in molecular biology and advances in biotechnology have accelerated the development of innovations which are of commercial importance (Jain 1999). Indeed, the entrance of the private sector has been credited as being behind the harmonisation of international IP laws and seeking stronger protection.

Another factor that has brought IP issues to the fore is the expansion of the scope of IP. This has taken various forms, namely expansion to cover new subject matter not previously covered, e.g. databases; inclusion of new ‘categories’ of subject matter, such that life forms now constitute patentable inventions in a number of jurisdictions; increase in period of protection, especially for copyright protection; and development of a *sui generis* system to protect non-traditional innovations such as new plant varieties. In addition to the expanded scope, there has been increased harmonisation of the IP protection regimes around the world. IP protection laws vary from one jurisdiction to another and generally speaking, registration or enforcement of IP must be pursued or obtained separately in each territory of interest. International treaties such as the World Trade Organization (WTO) Agreement on Trade Related Aspects of Intellectual Property Rights (TRIPS) have ensured continued harmonisation of IP protection laws amongst members of the WTO. There are other intergovernmental facilities through which protection in more than one jurisdiction can be sought.

The combined effect of globalisation, liberalisation of markets and the shift of the global economy from industry to knowledge-based economy is supported by advances in information and communication technology. Today, information is not only much more readily available and accessible but it is also easier to copy. While there is a remarkable acceleration in generation and dissemination of new knowledge, access, exchange and use of this knowledge is regulated by IP protection regimes including patents, copyrights, trademarks and trade secrets. Not surprisingly, advance in information technology has been paralleled by enhanced and stronger IP protection regimes. The TRIPS agreement sets out minimum standards of protection of intellectual property which member countries have to institute at the national level.

Implications of changes in IP landscape for agricultural public research

Until recently agricultural technologies were unencumbered by proprietary claims and were freely available to all. Agricultural history is an account of innovations spilling across firms, sectors of the economy and countries (Philip and Brian 2001). In the 1970s, advances in molecular biology paved the way for successful genetic transformations. Then the 1980s witnessed an unprecedented protection of products of biotechnology, especially in the agricultural sector, triggered by expansion of patentable subject matter to include life forms. Two events are noteworthy: first is the US Supreme Court decision of 1980 (Diamond v. Chakrabarty 447 U.S. 303, 1980) which concluded that a genetically modified bacterium was patentable. Genetic engineer Ananda Mohan Chakrabarty, working for General Electric, had developed a bacterium derived from the *Pseudomonas* genus capable of breaking down crude oil, which he proposed to use in treating oil spills. He requested a patent for the bacterium in the US but was turned down by a patent examiner, who believed that living things were not patentable. Following a series of actions that finally ruled the case in favour of Chakrabarty, Sidney A. Diamond, the Commissioner of Patents and Trademarks, appealed to the Supreme Court. The court decided that the micro-organism plainly qualifies as patentable subject matter because the inventors claim was to non-naturally occurring bacterium—a product of human ingenuity.

The second equally significant event is the granting of a patent by the US Patents and Trademarks Office on a genetically modified mouse, the Oncomouse, developed by Harvard University in 1988. The mouse had been genetically modified to carry a specific gene, an activated oncogene, which significantly increases the mouse's susceptibility to cancer, thus making the mouse an important tool for cancer research. This was the first higher animal patent.

The possibility to have proprietary claims on genetic material and life forms constituted an incentive for the private sector to invest in agricultural research and development. While returns from licensing are a blessing to the private sector, the proliferation of patented agricultural technology has increasingly been seen as a research barrier for the public sector. But IP in life form has been criticised for several reasons besides being a barrier to innovation. Those in favour hold that IP plays an important role in stimulating biotechnological innovation, in fostering competitiveness and in advancing medical research including diagnostics, therapies and cures. Those against protection of life forms range from animal rights activists who see patents on animals as aggravating the degradation of animals; environmentalists who fear that genetically modified life forms threaten the integrity of the environment; clerics who see patenting as reducing divinely created creatures to mere objects; and small-scale farmers who are concerned about continued privatisation of agricultural innovations on their livelihoods.

The relevant question for public agricultural biotechnology is broader than the above debate and is founded on the recognition that IP protection for life forms as well as for other innovations, will continue in the foreseeable future. The relevant question is whether the existence of IPR and continued harmonisation of enforcement mechanisms are barriers to research aimed for the poor. Studies done by the International Food Policy Research Institute (IFPRI) can be insightful in answering this question. IFPRI found that IPR embodied in the key enabling technologies used to transform crops were actually not protected in most developing countries because these technologies were held by commercial companies which are interested in profits (Pardey and Wright 2001) while their primary markets are in developed countries. Since IPR are territorial, i.e. they are only enforceable in countries in which protection is sought for and is granted, these technologies can be freely exploited in developing countries in which they are not protected. A problem would, however, arise if products incorporating these technologies are subsequently exported into a country in which the technologies are protected.

The public sector has to consider a number of IP related needs in addressing the challenge posed by an IP saturated research environment. This includes the need to establish collaborative links with advanced laboratories to access technologies, ensure product development and delivery to relevant beneficiaries and the need to guard against misappropriation of technologies developed by the public sector. IP should be used as a tool to meet these needs. Public institutions can use IP as a tool to establish collaborative linkages with advanced laboratories or with the private sector to access the technologies and to form partnerships for product development and delivery. Protecting IP for to promote linkages with the private sector is often seen as one instance where protection makes economic and social sense (Maredia et al. 1999). In each given situation, an enquiry should be made on the research goal, technologies needed to achieve it, accessibility of these technologies, management of the research process whilst respecting obligations to third parties, products developed and their delivery to end users, and, interventions put in place to prevent misappropriation by third parties. This requires that the necessary capacity to deal with matters related to IP be built at the national and research institutional level. At the national level, there is need for developing countries to build capacity to engage in negotiations on matters relating to IP at global level. In addition, there is need to have capacity to institute policy and legislation and to enforce the legislation. At the public level, there is need to implement policies that are supportive of the public good agenda while at the same time fostering collaboration with a wide range of players including the private sector.

Conclusion

Partnerships with the private sector are becoming increasingly inevitable as public institutions seek to access patented technologies and to deliver research products to relevant beneficiaries. Since the private sector focuses on high return research that is not necessarily relevant for the poor, public sector research will continue to be important in addressing problems of the poor. Intellectual property rights in biotechnological research raise several opportunities and challenges for the public research sector. In addressing the challenges, public institutions should view IP as a tool that facilitates research collaboration and delivery of research products to the poor. In the end IP and biotechnology research for the poor are neither strange bedfellows nor partners in crime. One is simply a means and the other an end.

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Implementing the Cartagena Protocol in West and Central Africa: Challenges and opportunities

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Abstract

Although modern biotechnology holds great potential for agriculture, especially in developing countries, if it is not well regulated and managed, it can be of great disservice to the very people it is intended to serve. The Cartagena Protocol on Biosafety is one of the international instruments that regulate modern biotechnology but some West and Central African countries face many challenges in its implementation. These challenges include, among other things, the lack of biosafety laws, the absence of access and benefit sharing regulations, the absence of clear biotechnology policies, poor government commitment to funding biotechnology research, poor or lack of laboratory equipment, poor public perception of biotechnology and poor access to information and communication technology. This paper discusses how these challenges hinder the proper implementation of the Protocol and proposes a way forward by examining the opportunities that are available for effective implementation of the Protocol in the sub-region.

Key words: implementation, Cartagena Protocol, biotechnology, obligations, challenges, opportunities

Introduction

Experts say agriculture will have to sustain an additional 2 billion people over the next 30 years from an increasingly fragile natural resource base. The need for further increase in production in the future while conserving the resource base of agriculture and minimising adverse effects on the wider environment, calls for ever greater contributions from agricultural research (FAO 2003). Although it has been generally acknowledged that biotechnology holds great promise for agriculture in developing countries, if not well regulated, it can cause a great disservice to the very people it is intended to serve. For this reason there was a need to come up with an international instrument to regulate modern biotechnology. Most developing countries have not yet passed legislation in this field and believe that their limited scientific capacities, their recurrent problems with checking products at their borders, and their restricted ability to make their own assessment of the risks and benefits involved do not allow them to manage properly the challenges that genetically modified organisms (GMOs) and other products of modern biotechnology pose. They therefore called for the establishment of international rules in this field. The Cartagena Protocol on Biosafety, which represents the multilaterally agreed response to these concerns provides the legal framework regulating transboundary movements of living modified organisms (LMOs), adds to the growing number of the multilateral environmental agreements (MEAs) that the international community, especially developing countries, are having challenges to implement nationally.

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[1]For details, see http://www.biodiv.org/biosafety/faqs.

[2]Article 37 (1) states: 'This Protocol shall enter into force on the ninetieth day after the date of deposit of the fiftieth instrument of ratification, acceptance, approval or accession by States or regional economic integration organizations that are Parties to the Convention.'

Apart from the fact that this growing body of MEAs suffers from the inability or unwillingness to implement and enforce them, implementation efforts in developing countries are often made more difficult by lack of financial and human resources, the sheer volume and complexity of associated obligations and responsibilities, inconsistency in implementation regimes between countries and occasionally, a lack of political will. In many instances, states recognise an environmental problem, negotiate an MEA to address the problem, and then sign and ratify the MEA, without conducting a serious assessment of whether particular states actually have the financial, personnel, and the required technical resources to implement the MEAs. Today, many states in West and Central Africa are faced with the challenge of implementing numerous MEAs with limited resources. In addition to scarce resources, politicians in the developing countries often need to be convinced of the importance of implementing some MEAs, considering the fact that there are other pressing priorities facing their countries. States are now asking questions about the best way forward (UNEP 2004).

The Cartagena Protocol on Biosafety

The Biosafety Protocol was finalised and adopted in Montreal, Canada, on 29 January 2000 at an extraordinary meeting of the conference of the parties. In accordance with the precautionary approach contained in Principle 15 of the Rio Declaration on Environment and Development. The objective of the Protocol is to contribute to ensuring an adequate level of protection in the field of, the safe transfer, handling and use of LMOs resulting from modern biotechnology that may have adverse effects on the conservation and sustainable use of biological diversity, taking also into account risks to human health, and specifically focusing on transboundary movements.[1] The 50th instrument of ratification by parties was on 13 June 2003 and in accordance with Article 37 of the Protocol it entered into force on 11 September 2003.[2]

Key features of the Protocol

The Protocol promotes biosafety by establishing rules and procedures for the safe transfer, handling and use of LMOs, with specific focus on transboundary movements of LMOs. It features a set of procedures including one for LMOs that are to be intentionally introduced into the environment (advance informed agreement procedure), and one for LMOs that are intended for use directly as food or feed or for processing. Parties to the Protocol must ensure that LMOs are handled, packaged and transported under conditions of safety. Furthermore, the shipment of LMOs subject to transboundary movement must be accompanied by appropriate documentation specifying, among other things, identity of LMOs and contact point for further information. These procedures and requirements are designed to provide importing Parties with the necessary information needed for making informed decisions about whether or not to accept LMO imports and for handling them safely. The Party of import makes its decisions in accordance with scientifically sound risk assessments. The Protocol sets out principles and methodologies on how to conduct a risk assessment. In case of insufficient relevant scientific information and knowledge, the Party of import may use precaution in making their decisions on import. Parties may also take into account, consistent with their international obligations, socio-economic considerations in reaching decisions on import of LMOs. Parties must also adopt measures for managing any risks identified by the risk assessment, and they must take necessary steps in the event of accidental release of LMOs. To facilitate its implementation, the Protocol establishes a Biosafety Clearing-House for Parties to exchange information, and contains a number of important provisions, including capacity-building, financial mechanism, compliance procedures and public awareness and participation. However, developing countries in general and West and Central African countries in particular have some practical challenges and opportunities to effectively implement the Protocol.

Challenges and opportunities for implementation in West and Central Africa[3]

Sands (1995), says that states implement their international environmental obligations in three distinct phases. First, by adopting national implementation measures; second, by ensuring that national measures are complied with by those subject to their jurisdiction and control; and third, by fulfilling obligations to the relevant international organisations, such as reporting the measures taken to give effect to international obligations. In this paper implementation refers to all relevant laws, regulations, policies and other measures and initiatives that contracting parties adopt and/ or take to meet their obligations under the Cartagena Protocol and its amendments if any. In trying to meet their obligations under the Protocol as stated above, countries in the sub-region face common practical challenges, especially as most of them have similar (but distinct) legal, institutional, linguistic and economic contexts. Conversely, there are equally some present and potential opportunities for the countries of the sub-region to seize for their effective implementation of the Protocol.

