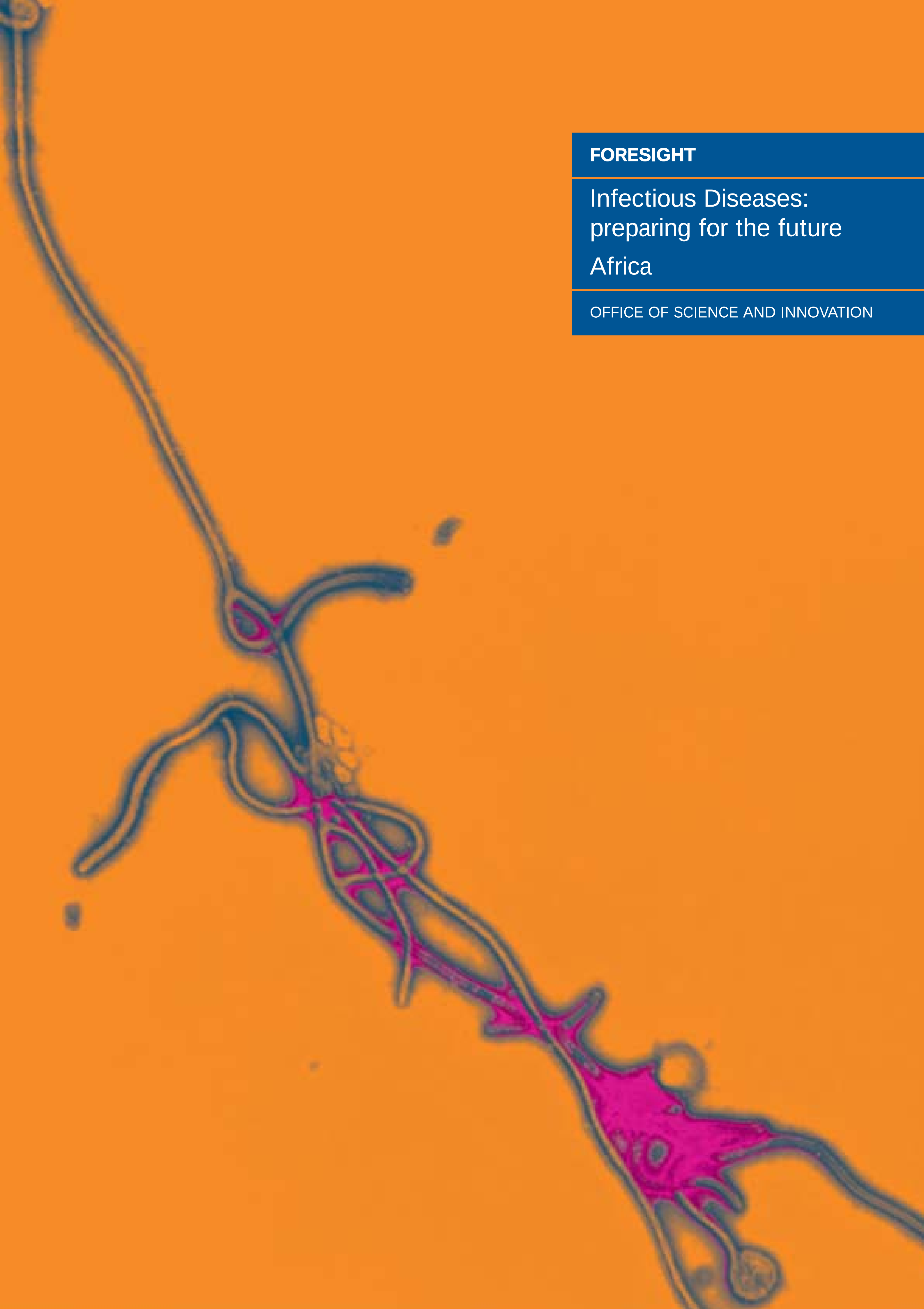

FORESIGHT

Infectious Diseases: preparing for the future

Africa

OFFICE OF SCIENCE AND INNOVATION

Infectious Diseases: preparing for the future

Africa

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This report is intended for:

Policy makers, professionals, business and a wide range of researchers concerned with infectious diseases in humans, animals and plants. As the report focuses on Africa, its findings will be of particular interest to African governments and institutions. However, because of the global nature of infectious diseases, it will also be of interest to international organisations and non-African countries.

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Foreword

Infectious diseases, whether they affect humans, animals or crops, continue to be a fundamental impediment to both economic development and human health in Africa. Until this challenge is met, the development of the continent will continue to be severely retarded.

I therefore very much welcome this international report on infectious diseases in Africa. It forms an important output of the Foresight project and draws on the work of over 50 leading African experts from across the continent. It provides a vision for the future threats, but crucially, it also provides analysis of how Africa could respond.

The report shows that the problems are considerable. And the biggest responsibility for addressing those must surely fall to those African leaders who develop and implement policies for disease control. I therefore encourage these leaders individually and collectively through the African Union, to consider the implications of this work, and to capitalise on this valuable resource.