Challenges

These challenges include, among other things, the lack of Biosafety Laws, the absence of access and benefit sharing regulations, the absence of clear biotechnology policies, poor government commitment to funding biotechnology research, poor or lack of laboratory equipment, poor public perception of biotechnology and poor access to information and communication technology by scientists.

a. Absence of or inadequate biosafety frameworks

The Cartagena Protocol requires a country to allow the importation of a GMO only after it has obtained all the necessary information about it and carried out a risk assessment to evaluate the likelihood of harm to human health, to agricultural systems, to its environment and to its socio-economic conditions. This requires that countries establish what is called a ‘national biosafety framework’, which includes a policy, a regulatory regime, a system to handle notifications, systems for monitoring and inspections, and systems for public information and participation. According to van der Meer (2003), the establishment of a national biosafety framework is not something that suddenly became necessary because of the Protocol. Since 1992, Article 8(g) of the Convention on Biological Diversity (CBD) has called for the establishment of such national mechanisms. But in the sub-region under consideration, very few countries have developed a biotechnology and biosafety policy document to guide in priority setting, development of laws and identification of the institutional frameworks to promote biotechnology capacity. Apart from Cameroon, that has adopted a Biosafety Law, the other countries in the sub-region are still at the stage of developing their legislations. For effective public involvement, the development of frameworks requires initial public sensitisation and as such funds are needed to organise meetings, workshops, documentation etc. The major challenge here is that these much needed funds are hard to come by, due to budgetary constraints.

b. Lack of or inadequate laboratory equipment for risk assessment

Under the Cartagena Protocol the objective of risk assessment is to identify and evaluate the potential adverse effects of living modified organisms on the conservation and sustainable use of biological diversity in the likely potential receiving environment, taking into account risks to

[3] This paper draws from the outcome of a survey carried out in West and Central Africa in 2002 by Prof. Walter S. Alhassan entitled ‘Agrobiotechnology application in West and Central Africa (2002 survey outcome)’ which included Burkina Faso, Cameroon, Côte d’Ivoire, Ghana, Mali, Nigeria and Senegal. However, experiences from the other Communauté Economique et Monétaire de l’Afrique Centrale known in English as the Economic and Monetary Community of Central Africa (CEMAC) countries have been included.

human health. Risk assessment is, *inter alia*, used by competent authorities to make informed decisions regarding LMO.[4] In the sub-region most biotech institutions are ill equipped to conduct the risk assessment studies, although the techniques required to evaluate risks of LMOs are available. Without risk assessments, governments will be unable to establish and implement the necessary policies and measures to ensure the safe application of biotechnology. The unavailability of laboratory spare parts and trained repair technicians is a major concern in the sub-region. As Alhassan (2003) says, other constraints are associated with staff skills in biotechnology, especially those with knowledge in molecular biology who are not practising their professions for lack of laboratories, such staff are likely to get 'rusty' and therefore frustrated.

c. Poor public perception of biotechnology

The Biosafety Protocol in Article 23 recognises the fact that for public participation to be meaningful, there must be access to information, and public awareness and education. A number of challenges present themselves. For example, how can to present scientific issues to the public in a manner that is understandable by lay people and how to raise public awareness with balanced information and ensure that the uninformed group (which forms the majority) does not fall victim to the mass misinformation that clogs some media? Other challenges are posed by diverse levels of education and literacy across the countries in the sub-region; low understanding of biotechnology among the public; lack of simple communication material; and difficulty in getting biotechnology- and science-based information from local sources. The insufficient dialogue between scientists, industry, policy makers, regulators, civil society organisations and the mass media affect public perception of modern biotechnology and its products. The media culture favours mainly social events, especially political events and science reporting has low priority.

d. The limited access to information and communication technology—BCH

The Biosafety Clearing-House (BCH) was established in Article 20 as one of the key tools to assist countries to implement the Cartagena Protocol. According to Pythoud (2003), there was a common understanding that the BCH should take advantage of the most recent information communication technologies and should therefore be mainly Internet based. The main challenge concerning the BCH in the sub-region is that access to the Internet is still a luxury and this will affect the usefulness of the BCH for the majority that do not have access to the Internet. To present a coherent and relevant view of local concerns and needs at the global level, it is imperative for the public to have access to the information that is available. It is very clear that there is a great need to build human and infrastructure capacity in this area and this needs lots of investment from the states and their partners.

e. Permeable state borders

The Protocol establishes an international, legally binding framework that allows countries, in particular, those that do not yet have in place a regulatory regime for biosafety, to make informed decisions on the import of GMOs into their territory. Therefore countries have the sovereign right to regulate GMOs and their products at the national level and they typically do this by reviewing certain technical information to determine safety. In the sub-region, the porous nature of borders due to the fact that the boundaries have weak control from the state is a major problem. Informal circulation of goods and humans across borders within the sub-region can make inspection and control an onerous task. Moreover, the sub-region is witnessing much ethnic unrest within the states and this forces cross-border movement of people and goods. For instance, at least 23,000 Fulani cattle herdsmen and their animals fled from Nigeria into nearby Cameroon to escape clashes with farming communities on the Mambilla plateau in Taraba State between 1 and 7 January 2002. More than 100 people were killed in the fighting. Some of the Fulani refugees

[4] See Annex III (Risk Assessment) to the Cartagena Protocol on Biosafety.

later returned to Nigeria but the majority remained and were raising their cattle in Cameroon until April 2005 when UNHCR arranged for the voluntary repatriation of some. Such examples are many in the sub-region and things can become very complicated when such situations arise between countries with different GM status.

Opportunities

In spite of the many challenges stated above, there are equally some opportunities that will favour or positively contribute to the effective implementation of the Protocol in the subregion.

a. Similar (but distinct) legal, institutional, linguistic and economic contexts

FAO affirms that 'Intercultural dialogue between developing countries facing similar food and agriculture problems is an important way of sharing expertise and technologies.'[5] Countries of the Central and West African sub-region share similar (but distinct) legal, institutional, linguistic and economic contexts. This is an opportunity in the sense that it is often possible to adapt approaches from one country in the sub-region to the specific context of another country. These shared contexts also facilitate regional, sub-regional and bilateral cooperation and coordination. Countries can learn from the experience of others and avoid repeating mistakes while building and improving on the proven successes. For instance, Nigeria and Côte d'Ivoire are developing their biotechnology policy documents while Cameroon has already adopted her Biosafety Law and the texts of application are at their final stage. These developments have not only been costly but they also required time and consultations. The other countries of the sub-region that are at initial stages of putting their own policies and regulatory instruments in place will have to learn from the weaknesses and the successes of these experiences. Some countries like Mali and Burkina Faso are in the initial process of testing BT cotton; results from their experiences will be useful in developing the policy of the other countries in the sub-region. The Sahel and West African Club (SWAC) says cotton plays an important part in West Africa's development. Between 1 and 2 million households produce cotton in West Africa; up to 16 million people are involved in cotton production in some way and West and Central Africa taken together are the world's second largest exporters of cotton after the United States.[6] Logically it means that the successes or failures of the trials of BT cotton in Mali and Burkina Faso will influence how 16 million people perceive this technology in the sub-region.

b. Favourable environment for regional co-operation

It is recognised that South-South cooperation in the form of sharing expertise and technologies has resulted in the transfer of many solutions suited to local conditions. African scientists and policy makers can gain from the experiences of other countries and regions. Regional networks and international cooperation are effective in sharing information, scientific and regulatory data, and expertise within specific geographic regions. For example, environmental and food safety risk assessments are expensive, and countries may benefit from each other by sharing regulatory data and information. The advances in Internet technology now enable rapid and free delivery of information (Eicher et al. 2005). West and Central African sub-region regional scientific cooperation initiatives are already in existence and only need technical and financial support to be more effective. For instance one of CORAF/WECARD's objectives is to promote cooperation, consultation and information exchange between member institutions and other partners.[77]CORAF/WECARD is a 21-member sub-regional organisation whose mission is to:

The sub-regional economic institutions like CEMAC and ECOWAS (Economic Commission of West African States) have taken the issues of food security, biotechnology and biosafety as a

[5]'Agriculture and intercultural dialogue' is the theme of this year's World Food Day, celebrated every year to mark the day on which FAO was founded in 1945. see http://www.fao.org/wfd/2005/.

priority on their agenda. The diversity of the procedures of analysis and control in this sub-region where the borders are permeable, constrained the states to reflect on the solutions of conformity and harmonisation. It is within this framework that the Heads of State of the CEMAC, came together in N'Djamena (Chad) on 14 December 2000, adopted the Regional Strategy of Food Safety, within harmonisation of the phytosanitary regulations. FAO provided support for the implementation of this strategy and a regional programme for food safety was established.

In addition, during the seminar organised in Nigeria on 1 March 2001 by the Africa Middle East Working Group of the Global Crop Protection Federation (AMEWG/GCPF) (which later became CropLife Africa Middle East), it was recommended to the participants to initiate a procedure of harmonisation of the phytosanitary regulations in CEMAC zone. In the Yaoundé meeting of March 2002, the six CEMAC countries agreed, among other things to establish a harmonised/ common phytosanitary regulation. A committee in charge of preparation and implementation of such legislation within CEMAC zone was created and governments agreed to support the initiative and adopt a harmonised official document. In mid-2005 CEMAC ministers in charge of agriculture met in Douala, Cameroon, to adopt the CEMAC common regulation on the homologation of pesticides. Many observers see this as a giant step towards harmonising regulations in other areas, especially biosafety.

A ministerial conference of ECOWAS states on biotechnology was held on 24 June 2005 in Mali. The objective of the conference was to adopt the necessary conditions defined by the meeting of experts held on 21 to 23 June 2005 for the implementation of the recommendations of the Ouagadougou conference, on the 'mastery of sciences and technologies to increase agricultural production in Africa: West African perspectives'. Some of the major recommendations of the meeting envisaged actions relating to biotechnology and biosafety.[8] On biotechnology, there will be the reinforcement of research priority setting identified by CORAF/WECARD by a quantitative economic analysis and to increase investments through partnership between private and public sectors to drive the best use of biotechnology tools to alleviate the constraints of production. Concerning a regional approach to biosafety there was a call on those countries that had not yet ratified the Cartagena Protocol to do so as soon as possible, so that by 1 July 2006 at latest, all the ECOWAS country members would have adopted their respective national policies and legislations on biosafety, thus, facilitating regional harmonisation of the biosafety system to July 2008. Another objective is harmonise national legislations and establish a regional regulatory framework on biosafety and an independent fund for the assessment of the socio-economic impacts of the use of GMOs. All of these indicate a favourable environment on which cooperation in biotechnology and biosafety issues in the sub-region can be built.

c. Capacity building opportunities

Article 22 of the Protocol requires parties to cooperate in the development and strengthening of capacities in biosafety, including through existing organisations and through private sector involvement. Such cooperation includes, *inter alia*, scientific and technical training and the enhancement of technological capacities in biosafety. By virtue of Article 28 paragraphs 4 and 5, special attention is given to the needs of developing countries. The Conference of the Parties to

[6] For details see SWAC West African Cotton Overview: Draft for comments January 2005 at: http://www.oecd.org/sah.

[7] CORAF/WECARD is a 21-member sub-regional organisation whose mission is to:

- Improve the efficiency and effectiveness of agricultural research in West and Central Africa by contributing to the construction and the consolidation of the capacities of the national agricultural research systems (NARS) through cooperation between its members, development partners, regional and international organisations, the private sector, non-governmental organisations and users of research results.
- Consolidate the position of the West and Central African sub-region within the context of the international agricultural research-for-development.

the Convention on Biological Diversity serving as Meeting of the Parties to the Cartagena Protocol on Biosafety (COP-MOP) is especially required when giving its guidance with respect to the financial mechanism for the Protocol, to take into account the needs of developing country parties in their effort to identify and implement their capacity building requirements. Capacity building for effective implementation of the protocol has been one of the top agenda items of the COP-MOP decisions. At its first meeting, the COP-MOP (in its decision BS-I/5) endorsed an Action Plan for Building Capacities for the Effective Implementation of Protocol and the coordination mechanism developed by the Intergovernmental Committee for the Cartagena Protocol on Biosafety (ICCP). The COP-MOP also considered a preliminary set of criteria and indicators for monitoring implementation of the action plan. Finally the COP-MOP decided to include capacity building as one of the standing items on its medium-term programme of work up to its fifth meeting.

At the second meeting, COP-MOP (in its decision BS-II/3) invited developed countries and relevant international organisations to provide support to developing country parties in capacity building, especially for the development and implementation of national biosafety frameworks. This invitation was particularly targeted at the least developed and small island developing states among them, including countries that are centres of origin and centres of genetic diversity, and parties with economies in transition. This second COP- MOP meeting also reiterated the importance of the roster of experts in assisting developing country parties conduct risk assessment, make informed decisions, develop national human resources and promote institutional strengthening associated with the transboundary movements of LMOs , while reaffirming the need to ensure the regional and gender balance on the roster of experts. It, however, noted with concern the limited use to date of the roster of experts and of the Voluntary Fund for the Roster of Experts, and reiterated the call to parties and governments to use the roster of biosafety experts in accordance with the Interim Guidelines for the Roster of Experts on Biosafety. The countries of the sub-region should capitalise on the fact that the international community is focusing her capacity building priorities on developing countries now and should come up with worthwhile projects and seize the opportunity while it is still there.

Conclusion

Experience has shown that implementation of MEAs in a sub-region like West and Central Africa where emphasis is more on economic development is handicapped by many constraints. Such is the case with the implementation of the Cartgena Protocol on Biosafety in particular and with the application of modern biotechnology that the Protocol seeks to regulate. Despite the potentials of modern biotechnology, the capacity of many institutions in the sub-region to undertake biotechnology research and development lags behind that of developed countries. This is largely due to poor infrastructure, lack of trained manpower and poor support for research and teaching. Successful introduction of biotechnology applications to the region must incorporate strategies that address these constraints. The institutions are ill equipped to conduct the risk assessment studies, although the techniques required to evaluate risks of LMOs are available. Risk assessment is the key feature of the Cartagena Protocol, for without risk assessments, governments will be unable to establish and implement the necessary policies and measures to ensure the safe application of modern biotechnology. All these constraints only point to a key way forward: a sub-regional approach for the effective implementation of Protocol. Some sub-regional initiatives and groupings already existing in the area provide a favourable environment for this approach and should be capitalised on.

[8] For details see 'MAIN CONCLUSIONS AND RECOMMENDATIONS' of the Ministerial conference of ECOWAS states on biotechnology, Hôtel de l'Amitié, Bamako, Mali, 24 June 2005 at: http://www.coraf.org/documents/report/final.pdf

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National Biosafety Framework for Tanzania: Regulatory regime on genetically modified organisms

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Abstract

The Office of the Vice President of Tanzania, in collaboration with national stakeholders and the United Nations Environment Programme (UNEP), has developed a National Biosafety Framework (NBF) for the implementation of the Cartagena Protocol on Biosafety. The process involved the establishment of a system of legal, technical and administrative mechanisms to address safety in the field of modern biotechnology in the country. In the process of developing the NBF, stakeholders' workshops and surveys were conducted in 2003 to ensure public participation. Existing local infrastructure and resources were identified to establish the status of the extent to which Tanzania meets the requirements for safe application of modern biotechnology.

There exists a widespread interest in the use of biotechnology among various stakeholder institutions in Tanzania. The majority of these institutions are engaged in second-generation biotechnologies (e.g. tissue culture and fermentation). A minority are dealing in third generation (modern) biotechnology (molecular diagnostics, genotyping and taxonomy). There is, however, no institution engaged in the application of recombinant DNA biotechnology. At national level biotechnology policy is currently absent. The Environmental Management Act 2004 was enacted in February 2005. The Act provides for the legal and institutional framework for sustainable management of the environment. The Act further provides for the regulation of development, handling and use of genetically modified organisms (GMOs) and products thereof. It empowers the minister responsible for environment, in consultation with sector ministries to make regulations, issue guidelines and prescribe measures for the regulation of the development, handling, and use and the importation and exportation of GMOs and their products. It is on the basis of the Environmental Management Act 2004 that the proposed draft Environmental Management (Biosafety) Regulations will be established and made operational by the environment minister.

This paper details the National Biosafety Framework in Tanzania and the administrative and decision making structure for GMOs. The Vice President's Office is the National Biosafety Focal point whereby all applications concerning GMOs should be addressed. The ministries of agriculture and food security, health, water and livestock development are some of the key competent authorities in their mandate. This paper also elaborates on the application procedures for the export or importation of GMOs, inspection and enforcement, public education, awareness and participation, monitoring, challenges and way forward.

Key words: GMOs, Biosafety framework, Tanzania

Background and context of the national biosafety framework (NBF)

Modern biotechnology is an emerging tool with potential for improving human and animal health, agriculture, industrial and agricultural production and environmental protection. However, the development and application of modern biotechnology have been associated with both opportunities and concerns over the risks of genetically modified organisms (GMOs) to human and animal health, biodiversity and the environment. Concerns raised against modern biotechnology may be grouped into environmental, human health, biodiversity and socio-economic and ethical concerns.

These and other concerns have made it necessary to establish national biosafety frameworks. The necessity emerged as one of the priorities following adoption of the Cartagena Protocol on Biosafety in 2000. Tanzania ratified this Protocol on 16 March 2003.

The National Biosafety Framework is an output of the 'National Biosafety Framework Project', an 18-month project which started in September 2002. This project was funded by the UNEP-GEF and implemented by the Office of the Vice President.

Objectives

The NBF has the following objectives:

- Establish science-based, holistic and integrated, efficient, transparent and participatory administrative and decision making system so that Tanzania can benefit from modern biotechnology while avoiding or minimising the inherent environmental, health and socio-economic risks.
- Ensure that the research, development, handling, transboundary movement, transit, use, release and management of GMOs are undertaken in a manner that prevents or reduces risks to human and animal health, biological diversity and the environment.

Scope

NBF applies to the research, development, handling, transit, contained use, transboundary movement, release or placing on the market of any GMO whether intended for release into the environment, for use as food, feed or processing, or a product of a GMO/product thereof that may have adverse environmental, human and animal health and socio-economic, and ethical and cultural effects on the inhabitants of Tanzania.

Key elements

A national biosafety framework is a policy, legal, technical and administrative instrument established to address safety for the environment and shall include the safety of humans and animals in the field of modern biotechnology. The NBF consists of the following key elements:

a) National policies related to biosafety
b) Regulatory regime
c) Administrative and decision mechanisms
d) Monitoring mechanisms
e) Mechanisms for public awareness, education and participation.

The NBF serves as a basic guide to the implementation of the biosafety system in Tanzania. The NBF shall apply in tandem with two important documents, the National Biosafety Guidelines and the Biosafety Regulations.

Biosafety regulatory regime

Environmental Management Act 2004

The President of the United of Republic of Tanzania signed the Environmental Management Act 2004, in February 2005. This Act provides for the legal and institutional framework for sustainable management of the environment; and the regulation of development, handling and use of GMOs and products thereof. It proposes to empower the minister responsible for Environment in consultation with sector ministries to make regulations, issue guidelines and prescribe measures for the regulation of the development, handling and use, and the importation and exportation of GMOs and their products. The regulations and guidelines will among other things specify:

- Measures to protect environment and human and animal health including socio-economic, cultural and ethical concerns
- Measures necessary to regulate the handling, transport, packaging and identification of GMOs and products thereof
- Measures to regulate, manage and control risks associated with import or export of GMOs and products thereof
- Measures to promote and facilitate public awareness, education and participation concerning the research, development, handling, transit, contained use, transboundary movement, release or placing on the market of any GMO whether intended for release into the environment, for use as food, feed or processing, or a product of a GMO/product thereof.

It is on the basis of the Environmental Management Act 2004, that the proposed draft Environmental Management (Biosafety) Regulations will be established and made operational by the environment minister.

The draft Environmental Management (Biosafety) Regulations

The draft biosafety regulations amply provide for tools to facilitate decision making in terms of risk assessment and risk management. It also provides for liability and redress and places strict liability on the one who carries out activities in relation to GMOs.

The draft Environmental Management (Biosafety) Regulations are arranged in 10 parts:

a) Part one deals with interpretation of various terms used in the regulations. Biosafety, being a new area, necessitates definition of some of the terms.
b) Part two dwells on general principles which give a general direction in implementation. Such principles include precautionary principle, the principle of prevention and strict liability.
c) Part three on institutional arrangement provides for the establishment of the National Biosafety Focal Point (NBFP). It also proposes the establishment of the National Biosafety committee (NBC) and Institutional Biosafety Committees (IBC).
d) Part four is on approval of an activity. This part prohibits any dealings in GMOs and their products without the prior written approval of the NBFP. It provides for an elaborate procedure of notification and approval which includes public participation and a duty to disclose certain information to the public.
e) Part five is on risk assessment and decision making. It is this part which elaborates the powers of the national focal point in decision making.
f) Part six deals with risk management and this includes measures that may be imposed by the NBFP that are necessary to prevent effects of GMOs or their products on human and animal health, biological diversity or the environment.
g) Part seven covers aspects of liability and redress. This part puts in operation the principle of strict liability. Strict liability is imposed on the person carrying out any activity in relation to GMOs or their products when they directly or indirectly cause harm, injury or loss.

h) Part eight specifies offences and penalties. It lists a number of things if committed or omitted constitute offences under the regulations. It also provides for sanctions.
i) Part nine is on schedules. The schedules and any regulations made under or pursuant to this legislation are proposed to be an integral part of this legislation.
j) Part ten is on entry into force. The proposed regulations shall enter into force on the date of its publication in the official gazette.

Biosafety guidelines

Risk assessment and management

Before any release is carried out, an evaluation of the impacts and risks posed to human and animal health and the environment by the release should be undertaken. Tanzania shall base its decision on a risk assessment carried out in a scientifically sound manner taking into account socio-economic and ethical and cultural considerations.

a) The applicant shall carry out or cause to be carried out an assessment of any risks associated with GMOs or products thereof in respect of GMOs in question.
b) No decision on any applicant to import, transit, make contained use of, release or place on the market a GMO or a product thereof may be made by NBFP without the assessment of risks to human and animal health, biological diversity and the environment, including the socio-economic conditions and cultural norms.
c) The risk assessment of a GMO or a product thereof shall be carried out by the applicant or the competent authority as appropriate on a case by case basis and shall be done in accordance with risk assessment procedures as provided in the National Biosafety Guidelines for Tanzania Section 3.0 and Annex VI.
d) The NBFP may require the applicant to bear all the costs for evaluating the risk assessment report or carrying out the risk assessment as the case may be.
e) No person shall be involved in the evaluation of risk assessment in respect of a subject matter in which she/he has any direct or indirect interest of any kind, or if, for any reason, there is, or there is likely to be, a conflict of interest as a result of her/his participation in the evaluation process. A person with a conflict of interest shall declare the fact and withdraw from the evaluation process.
f) If an independent risk assessment cannot be undertaken, or if there is no possibility of verifying the independence of the risk assessment, the NBFP may reject the application.
g) The competent authority shall develop, maintain and use, as the need arises, a risk management strategy for protecting human and animal health, biological diversity and the environment, from the accidents of genetic engineering, the use of GMOs and their products. The risk management should be undertaken in accordance with risk management procedures provided in the National Biosafety Guidelines in Section 4.0 and Annex VII.

Administrative and decision making mechanisms

Institutional structure and administrative mechanisms

The draft Biosafety Regulations proposes the following four institutions for the regulation of GMOs:

- National Biosafety Focal Point (NBFP)
- Competent authorities: ministries responsible for environment; agriculture; livestock; health; wildlife; fisheries; forestry; transport and communication; industry and trade; and science and technology
- National Biosafety Committee (NBC)
- Institutional Biosafety Committees (IBCs)

The NBFP, competent authorities and other concerned agencies should address issues regarding the use of modern biotechnology particularly on biosafety issues, such as health, environmental and socio-cultural and ethical impacts. These authorities and agencies should make consultations, formulate departmental directives and regulations on the access and use of the products of modern biotechnology, coordinate activities and programmes on research and development and their applications and allocate appropriate resources for the upgrading of capacities and capabilities to effectively regulate the GM technology and its products.

The biosafety institutional structure is summarised in Figure 1. At the onset, the proposed structure recognises the mandates of competent authorities in their respective disciplines.

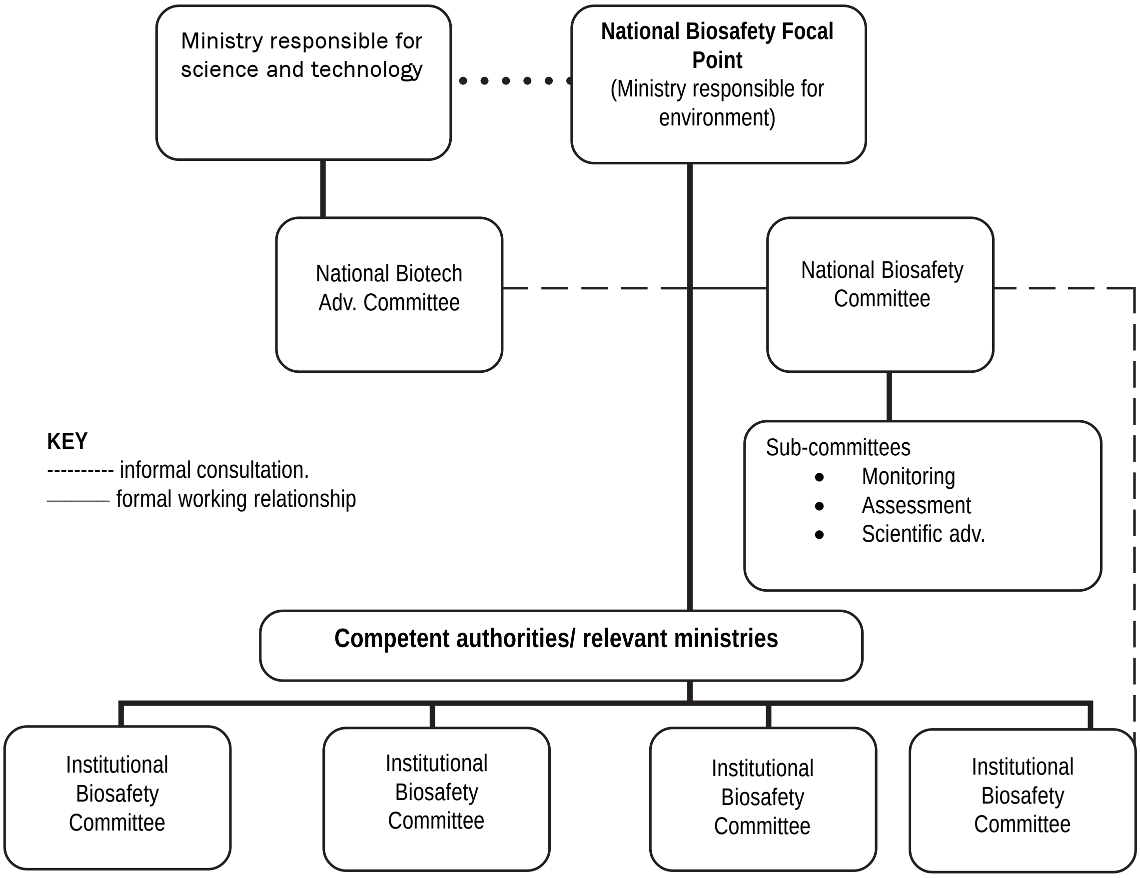

Figure 1. Biosafety institutional structure.

National Biosafety Focal Point (NBFP)

The NBFP should be the ministry responsible for environment. The roles and responsibilities among others are to:

- Review and approve biosafety applications for research, confined release, pre-commercial release or placing on the market, including to receive and forward applications to the competent authorities.
- Establish contacts and linkages with national, regional and international agencies/institutions.
- Establish a database to facilitate collection, storage, retrieval and dissemination of information relevant to biosafety.
- Decide whether to accept or reject an application based on the advice of the competent authority and NBC and to notify the applicant about the results of the review.
- Declare through the Biosafety Clearing-House that a GMO or product thereof intended as

food or feed or for processing (FFP) may be subjected to a full risk assessment.
- Maintain and make available to the public on request, a database on GMO or product thereof intended for direct use as food or feed, or for processing.
- Designate inspectors and undertake inspection and other control measures to ensure compliance with the Biosafety Regulations.
- Establish a list of GMOs and products thereof to be regulated in Tanzania. The list will be reviewed periodically.

The decision making structure of the NBFP is illustrated in Figure 2.

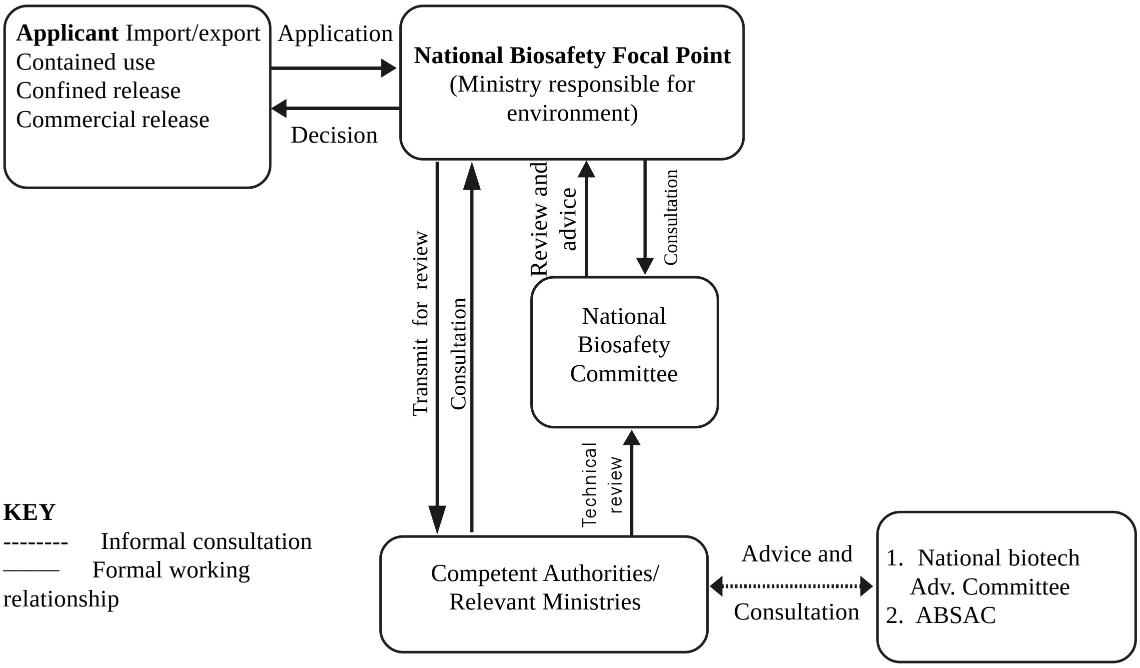

Figure 2. Decision making structure of the National Biosafety Focal Point (NBFP).

The NBFP should designate the National Biosafety Scientific Advisory Sub-Committee comprising of a multidisciplinary team of experts in the field of biotechnology and biosafety. The National Biosafety Scientific Advisory Sub-Committee should be answerable to the NBC. It shall advise the NBC on scientific biosafety concerns. Such functions should include the review and ascertaining of the suitability of both physical and biological containment, confinement and control procedures appropriate at the level of assessed risk involved in relevant research, development and application activities.

National Biosafety Committee (NBC)
The NBC should comprise representatives from governmental and non-governmental organisations and the private sector that are relevant to the issues of biotechnology and biosafety.

The NBC should have the following functions:
- Review relevant applications
- Advise on policies, legislation and other policy instruments
- Undertake study and evaluation of biotechnology research and control and minimise the concomitant risks and hazards associated with the deliberate release of GMOs in the environment and to advise the NBFP and competent authorities
- To ensure that adequate testing of GMOs developed elsewhere has been performed in the country of origin before it is introduced in a local trial programme

- To review biosafety regulations and guidelines from time to time as necessary
- To facilitate the undertaking of socio-economic impact assessment and to initiate scientific and technical review on biosafety applications.

Relevant ministries/competent authorities

The NBFP shall designate competent authorities which shall be responsible for following up, supervising and controlling the implementation of the biosafety regulations, i.e. perform the following roles and responsibilities:

- Review relevant applications or proposals for development, introduction, import, export, transit, contained use, release or placing on the market.
- Review, make or have made risk assessments of GMOs or products thereof. When the GMO or products thereof is to be imported, the cost will be borne by the exporter.
- Advise the NBFP.
- Designate inspectors and undertake inspection and other control measures to ensure compliance with the Biosafety Regulations.
- Undertake assessment of socio-economic impacts and ethical and cultural impacts.

Institutional Biosafety Committee (IBC)

Institutions that are involved in the import, export, handling, contained use, release or placing on the market of GMOs or products of GMOs should establish IBCs to institute and control safety mechanisms and approval procedures at the institutional level. These committees should have multidisciplinary teams whose roles and responsibilities shall include to:

- Review the containment and confinement levels required by the Guidelines for the proposed research
- Hold discussions on the comparative ecological, economic and social impacts of alternative approaches to attain the purpose/objectives of the proposed GMO and other services
- Report immediately to the relevant ministries/competent authorities and appropriate official in the concerned organisation, any significant GMO activities, problems with or violations of the regulations and any significant research related accidents and illness.

Genetically modified (engineered) crops

Currently, there are no GMO products or GMO crops grown in the country either for research or commercial purposes. However, it was indicated that Tropical Pesticides Research Institute (TPRI) in collaboration with ICIPE are planning to introduce B*t*-cotton in the Southern Regions of Tanzania for research purposes. Other institutions such as Mikocheni Agricultural Research Institute (MARI), Animal Diseases Research Institute (ADRI), Sokoine University of Agriculture (SUA) are also ready to undertake research on GMOs if they are required to collaborate with any other institutions at regional or international level. However, it is very important to all applicants who wish to import or export GMOs for research or commercial purposes to follow procedures as stated in the Environmental Management Act 2004 that operationalise Biosafety Guidelines, Biosafety Regulations and Biosafety Framework.

Import of GMOs

Application procedure

Any person who wishes to carry out an import, or transit, or deliberate release, or contained use of, or placing on the market, a GMO or product thereof or intended for direct use as food or feed, or for processing shall submit an application in writing to NBFP. The applicant must have a collaborating partner, and institution recognised by NBFP and the competent authorities. The application form must be completed and submitted by regular mail or courier delivery to the

NBFP.

a) No person shall import, transit, carry out the contained use of, or release of, or place on the market, a GMO or a product thereof without an advance informed agreement (AIA) or the explicit written approval of the NBFP.

b) The application shall include:
   - i) The information specified in Annex III of the National Biosafety Guidelines for Tanzania and any other information as may be prescribed by the competent authority
   - ii) Assessment report on risks that may be posed by the GMO or product thereof on human and animal health, biological diversity and the environment, including the consequences of unintentional release
   - iii) Information from previous or current release of the GMO or product thereof in the country or in any other country
   - iv) Information on previous approvals or rejections of the GMO or product thereof by any other country
   - v) If the request for approval is for research and development, the recommendations of the IBC
   - vi) A clear and sequential description of the steps to be taken in the implementation of the project, the monitoring and evaluation that will be made at the end of each step, and the method of disposing of any waste
   - vii) The place where and the purpose for which the GMO or product thereof is planned to be developed, used, kept, released or marketed, including detailed instructions for use and a proposed labelling and packaging scheme
   - viii) The applicant shall submit a declaration confirming that the information provided is correct including, where appropriate, an undertaking from the originator of such information affirming its accuracy and completeness.

c) Application should respond to all items listed in the course of action for transboundary movement of GMOs. Application(s) should be submitted four (4) months before importation.

d) If portions of the application contain trade secrets or confidential business information (CBI), each page of the application containing such information should be marked ‘Commercial-in-Confidence’ or ‘CIC Copy’ by the notifier.

Inspection and enforcement

In accordance with the Environmental Management Act 2004 and the draft Biosafety Regulations, the Inspectorate of Competent Authorities shall perform inspection and supervision. The authorised party shall pay inspection fees that will be established by the competent authorities. Inspectors have the authority to inspect sites containing GMOs like field trial sites etc. for compliance with terms and conditions of authorisation. Inspectors also have the authority to inspect contained facilities that may be used for research or storage of GMOs. Competences for the inspection supervision will be specified in permits or approvals.

The proposed system has flexibility to appoint different competent inspectorates on a case-by-case basis. Since the competent bodies already have other mandates, separation of the competences will have to be formalised for GMO regulation.

If an inspector during the performance of work or based on a notification establishes that because of unfulfilled required conditions and requirements, the environment, human and animal health or socio-economic and ethical issues are at risk, she/he shall order the following measures:

(a) Prohibit contained use, deliberate release of a GMO into the environment or placing a product on the market

(b) Order the temporary suspension of contained use, the deliberate release of GMOs into the environment or placing a product on the market

(c) Order the rectifying of established irregularities within a time limit that the inspector specifies
(d) Order remediation and other measures to rectify or reduce the consequences of adverse effect that have occurred because of GMO management.

For the inspectors to discharge their duties effectively, it is necessary to:

a) Carry out a capacity needs assessment
b) Develop and implement capacity building programmes including training, infrastructure, equipment and tools.

Monitoring

The purpose of monitoring and evaluation is to gather data concerning the GMOs in order to assess the extent to which transgenics have affected biological diversity, environment and human and animal health. When referring to the environment, the main focus is on confined field trials and commercial release of GMOs. Thus, monitoring would determine effects, which could be categorised as severe, moderate, low, negligible or no harm. In the case of plants, monitoring should be undertaken to determine the level of horizontal gene transfer and to develop a monitoring and evaluation prospectus. Monitoring of the GMOs should be undertaken at different levels. The objective of monitoring plan is to:

a) Confirm that any assumption regarding the occurrence and impact of potential adverse effects of the GMO or its use in the environmental risk assessment are correct
b) Identify the occurrence of adverse effects of the GMO or its use on human and animal health or the environment which were not anticipated in the environmental risk assessment.

Types of monitoring

For the purpose of this NBF, monitoring is used to gather additional scientific data to assist the assessment of risk and decision-making. Monitoring is carried out for specific reasons and at specific times in the development of GMOs. The various types of monitoring that may be used by monitoring agencies are:

1. Case-specific monitoring
2. General surveillance monitoring (see earlier comment)
3. Voluntary monitoring
4. Monitoring by applicants
5. Experimentation
6. Tracking
7. Surveillance.

The competent authorities should implement monitoring of post-emergence following post-emergency time periods established. Post-release/harvesting monitoring is necessary where the risk assessment determines that the continuous presence of the released GMO presents risk of harm. Post-release monitoring will need to concentrate on confirming the removal of the released GMOs. Where appropriate, monitoring should concentrate on detecting and controlling any volunteer GMOs arising form the release. In some cases there may be uncertainty regarding the risk of harm from continued presence of an organism, especially over the long term. Post-release monitoring should then be designed to provide data to enable the uncertainty to be resolved. In case of plants, factors to be taken into account include:

i) Seasonal effects, such as flowering and likely germination times
ii) Post-trial treatment of the release site
iii) Longevity of seed or tubers in soil.

Reporting requirements

The authorised party should comply with the reporting format set in the terms and conditions of authorisation. However, for every GMO there is a need to determine when to undertake monitoring and when to evaluate the work. The same process would explicitly identify who would undertake the monitoring and evaluation, and who would receive the reports.

Public awareness, education and participation

Tanzania has experienced lively public debates on a wide range of issues related to science and technology but not on GMOs. However, the debates on GMOs coincided with growing public awareness on societal issues such as environment and sustainable development. This reflects the fact that involvement of the general public is crucial in the formulation and implementation of national policies.

The level of public awareness on biotechnology and biosafety in the country is extremely low, even amongst the scientific community. Possible explanations for low awareness include:

a) Recent nature of GMO technology
b) Limited knowledge on GMO technology at all levels
c) Limited access to relevant publications, the internet and other information sources
d) Low level of awareness by the general public on benefits and risks associated with GMOs.

Why public awareness, education and participation?

As biotechnology develops rapidly, more and more GMOs and their products will be released into the environment and may thus pose potential risks to the environment and human and animal health. A proper mechanism should be established to create awareness and enable the public to participate in implementation of the biosafety measures. Awareness and participation are important to:

a) Build consensus on issues that affect people directly or indirectly
b) Build a sense of ownership and collective responsibility
c) Promote sustainable development
d) Promote smooth implementation of the decisions
e) Build transparency and accountability
f) Provide balanced information in terms of pros and cons
g) Harmonise institutions that provide awareness activities.

The competent authorities and other agencies, in making biosafety decisions, should promote and facilitate public awareness, education, and participation concerning the research, development, handling, transboundary movement, transport, use, transfer, release and management of GMOs. They should incorporate into their respective administrative issuances and processes best practices and mechanisms on public awareness and participation.

Right of access to information

The right of the public and the relevant stakeholders to information about applications for the research, development, handling, transboundary movement, transport, use, transfer, release and management of GMOs shall be respected. Concerned government departments and agencies should, subject to reasonable limitations, protect confidential information as provided in the proposed regulations, and should disclose all information on such applications in a prompt and timely manner.

Confidential business information (CBI): All ministries agencies and institutions handling GMO applications shall ensure that they have procedures to protect confidential business information.

In no case shall the following information be considered confidential:

- The name and address of the applicant.
- A general description of the GMOs.

- A summary of the scientific risk assessment conducted by the applicant.
- Where applicable, any methods and plans for emergency response.

For information claimed as CBI, the applicant must provide written justification.

Information on biosafety decisions: The public and relevant stakeholders should have access to all biosafety decisions approving or denying applications for the research, development, handling, transboundary movement, transport, use, transfer, release and management of GMOs. Such decisions need to summarise the application; the results of the scientific risk assessment and the evaluation of socio-economic risks; the public participation process followed; and the basis for approval or denial of the application.

Enabling environment

An enabling environment for public awareness, education and participation is a requirement to ensure smooth implementation of the National Biosafety Framework. There is a need for:

a) Capacity building
b) Establishment and implementation of appropriate programmes and policy guidelines on participatory approaches
c) Networking among stakeholders
d) Regional/sub-regional and global cooperation
e) Effective participation at all levels, public, government and private.

Challenges and way forward

Arguably, to conduct work of a highly technical nature such as modern biotechnology in a manner that is safe and which contributes to sustainable economic development, caution has to be exercised not to perpetuate economic dependency without the necessary local capacity to deal with it.

In that respect, perhaps the key question is, are we ready? Certainly, this review has confirmed the findings from previous studies that, like many developing countries, Tanzania is still under equipped in terms of technical capacity to conduct biotechnology and biosafety R&D while safeguarding biodiversity, human health and the environment taking into account socio-economic, cultural and ethical concerns. Currently, the available resources and capacity are severely limited and donor-dependent.

The issue of market for GMO is very crucial in connection to traditional export. Currently, most of the exported crops are non-genetically modified crops and marketed in the EU and in other countries. Potential market of GMOs is a key prerequisite for Tanzania before commercialisation. Certainly, modern biotechnology brings new challenges for policy and regulatory frameworks in the future. Close cooperation on biotechnology, biosafety issues and trade at national, regional and international levels is very crucial and should be encouraged.

The potential benefits and challenges of agricultural animal biotechnology to pastoralists

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Abstract

The livelihoods of pastoralists revolve around their indigenous livestock. Combining high production with disease resistance using genetic engineering is a biotechnological intervention hailed by some as a promising avenue to mitigate food insecurity and poverty. Considerable human and financial resources have already been devoted to exploring this option. However, the challenges are enormous. It is unlikely that such livestock would survive in the harsh ecosystems where pastoralists live and that it would meet their diverse and breed specific social and economic requirements. Furthermore, the questions of intellectual property rights over genetically engineered livestock need to be resolved otherwise there is the danger of the genetic traits of indigenous livestock being pirated by industrial breeders. The loss of biodiversity and of pastoralist livelihoods might also be possible consequences. Instead of genetically engineered livestock, pastoralists need recognition of their livestock breeds and management skills, the right to their own breeding decisions and improved services to enhance their livelihood and support their breeds.

Key words: biotechnology, livestock, pastoralists, livelihoods, rights, food

Introduction

Occupying arid to dry humid ecosystems that inadequately support rainfed crop production, pastoralists derive their livelihood from keeping uniquely adapted livestock that they manage with their own indigenous knowledge. Most pastoralists are nomadic, with their patterns of movement depending on the season and other factors such as disease outbreaks, the security situation, pasture and water availability, drought and markets (Sanford 1983). Pastoralists' livelihoods are intricately linked to specific species and breeds that provide them not only with food (meat, milk, blood and milk products including butter, cheese etc.) and raw materials (including hides, fur and wool) but also play an in important role in certain rituals, recreational activities and in preserving the dignity of the owners. While pastoralists mainly keep their animals for subsistence, they often sell some of their livestock and livestock products at nearby markets. Thus they also make significant contributions to the gross domestic product (GDP) of their respective countries. At the same time, pastoralists are vulnerable to animal epidemics, unreliable rainfall and frequent droughts leading to low animal and crop productivity, stock theft, inadequate service provision, poor markets for livestock and livestock products, lack of opportunity for adding value to livestock and specialty livestock products, and absence of supportive policies for them. As a result many pastoralists are poor.
In developing countries more than 70% of total poverty is found in the rural areas and although these are the locus of food production, this is also where hunger is concentrated (Dixon et al. 2001).

While the global number of pastoralists is up for debate, there are an estimated 140 million of them in Africa (Dixon et al. 2001) alone where they live in the Sahara, the Sahel, the Horn of

Africa, East Africa and parts of Central and Southern Africa. Since they comprise a significant proportion of Africa's poor livestock keepers, research and development interventions that claim to have the goal of poverty alleviation should take the needs and aspirations of this diverse but distinct group of livestock keepers into account. This paper will examine the potential and challenges for advanced animal biotechnological research to make a positive impact on the livelihoods of pastoralists. It will focus especially on the potential for genetic improvement of pastoralist livestock, keeping in mind that the breeding goals of pastoralists are multifaceted (Köhler-Rollefson 2000). These goals do not only entail productivity 9large body size/weight, much milk, meat, blood etc.) but also encompass other aspects, such as the taste of meat, blood, milk and milk products, agreeable temperament, preferred fur colour, religious and cultural requirements, disease and parasite resistance, good mothering instincts, ability to walk long distances and ability to survive natural calamities including long droughts, extreme cold/heat and flooding.

The potential benefits of agricultural animal biotechnology to pastoralists

Pastoralists would appreciate improved economic returns from their livestock through biotechnology that increased the size and growth rates of their livestock and upgraded the quality of their livestock products quality including food, hides, fur and wool (FAO 2000a).

In the animal health sector, it would be appreciated if biotechnologically developed diagnostics and therapy that could make it possible to rapidly and accurately identify disease-causing agents, besides providing sustainable curative services and carrying out disease control programmes. This would boost the productivity of pastoralist herds. The pastoralists would benefit from vaccines against livestock diseases and could even control parasitic infections (FAO 2000a; Dixon et al. 2001; NARO 2002).

Reproductive biotechnologies (transgenics, embryo transfer and artificial insemination) are said to hold the promise of increasing reproductive efficiency (FAO 2000a; NARO 2002) which would generate livestock with the traits that pastoralists desire.

The challenges of animal biotechnology to pastoralists

Biological challenges

There is a trade-off between production traits on one hand and disease and drought resistance on the other. Animals that are highly productive are more sensitive to stresses. So it is unlikely that agricultural biotechnology could produce animals that survive the often harsh environments of pastoralists and that meet their many breed specific economic and socio-cultural requirements.

Financial challenges

Keeping in mind the often low economic returns of pastoralists and the high cost of agricultural animal biotechnologies, such research is unlikely to be cost-effective. Expensive equipment, facilities and experts are required to carry out biotechnological processes. It can be anticipated that the costs of these technologies would outweigh the intended benefits.

Biotechnology seems to be driven by industries and has been targeted at farmers in developed countries (FAO 2000b) and a small number of wealthy farmers in the developing world. It would be an enormous task for the technology to meet all the diverse breeding goals of indigenous pastoralists.

Challenges of equity and intellectual property rights

Over many centuries of selection by the forces of nature, pastoralists have developed breeds that are optimally adapted to their specific environments. In particular, pastoralists already have worm-resistant breeds, such as the Red Maasai sheep, so research on identifying the genetic basis of this trait benefits exclusively the farmers in developed countries and cannot be considered to be in the interest of poverty-alleviation. Furthermore, it is a general procedure that for any genomic discovery that intellectual property protection is automatically sought to secure future financial returns. It is well known that a small number of companies from the developed countries dominate the biotechnology sector and that the acquisition of patents is the driving factor behind the genomics research by these companies. This is leading to increasing control of the food sector by a small number of companies.

However, the rights of pastoralists over the genetic resources that they have nurtured for generations using their indigenous knowledge are currently not protected. In the interest of fairness and equity, these should also be secured and rendered inalienable rights.

Precedents for biopiracy are known from the plant sector. A case in point is an American company that was granted a patent on the medicinal value of the neem plant, *Azadirachta indica* (native to India), used by traditional indigenous communities for many centuries (FAO 2001). Similarly, medicinal products derived from Brazil's guarana plant, *Paulinia cupania*, have been patented in the United States (Science and Development Network 2005). It can only be expected that similar incidents will happen with indigenous livestock.

Technical challenges

In agricultural animal biotechnology, production of transgenic agricultural mammals is difficult, inefficient and expensive because of their low productive rate and internal fertilisation and development (FAO 2000a; FAO-WHO 2004; FAO 2005).

Food safety challenges

Food related hazards associated with genetically modified animals are diverse, e.g. the morphological and metabolic/physiological abnormalities that may occur (FAO-WHO 2004).
The gene flow from genetically modified animals to non-genetically modified individuals, and resulting in the production of fertile offspring may cause genetic pollution (FAO 2002), as animals with queer characteristics (morphological, physiological, behavioural, diseases etc.), and hence non-productive to the pastoralists, may be inadvertently introduced into the environment.

Trade and marketing challenges

The production of livestock through agricultural animal biotechnology might hinder trade in livestock by pastoralists, as some countries do not permit genetically modified animals and/or their products into their territory (FAO 2002). Similarly, the free movement of pastoralists across regional and international borders in search of pasture and water would be jeopardised by these restrictions.

Genetically modified livestock would also not be compatible with the standards set in organic agricultural animal production, thus destroying the possibility of accessing lucrative markets and the associated income opportunity for pastoralists (FAO 2002).

Biodiversity challenges

The introduction of livestock produced through biotechnology into pastoralists' areas might cause biodiversity erosion as only very few breeds with similar genomes would be used for production.

Discussion, recommendations and conclusion

The world should recognise the unique breeds owned by pastoralists and legally confer upon the livestock keepers inalienable rights over their breeds and the particular genes and/or DNA sequences that the animals contain. Otherwise there is danger that they might lose their treasured well-adapted breeds to industrial livestock breeders. Furthermore, pastoralist community breeding systems that act as custodians of desirable animal genetic resources need to be supported and sustained through appropriate mechanisms by their national governments and the international community.

A legal framework for sharing benefits from animal biotechnology should be formulated in cases where the genetic material from indigenous livestock is used commercially.

Comprehensive research is necessary to determine how best to improve the production potential of the pastoralist livestock systems and to design policies that improve pastoralist livelihoods and conserve their breeds.

Pastoralists need improved and sustainable social and other service delivery systems from their national governments, private agencies and the international donor community that are adjusted to their mobile livelihoods. These should include information, training, infrastructure supportive to their livelihoods and indigenous livestock production. It is not a secret that service delivery in most developing countries targets only sedentary communities.

Some pastoralist areas regularly suffer from lack of protection/law enforcement which hinders livestock production. This is an issue that needs to be more urgently addressed than biotechnology for food security.

Government land policies should accommodate the land rights of the pastoralists and indeed protect their land from undue encroachment by other exploitative land users, including ‘investors’ (Loquang 2003). This would help them maintain the basis for their livelihood. Myths perpetrated by some ‘experts’ that pastoralism is not economically viable should be dispelled since it is explicit that pastoralism is the only time proven system for conserving the dry environment in which they live because of their careful movement to diverse pastures while preserving others for later use (Oxfam GB 2004).

The pastoralists need fair markets for their livestock and livestock products. Unjustly low market prices greatly contribute to poverty and food insecurity among pastoralists. Furthermore, pastoralists should be encouraged to explore new avenues for adding value to their products in efforts to alleviate poverty including handicrafts (from livestock horns, hides, wool, fur and bones), livestock food products and ecotourism (Köhler-Rollefson 2000; Köhler-Rollefson 2004a).

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Partnerships do improve smallholder livestock systems: Experience from Limpopo and North West provinces in South Africa

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Abstract

A profit thinking framework was used to select a multidisciplinary farmer support team (FST) to implement a focused participatory approach among livestock farmers in the Limpopo and North Western provinces of South Africa. Farmers were subsequently organised into teams, which meet once in 30 days to identify needs, set objectives, take actions with support from the FST and report every 90 days to measure progress. These meetings are also used to identify new opportunities for future actions.

The results show that farmers recognise that profit maximisation should be the main focus of a beef enterprise with all other activities oriented towards this goal. Farmers were more eager to take actions that improved profit. Accessing new markets, learning pricing techniques and addressing issues such as transport costs, improved prices for beef. The FSTs obtained an in-depth understanding of technical challenges in farmers' operations and assisted farmers to implement appropriate solutions. The results showed that partnerships involving a dynamic mix of scientific knowledge and socio-economic conditions assist researchers and extension workers to considerably improve the performance of emerging beef farmers through participatory methods.

Key words: partnerships, livestock systems, smallholders, livelihoods improvement

Introduction

Conventional farmer development systems assume a top-down approach where extension officers provide logistical support to disseminate technologies to farmers (Kaimowitz 1991). This approach has proved to be both unsustainable and often irrelevant to the needs of farmers (Rivera 1993). Focus is now being placed on strategies to strengthen linkages between research and extension in developing countries (Röling 1990). However, there is growing evidence that alternative methods also have certain disadvantages, especially for small-scale farmers (Rivera 1991). The sustainable alternative would be to adopt a participatory approach that recognises the complex conditions experienced by farmers and is able to demonstrate the benefits of changed behaviour (Gibson 1977; Rogers 1983; Whale 1984). This also necessitates a paradigm shift from a technically-based support system to a system that responds to key issues (Baker and Verma 1993).

The challenge in South Africa is that emerging beef producers perform below potential both in terms of throughput and profit while interventions in current beef systems focus on training in production techniques with little emphasis on business development and the capacity to continuously improve and innovate. Using an outcomes approach to emerging beef business development, a five-year multi-disciplinary Beef Profit Partnerships (BPP) programme was implemented in 2002 to develop a farmer support method that could enable the South African emerging beef producers to achieve sustained improvement of profit. This paper presents the results of BPP and highlights the impact of a participatory research and development (R&D) approach on the performance of an emerging beef business.

Methods

Eighteen livestock production and marketing specialists, (five from Limpopo, nine from North West and four from the Agricultural Research Council (ARC)) participated in a five-day capacity building workshop on participatory R&D processes and tools in July 2001 and March 2002. Two farmer support teams (FSTs), one in each province were formed to facilitate the formation of a network of farmer teams. Each team consisted of not more than 20 individuals. The focus of each team member was to achieve improved profit. A profit thinking framework was used to enhance the focus of the main drivers of profit (Figure 1).

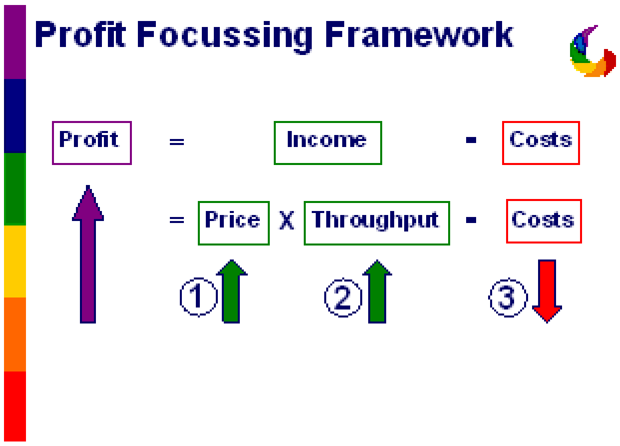

Figure 1. Profit thinking framework for sustainable beef business.

Farmer teams conducted regular focus sessions to do situation analysis, impact analysis and action design, action implementation, performance assessment and creation and synthesis of new opportunities for impact on profit (Figure 2). This spiral of steps was conducted over 30 to 90 days. Responsibilities were shared both by farmers and FST members in partnership. Individual and team action taken and results achieved were reported and supported during the focus session. The reporting involved the computation of measurements such as market prices and herd performance.

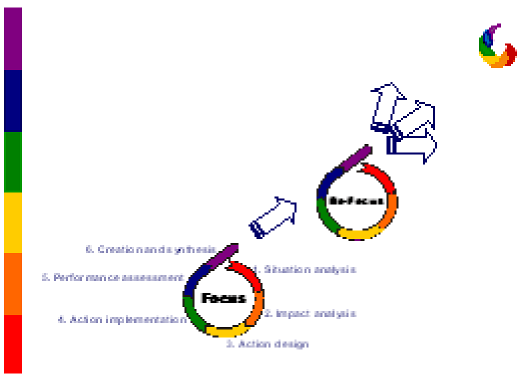

Figure 2. The continuous improvement and innovation process.

Results

Teams

The project leaders agreed beforehand with farmer support teams (consisting of researcher and extension officers) on the number of farmer teams (groups of farmers in one location focusing on beef) that had to be established and participate in the project. The first teams were formed in April 2002. By March 2003 there were 14 farmer teams (Figure 3) consisting of a total of 290 individuals (Figure 4). The expansion of the teams was also determined by extension officers' interest where they joined existing FSTs and assisted by including their current customers in the programme. By March 2003, ten extension officers had joined the FSTs and performed functions as other members.

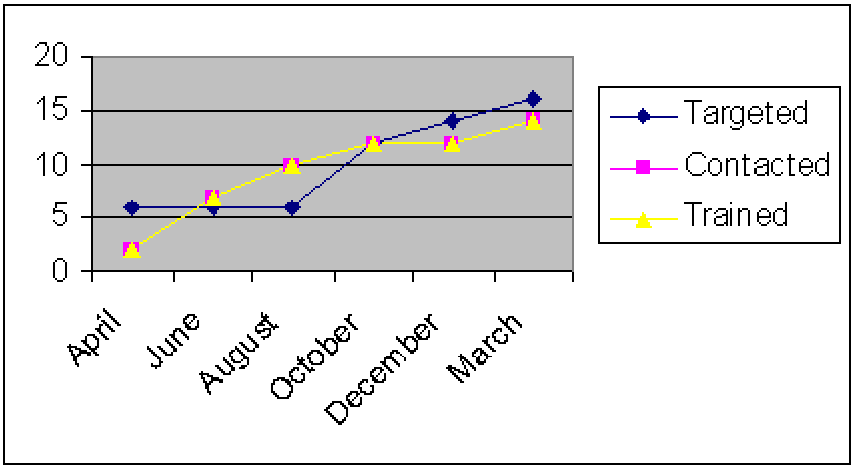

Figure 3. Farmer teams participating in the programme.

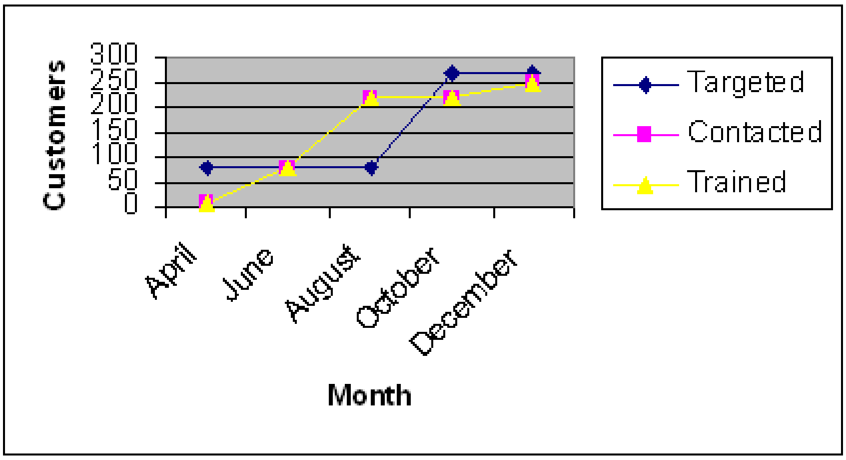

Figure 4. The number of customers retained in the programme.

The action design process

First focus sessions aimed at enabling farmers to determine the focus that would have the greatest impact on their business and identifying the actions that would have the highest impact on profit.

In contrast to the notion that traditional farmers keep cattle for non-economic reasons, the common output at the first sessions was that farmers keep cattle to make profit.

It was found that farmers only use three market outlets with diverse price structures (Figure 5). These outlets did not use appropriate quality assurance equipment such as weighing scales for live animals, and less formal outlets were less economic than formal auctions. Nevertheless, farmers did not realise expected incomes because of a lack of information skills and tools on pricing.

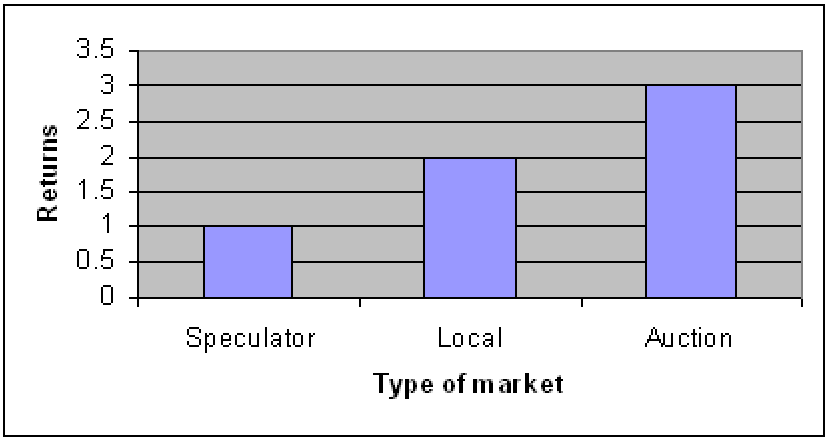

Figure 5. Types of market outlets commonly used by programme customers.

Farmer innovation

Participating farmers took several initiatives to address challenges as part of the action designs agreed upon at focus sessions. In one farmer team at Khomela village, farmers identified a loading ramp as a high impact opportunity for improving access to the market. They built the loading ramp using local materials such as rock and wood, and were therefore able sell their cattle directly to a local feedlot from the village.

In another farmer team at Mmakgatle village, farmers identified the erection of an auction kraal as a high impact opportunity to improve price and reduce marketing costs. After building the kraal, the farmers were able to hold monthly auction sales that included farmers from neighbouring villages.

Another innovation came from a farmer team on Kromspuit farm which had experienced an extremely low calving rate during 2002 (Figure 6). The team identified testing for reproductive diseases as a high impact opportunity to improve throughput. This has led to the introduction of rapid test kits for Brucellosis, which are currently used widely in the area.

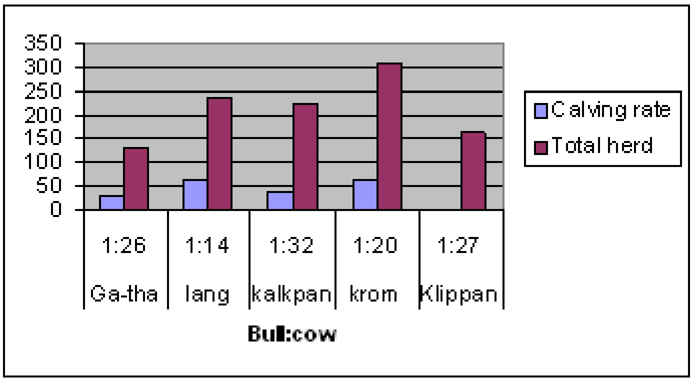

Figure 6. Herd compositions among customers.

In Kuruman, farmers identified communal transport as a high impact opportunity to reduce costs, which, upon implementation, significantly reduced marketing costs as indicated in Figure 7.

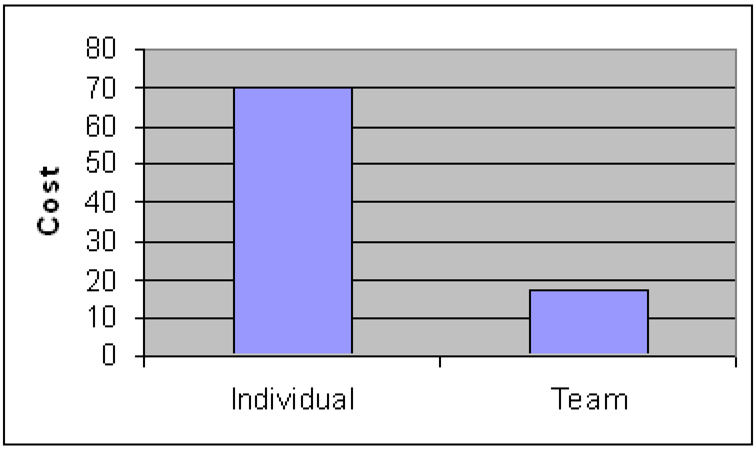

Figure 7. The effect of team marketing on transport costs.

Conclusions

The use of partnerships is a real alternative to conventional top-down approaches because it facilitates farmer centred programmes which enable both researchers and extension workers to participate in a learning process with farmers to identify and address real needs. This has facilitated the use of common conceptual frameworks for profit and to make informed decisions and take actions on different key drivers such as throughput, marketing, pricing and cost. The capacity of farmers to market, develop and monitor key performance indicators (KPIs) such as change in profit, change in price, change in calving rate is gradually improving with a noticeable impact on profits. It is therefore hoped that partners will agree on using a profit-thinking framework to make informed decisions or take any action towards change in the business.

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Issues and implications for livestock development policies in eastern and southern Africa

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Abstract
Empirical studies and reviews from eastern (Kenya) and southern (South Africa) Africa have been used to construct a policy framework to guide livestock development in these two regions. Five overarching, integrated elements have been identified. These include food production and security, capacity strengthening for livestock research, livestock and the environment, health and genetics and marketing of livestock and livestock products. The framework that emerges is complex due to the dramatically increasing demand for livestock products and, as a result, the far-reaching changes in the structure of smallholder livestock production. This framework emphasises that many of the policy challenges remain pertinent and important. Significant progress has been made to address some of these challenges, but the fact remains that these macro-policy concerns need to be addressed. This translates into complex, multi-disciplinary and multi-sectoral policy implications for governments, and increasingly, for the private sector.

Key words: livestock, smallholder development, policy framework

Introduction
Sub-Saharan Africa has often been regarded in the development field as a homogenous entity with common problems that require similar strategies. Most countries in sub-Saharan Africa became independent in the early 1960s, but the process of developing agricultural strategies started much earlier. Agriculture plays a significant role in overall development strategies on a continent where, on average, agriculture accounts for 70% of employment, 40% of exports and 33% of gross domestic product (GDP) (Delgado 1997). Evidence from elsewhere in the world, and more particularly from elsewhere in Africa, overwhelmingly demonstrates that smallholder agriculture has been the principal economic driver in rural areas and that smallholder agricultural units have been far more productive over time than large-scale, commercial operations, based on output per unit of labour (Delgado 1997).

Livestock production systems play an important role in the agricultural economy of sub-Saharan Africa. Agriculture contributes between 4% and 5% to the GDP in South Africa, while it contributes 27% to the GDP in Kenya (Kajume and Muthee 1998; Stroebel 2001). Livestock and related products are the major contributors to these figures and there is considerable potential for improving these systems and further enhancing the contribution of livestock to food and livelihood security.

Materials and methods

The study areas
The Nzhelele Area is located in Ward 27 of the Makhado Municipality of the Vhembe District in the eastern part of the Limpopo Province, South Africa. This area was part of the former Venda homeland. It is located at 23°S latitude and 30°E longitude at an altitude of 903 m. The area is

close to the borders of Zimbabwe and Botswana. The population of the Makhado Municipality is estimated at 500,000 people, of whom approximately 11,300 reside in the Nzhelele Area (StatsSA 2003). The education level is very low, with more than 26% of the population having less than a primary education level (Standard Five/Grade Seven). Of the total labour force, 41% of the population is involved in formal agricultural activities. Average temperatures vary between 15°C and 26°C. The mean annual precipitation is 780 mm, of which 80% occurs during the summer months (October–March). Livestock and crop farming are the predominant forms of agriculture, practised by approximately 50% of the population in the area (Acheampong-Boateng et al. 2003). Smallholder farms are located throughout the Nzhelele Area, characterised by low levels of productivity and holdings of approximately 1.5 ha per farmer, although this figure varies greatly. Production is primarily for subsistence with little marketable surplus, a situation that farmers and government would like to change.

Baringo is one of the 14 districts in the Rift Valley Province of Kenya. It borders Turkana and Samburu districts to the north, Laikipia to the east, Nakuru and Kericho to the south and Uasin Gishu, Elgeyo Marakwet and Pokot to the west. The district is located between longitudes 35°30' and 36°30'E and between latitudes 0°10'S and 1°40'N. The Equator passes through the district at the southern tip at Mogotio town. The district covers an area of 10,949 km^2 (Kenyaweb 2004). It is estimated that Baringo District has a population of 242,000 people, with a high annual average growth rate of 3% (CBS and ILRI 2003). The range of people falling below the Kenyan poverty line of US$ 0.53 per day is between 29% and 73%, for a district mean of 46%. This variation is based on the presence of an irrigation scheme, and the irregular rainfall, negatively influencing the livelihood of a large part of the population in the area. The district, like the country, has a very youthful population, with 50% falling in the age category 0–14 years. There are approximately 72,000 households, with an average of 5 people per household. Baringo District has an arid to semi-arid climate, with variations depending on the topography. Rainfall varies between 600 mm to 1500 mm, with 50% reliability. Livestock production activities are found throughout the district, but predominantly in the upper and lower midlands (Kenyaweb 2004).

Data collection and sampling

A non-probability sampling method was used to select a sample of 189 homesteads for the survey in South Africa (Byerlee and Collinson 1984). The selection of the sample was purposive, as it was assumed that most of the homesteads in the selected villages were typical, based on findings of previous studies in the area. Methods of data collection included completion of a structured questionnaire, unstructured interviews and observation. In the case of the Nzhelele Area, key informant interviews, focus group discussions and homestead surveys were conducted. In Baringo District, key informant interviews and focus group discussions were held. Due to the general nature of the data collection in the Baringo District, key informant interviews were the only source of primary data; all the other data were collected from secondary sources. Interviews were organised based on the knowledge of the respondent of livestock systems and policy issues in Kenya. In addition, an experienced extension officer was recruited to provide detailed information on the Baringo District.

Results and discussion

For a detailed discussion of the history of policy development in the two countries, refer to Stroebel (2004).

Similarities and differences between eastern and southern Africa

The assessment of livestock production systems in eastern and southern Africa (with specific reference to Kenya and South Africa) has indicated a number of similarities and differences between the two sub-regions. Initially, some description of these issues are pertinent as it permits a sharper focus on the nature of the sub-regions, the roles and contribution of livestock, the types of production systems, priorities for research and the strategies required to address the opportunities presented for improvement of smallholder livestock production systems. The major differences between the two sub-regions include:

- Incidence and levels of poverty (percentage of the population living below US$ 1 per day) are much greater in Kenya than in South Africa (50% and 24% respectively), which makes the challenge of poverty alleviation and food security more critical in Kenya (IFAD 2001).
- The main agro-ecological zones in South Africa vary between arid and subhumid, with the predominant area being subhumid, while those in Kenya are predominantly arid with semi-arid and subhumid areas (Blench et al. 2003). In both cases, the majority of the population live in sub-humid areas.
- Increasing human and animal population densities and greater pressures on available land in Kenya, make integrated natural resource management more complex than in South Africa. For instance, the population density in South Africa is approximately 36 persons per km^2, as opposed to approximately 54 persons per km^2 in Kenya (Bhushan 2002; StatsSA 2003).
- A larger area in South Africa (85%) is mainly suited for livestock production than in Kenya (25%) (Bhushan 2002; DoA 2003).
- Smallholder intensive dairy production is more advanced in Kenya (Waweru 1998).
- Landless urban and peri-urban production is more advanced in Kenya than in South Africa largely because there are more non-agricultural employment opportunities in South Africa.
- Systems integrating tree crops and ruminants are much more common in Kenya than in South Africa (Place et al. 2003).
- The size and diversity of animal populations are much greater in Kenya. Furthermore, the number of indigenous breeds within species is larger in Kenya than in South Africa (Rege 1998).
- Animal feed deficits are more critical in South Africa as a result of lower rainfall and temperature limitations (Kajume and Muthee 1998; DoA 2003).
- Feed resource availability varies as a major constraint to production in Kenya, while in South Africa it is consistently a main constraint (Kajume and Muthee 1998).
- The integration of wildlife and livestock is far more advanced in Kenya than in South Africa (Boyd et al. 1999).
- The marketing systems for smallholder farmers in Kenya and in South Africa are not conducive to trade, although it is better developed in Kenya than in South Africa (CTA 1998; Bailey et al. 1999).

The major similarities provide important linkages between the two sub-regions. These include:

- Both Kenya and South Africa are regarded as leaders in their respective sub-regions in terms of livestock production, smallholder development and regional agricultural research capacity.
- The lack of integration of farming system approaches and technology development and transfer in research is common to the two regions.
- Despite the interest in urban and peri-urban agriculture, this sector of the livestock industries, except for poultry, is relatively undeveloped in both countries.
- The integration of animals with annual cropping systems is common to both regions.
- There is limited use of improved forages in both regions.
- Both regions have inadequate socio-economic and policy research and training focusing on livestock.
- There is a need to strengthen the research capacity in the national agricultural research system (NARS) in both Kenya and South Africa.

Towards identifying elements for a livestock policy framework

Based on the previous analysis, the following elements and implications have been identified as core elements of an integrated policy framework for livestock development in sub-Saharan Africa, more specifically in southern and eastern Africa. Elements of this integrated policy framework are spatially represented in Figure 1.

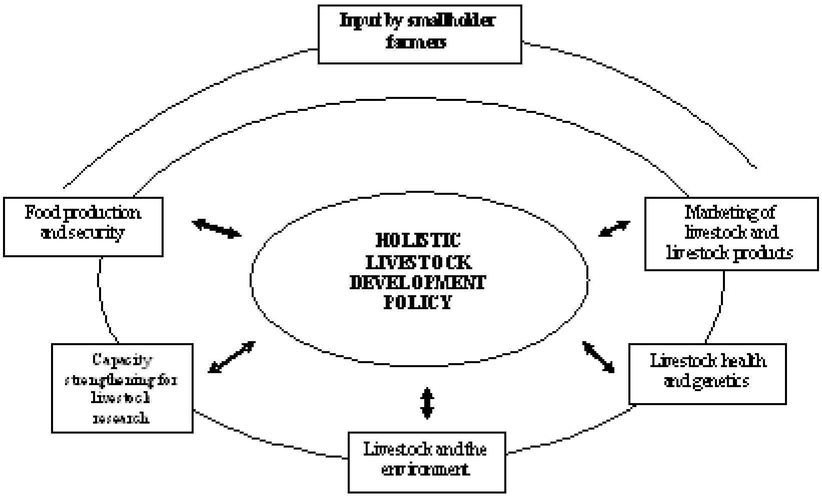

Figure 1. Spatial integration of the main policy issues affecting livestock production in sub-Saharan Africa Source: Adapted from CTA (1998); ILRI (2000).

Conclusion

The elements identified summarise the priority areas for policy research required to compile a holistic, development-oriented framework for livestock development in eastern and southern Africa. It is based on findings from the larger study of the socio-economic complexities of smallholder resource-poor ruminant livestock production systems (Stroebel, 2004) and has been integrated into existing issues and challenges identified by other researchers in previous research analysis as referred to elsewhere. The framework that emerges from these findings is clearly one of urgency and at the same time of complexity. The urgency stems from the dramatically increasing demand for livestock products and, as a result, the far-reaching changes in the structure of smallholder livestock production. The complexity stems from the use of livestock by smallholder agriculture for multiple needs, producing in the process multiple environmental benefits and costs. This framework emphasises that many of the policy challenges remain pertinent and important. Significant progress has been made to address some of these challenges, but the fact remains that the macro-policy concerns that have been identified need to be addressed. This translates into complex, multi-disciplinary and multi-sectoral policy implications for governments and, increasingly, for the private sector.

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Demand-led research, biotechnology and the poor: Issues from the livestock sector

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Abstract
Demand, is the often quoted link between biotechnology development and poverty alleviation. Nonetheless, there is often little evidence as to the exact influence of demand on the research processes. Therefore, the following paper explores the perceptions vs. the reality of demand-led processes using examples from the livestock sector. First, an aspect of the literature, i.e. community-based delivery systems was evaluated using the core issues raised in the wider literature on demand. Second, the perspectives of 190 stakeholders were catalogued and disaggregated. The example from the literature demonstrated that independent views were largely in the minority with the discourse dominated by actors from donor-funded projects and programmes. The exploration of researcher perspectives demonstrated that while the researchers themselves, generally did not account for farmer demands, neither did they themselves appear to be driving research agendas. Thus, on a wider paradigmatic level, the risk is that notions of demand will simply mask the traditional drivers of biotechnology research with little overall impact on the poor.

Introduction
The debate on biotechnology and poverty is frequently framed using arguments of demand, more specifically, the rising demand for agricultural products in the South (de Janvey et al. 1999; Graff et al. 2005; Rolan-Holst 2004):

> Because of population growth and rising incomes, the demand in the developing countries is predicted to increase by 59 per cent for cereals, 60 percent for roots and tubers, and 120 per cent for meat (Perstrup-Anderson cited in Graff et al. 2005).

As such, biotechnologies are increasingly viewed as key to meeting this demand, as Rolan-Holst et al. (2004) notes:

> …biotechnology…can greatly improve the living standards in the developing world. As the touchstone for a new generation of rural development, biotech can increase food output, nutritional quality, and rural employment more quickly than populations will grow, alleviating direct nutritional deficiency and increasing incomes for the world's poor…

Thus, it is argued that biotechnologies will enable the poor to participate in this 'revolution' and help to meet this increased demand for food products by consumers in the South. Consequently, by default, many of these technologies are now portrayed as being developed by research processes which are demand-led. Traditionally, within development, research has been conceived as being driven by the suppliers of research with little consideration for the needs of beneficiaries (Chambers 1983; Lloyd-Jones 2001; Mkandawire 2001). Much of the literature goes even further by pointing the problem squarely at Northern researchers and their institutes (Engelhard 2001; Bastista et al. 2001). Indeed, it is believed that research has failed to bring about sustainable development largely due to 'the academic orientation of local research and the prevalence of Northern paradigms rather than being orientated towards concrete issues and problems confronting the South' (Engelhard 2001).

Conversely, demand-led research is believed to generate knowledge which is able to reverse these long-standing development polarities (Nair and Menon 2002). As the authors' state:

> Demand-led research can generate knowledge that will empower individuals and enable them to acquire the capabilities necessary to make informed choices on their own, without Northern intellectual inputs.

Hence, within the literature, demand-led research is frequently justified as a means of addressing the patronising and iniquitous relationship between Northern and Southern research partnerships (Bautista 2001; Velho et al. 2001; Engelhard 2001; Nair and Menon 2002).

Therefore, utilising the wider literature on demand as a backdrop, the following questions frame the forthcoming analysis:
1. Do Northern researchers hold a disproportionate sway over the direction of research?
2. Are Southern viewpoints undermined by a Northern hegemony?
3. Is there evidence that current practice has been informed by end-user or receptor demand?

To explore these questions further, the study first examined an example from the livestock literature on community animal healthcare programmes as such workers will likely be key entry points in the delivery of biotechnologies to the poor. Second, the drivers of demand, at the researcher level, are explicated via interviews with 190 animal health stakeholders. Notions of demand are explored in addition to perceptions regarding research priorities. Thus, the paper hopes to answer who is driving animal health research: the decision-makers, the poor or the researchers themselves? All of these issues are relevant to the current debate on poverty and biotechnologies.

Community animal healthcare programmes: Whose demand?

To explore the literature on community animal health workers (CAHW) programmes from a demand perspective, a total of 106 articles, both formal and the grey literature, were reviewed. For each document, the origin of the primary author was catalogued in addition to the overall orientation of the work, i.e. either broadly positive (in support of CAHWs) or negative (critical of the approach). The orientation was derived from the sum of the total arguments presented. As such, while some authors did offer caveats to their assessments, it was the preponderance of the arguments which determined the classification as positive or negative. The majority of the literature was produced by authors from the North (Table 1).

Table 1. The literature on community animal health workers.

Primary author	Positive	Negative	Total
Northern authors (n = 59)	54	5	59
Southern authors (n = 47)	36	11	47
Total	90	16	106

Northern authors were overwhelmingly positive whereas Southern authors were slightly more circumspect in their appraisal of community-based delivery systems (Table 1). However, when a breakdown of the institutions was undertaken the results were more revealing (Table 2).

Table 2. Institutional affiliation of primary author (n = 106).

Institutions	Positive	Negative	Total
Northern-funded projects	30	1	31
Northern NGOs	22	1	24
Northern consultants	7	1	8
Northern universities	9	4	12
Northern professional association	1	0	1
Donor	12	0	12
Sub-total	***81***	***7***	***88***
Southern university	1	2	3
Government	6	2	8

Results showed that the literature is dominated by Northern institutions (Table 2). Indeed, a single Northern-funded institution produced nearly one-third (30 papers) of the total literature reviewed, all of which had a positive orientation. NGOs and consultants were equally positive. Nevertheless, the donor-funded project and NGO authors were generally writing about the impact and uptake of projects implemented by these self-same institutions. Thus, there are few, non-project associated evaluations of CAHW programmes. Consultants, NGOs and donors with a stake in the projects are uniformly evaluating themselves. Thus, the literature on CAHW programmes demonstrates that a neutral mechanism for appraising development research is required.

Conversely, the Southern institutions registered more viewpoints that were negative. A recent report illustrated the open hostility to community-based animal healthcare programmes from veterinary professionals in Kenya (Young et al. 2003). Indeed, the Kenyan veterinarian community has resisted the formal acceptance of CAHW programmes for a number of years. Within the local veterinary community, there has been little natural support for legalising and legitimising these community workers as para-professionals. Indeed, it appears that there has been widespread donor leverage to force the government to accept such projects (Young et al. 2003). As the authors note:

DFID, the EU and OAU-IBAR started to put pressure on the government to support CAHW schemes in the mid-1990s. The EU and DFID supported some of the early CAHW projects being developed by ITDG in Kenya, and the EU as a major donor to KVAPS [Kenya Veterinary Associate Privatisation Scheme], became more directly involved in veterinary service policy issues in the early 1990s.

Hence, the question in this case is: whose demand is being reflected? It is clear that while CAHW programmes are touted as participatory and demand-led many end-users have a measured hostility. Equally, it appears that the evidence to support arguments for community-based animal healthcare providers is owned, almost exclusively, by Northern-funded institutions directly involved in the implementation of projects and programmes. Dissenting voices are few and are often portrayed as minority trouble makers (Young et al. 2003) Hence, it may be argued that Southern researchers and Southern agendas are being suppressed by a paradigm developed in the north, which buttresses its own arguments using the development discourse of participation and demand-led processes.

[1]Respondents were participants in the 10th International Society of Veterinary Epidemiology and Economics International Conference, Santiago, Chile, 17–21 November 2003. The study also canvassed international opinion in an e-mail consultation held during March–April, 2004.

However, it would be a mistake to view these results simply in terms of the polarity between Northern and Southern researchers and institutions. The origins of research projects and programmes are irrelevant to the success. Rather, it is the quality of research and the technologies that are produced that will determine their ultimate value and hence, adoption levels and diffusion. Thus, the larger issues appear to be how to ensure inclusiveness within demand-led processes and neutrality within demand-led assessments.
To further explore current attitudes toward demand-led research and development, the next section explores stakeholder attitudes.

The perceptions of the primary actors in animal health research

To explore perceptions regarding demand, 190 animal health researchers, practitioners and policy makers, whose disciplines and areas of interest ranged from veterinary medicine to livestock economics, production and extension, took part in the study.[1] Participants represented a total of 41 nations from four continents: North and South America, Africa, Europe and Australasia (Table 3).

Table 3. Geographic distribution of study participants.

Geographic location	Number of respondents
Central/South America	49
North America	40
Europe	45
Australasia	21
Africa	35
Total	190

As the objective of the exercise was not to simply solicit expert opinion, but rather to better understand current priorities within the context of demand, participants were asked the following three questions:

1. In your opinion, what are the three largest animal health constraints in Southern countries?
2. What is your understanding of demand-led research and how can current projects be more effective in reflecting demand?
3. What delivery pathways would you suggest for your research outputs?

The questions were open-ended to enable respondents to freely express their opinions. Further, to avoid biases with regard to specialist interests, the first question asked for a rank of three diseases. In this manner, participants would be less likely to simply prioritise their research area. Equally, to avoid influencing respondents the questions were intentionally kept neutral, i.e. without a clear poverty focus.

Livestock disease priorities

Researchers tended to respond to the first question in two ways. Not surprisingly, most of the group mentioned a specific disease or disease complex. Indeed, study participants cited a total of 30 diseases/disorders/syndromes as being the most problematic to livestock keepers in Southern countries. Further, many researchers appeared loath to mention a specific disease but rather ranked groups of diseases, e.g. tick-borne, zoonotic, reproductive disorders etc. Conversely, 15% of researchers, in at least one place in the rank, rather than a disease, offered a larger problem faced by livestock keepers or governments in Southern countries, i.e. access to veterinary services or the lack of effective policies for disease control. The frequency of mention for the top six disease constraints is illustrated in Figure 1.

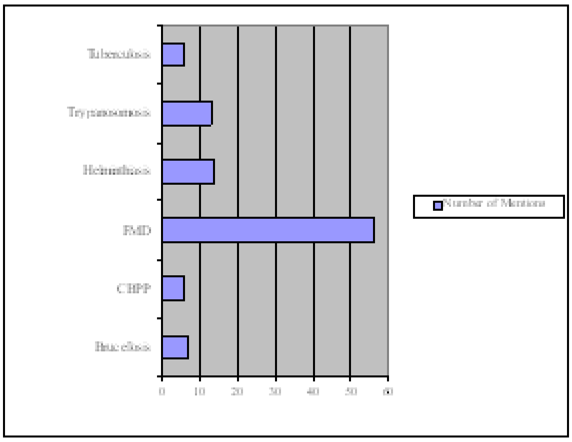

Figure 1. Top six, first order priority livestock diseases (n = 139).

Foot-and-mouth disease (FMD) dominated the ranking, with helminthiasis and trypanosomosis occupying the second and third positions respectively (Figure 1). To explore the finding further, the FMD responses were disaggregated. The first level of analysis explored the geographic area of the researchers involved (Table 4).

Table 4. First Foot-and-mouth disease responses disaggregated by geographic region.

Region	Responses
South/Central America	24
North America	21
Europe	7
Africa	3
Asia	1
Total	56

The highest response rates were recorded from researchers residing in the Americas (Table 4). As the overall responses are evenly divided between Northern and Southern participants, the findings may be viewed as discounting notions of a Northern hegemony in research priority setting. Indeed, perceptions regarding FMD appeared to be the same among a certain sub-set of Northern and Southern participants. Alternatively, it may be argued that notions regarding the importance of FMD are limited to researchers from a single continent and as such, simply display a well-known, geographic bias.

Both conclusions, however, may be too simplistic and offer little insight as to the ‘external’ demands that may be placed on the providers and clients of animal health research. The majority of the South American respondents worked for their respective governments and national agricultural research centres (NARS) and agricultural research institutes (ARIs). Conversely, most of the North American respondents represented governments and universities (Table 5).

[2]A distinction is required between needs and problems. Oxford Dictionary (1996) defines a need as the ‘circumstances in which something is lacking or necessary’. Conversely, a problem is defined as ‘a thing that is difficult to deal with or to understand, something that needs to be solved’.

Table 5. First rank Foot-and-mouth disease responses disaggregated by institutional affiliation.

	Universities	Government	NARs[1] and ARIs[2]	International institutions	Total
North	12	10	0	2	24
South	14	9	9	0	32

[1]National agricultural research institutes.

[2]Agricultural research institutes.

Hence, it would be easy to conclude from the results that the demand was driven by governments and echoed by their university providers of research (Table 5). Nevertheless, when the area of research was explored, the study found that far from being a direct relationship, few of the provider institutions were actually involved in FMD research (Table 6).

Table 6. Institutional involvement in Foot-and-mouth disease research.

	Universities (n = 26)	Government (n = 19)	NARs[1] and ARIs[2](n = 9)	International institutions (n = 2)	Total
North	3	6	0	2	11
South	2	8	5	0	15

[1]National agricultural research institutes.

[2]Agricultural research institutes.

Even in the Southern countries involved, only a minority of the provider institutions, i.e. universities, NARs and ARIs were directly involved in research on FMD (Table 6). While many of the Southern governments supported FMD projects and programmes, many of the representatives were from ministries and departments not directly involved in the eradication or control of the disease. As such, the question remains, what are the drivers for FMD prioritisation?

Many countries in South America are seeking freedom from FMD to better participate in a variety of different trade agreements at both the continental and wider international levels. Hence, FMD is a priority disease from an economic standpoint for the countries concerned, both North and South. As such, it may be that these national-level goals are the 'external' drivers influencing the perceptions and priorities of researchers and therefore, demand. Equally, plausibly, within the field of animal health, there is the belief that transboundary diseases are currently on the rise (FAO 2004). As such, some of the Northerners surveyed may be responding to the threat of introducing the disease in the North, rather than the actual impacts of the disease on nations/ communities in the South. To accurately elucidate demand, a further understanding of the motivations of the individuals involved is required.

Nevertheless, a global study on the disease priorities of the poor revealed that for 5372 poor farmers on three continents, helminthiasis, rather than FMD was the disease reported with the highest frequency (Heffernan et al. 2004). Interestingly, when asked to prioritise animal health constraints, 29% of farmers, like the experts, were most concerned about FMD. Nevertheless, only 4% of farmers reported the occurrence of the disease in the previous 12 months. The finding was nearly reversed for helminthiasis. Indeed, while 7% of farmers noted the disease to be most important, over 20% of the study sample reported a case or cases during the past year. Thus, the finding demonstrates that simply elucidating priorities and perceptions is insufficient without understanding both the drivers of demand and the reality on the ground. In this case, it would be easy to justify enhanced levels of support for FMD research using the perceptions of the farmers.

Further insight was offered, however, when the drivers of demand for farmers regarding FMD were examined. Indeed, when the same study explored where farmers derived information, over 50% of the households in Bolivia had heard messages about the gravity of FMD from formal sources such as the radio, TV or campaign posters. Interestingly, 41% of households who prioritised the disease did not own a species which could be infected. Therefore, it is clear that the priorities of the experts are influencing the 'demand' of the farmers. Further, while nearly half of farmers linked prevention of the disease to vaccination only 30% of households actually vaccinated their animals. Thus, the behaviour of farmers did not change, regardless of their perception or indeed, knowledge. Consequently, the danger is that perceptions alone will be used to justify agendas under the aegis of a demand-led approach.

Hence, it becomes clear that listing priorities and perceptions in and of themselves is not sufficient and these responses alone cannot be construed as capturing demand. Rather, without an understanding of the type and drivers of demand it is unlikely that decision makers will be able to respond effectively. This is not to say, however, that perceptions regarding disease priorities are not of interest, but rather the multitudinous nature of demand must be accounted for in the interpretation of demand. Indeed, the expert's rank of priority diseases provides an interesting insight into current thinking and a further understanding of present and emerging directions of research. While the rank offered by the farmers, lends further understanding to the complexity involved in the interpretation of disease perceptions.

Thus, given the results the key question becomes, how did the study participants view demand?

Notions of demand

When asked to define demand-led research, participant responses could be generally categorised into two groups. The majority of respondents (64%) related demand-led research directly to the end-users. Conversely, fewer respondents defined demand-led research as a general response to a problem or a need.[2] However, the relationship to the end-user took on a variety of forms (Table 7).

Table 7. Conceptions of demand: The relationship to end-users.

Demand-led research	Responses
Driven/requested/identified by end-users	26
End-user consulted	25
Responds to end-user needs	20
Responds to end-user problems	7
Responds to end-user priorities	8
Responds to end-user aspirations	1
Total	87

Overall, 30% of the respondents viewed demand-led research as being driven or initiated by end-users, as the following examples illustrates:

…the farmer, as a stakeholder, makes a claim that certain issues/diseases are critical to the viability and success of his farming operation.

…demand-led research indicates research that is driven by 'actual' identified demand from the identified beneficiaries of the research...

Conversely, 29% viewed demand-led processes as simply consulting those involved, with researchers having the final say:

…get the right questions enlisted (all stakeholders) and let the researchers make their pick.

Thus, the level of involvement of the end-user in conceptions of demand varied widely. In the former responses, the receptors needs or problems drove the process, conversely, in the latter stakeholders were generally viewed as passive suppliers of information, with the researchers taking the dominant role. However, while participants related demand-led research to the end-user, notions of who the end-user was varied (Table 8).

Table 8. The end-user identified in demand-led research.

End-users	Per cent mention (n = 131)
Farmers/communities	42
Veterinarians/veterinary services	4
Researchers	12
Government	12
Commercial sector	13
Unspecified stakeholders/beneficiaries/clients	17
Total	100

The majority of respondents related demand-led research to stakeholders other than the communities involved (Table 8). Indeed, end-users of demand-led processes included national veterinary services, researchers, the government and the commercial sector. Nevertheless, it is clear that the single most frequent response related demand to farmers and communities.

From the above analysis, it is tempting to conclude that researchers broadly understood and/or supported the objectives of such research, given the association between the receptors of research and demand. The conclusion, however, would be misleading. Indeed, the linking of research directly to the farmer was contentious for some study participants for example:

> Demanded by whom? Identification of needs by the people one hopes will be the ultimate beneficiaries of research is important but must be treated with caution.

Although a minority, some participants articulated demand-led processes simply as a donor fad, which had to be accommodated, rather reluctantly:

> …[demand-led research] is research directed by where the money is. This is the sad reality. Ideally, it should be directed to where the needs are.

> …the current fashion is that you have to go to the ultimate beneficiaries and find out what they want…this is only useful in understanding the context.

This perception, however, was echoed more subtly in other responses which ostensibly would appear to be conforming to views that are more ‘acceptable’:

> Technically, greater outcomes may be achieved (in principle) through top-down research but lack of uptake and ‘ownership’ by stakeholders may negate this potential benefit. Demand-led research may lead to simpler outcomes …but greater stakeholders involvement should (again, in principle) lead to a greater ultimate impact.

Thus, demand-led research was viewed as a trade-off necessary to improve research outcomes but ultimately limited in the ability to generate new knowledge. Hence, while it was recognised that use of the term could enhance funding opportunities, the general view was that it offered no new benefits to scientific understanding or indeed, the wider problems facing the animal health sub-sector. Hence, while the objectives of demand-led research were understood its value was questioned, particularly by blue-sky researchers.

Nevertheless, when viewed in relation to the results offered above the finding raises additional issues. From the previous analysis, researchers believed that there were wider constraints inhibiting livestock disease control in Southern countries. These constraints focused upon the farmers, the government and, at least some of the time, on the researchers themselves (Table 8). However, only two of the study participants linked demand-led research to poverty alleviation. Thus, demand-led research was not viewed as a potential solution to some of the wider problems affecting the animal health sub-sector.

Conclusions

Currently, the reality of demand-led research does not match up to the rhetoric. Across stakeholder groups, the study demonstrated the large gap between the perceptions of different actors. Clearly this gap will ultimately affect the future development of biotechnologies and their uptake by the intended clients. Nonetheless, these gaps tended to be among stakeholder groups and not between the different target audiences. For example, both Northern and Southern researchers tended to prioritise the same livestock disease constraint. Farmers were also consistent regarding priority diseases affecting their geographic areas. Unfortunately, the views rarely coincided. To create and deliver sustainable animal health technologies the key question becomes how can these demands be joined up?

At present, the view of demand-led processes as a panacea to enhance development outcomes is unlikely, in the long run, to be effective. Notions of 'demand' appear too easily manipulated to be an effective force for true change. For such processes to be effective, new tools and methods are required to measure demand in a neutral fashion that cannot be influenced by the perceptions of either the experts or the poor. Given the highly polarised debate surrounding many biotechnologies, there is an urgent need to accurately measure the demands of stakeholders to support evidence-based policy and practice.

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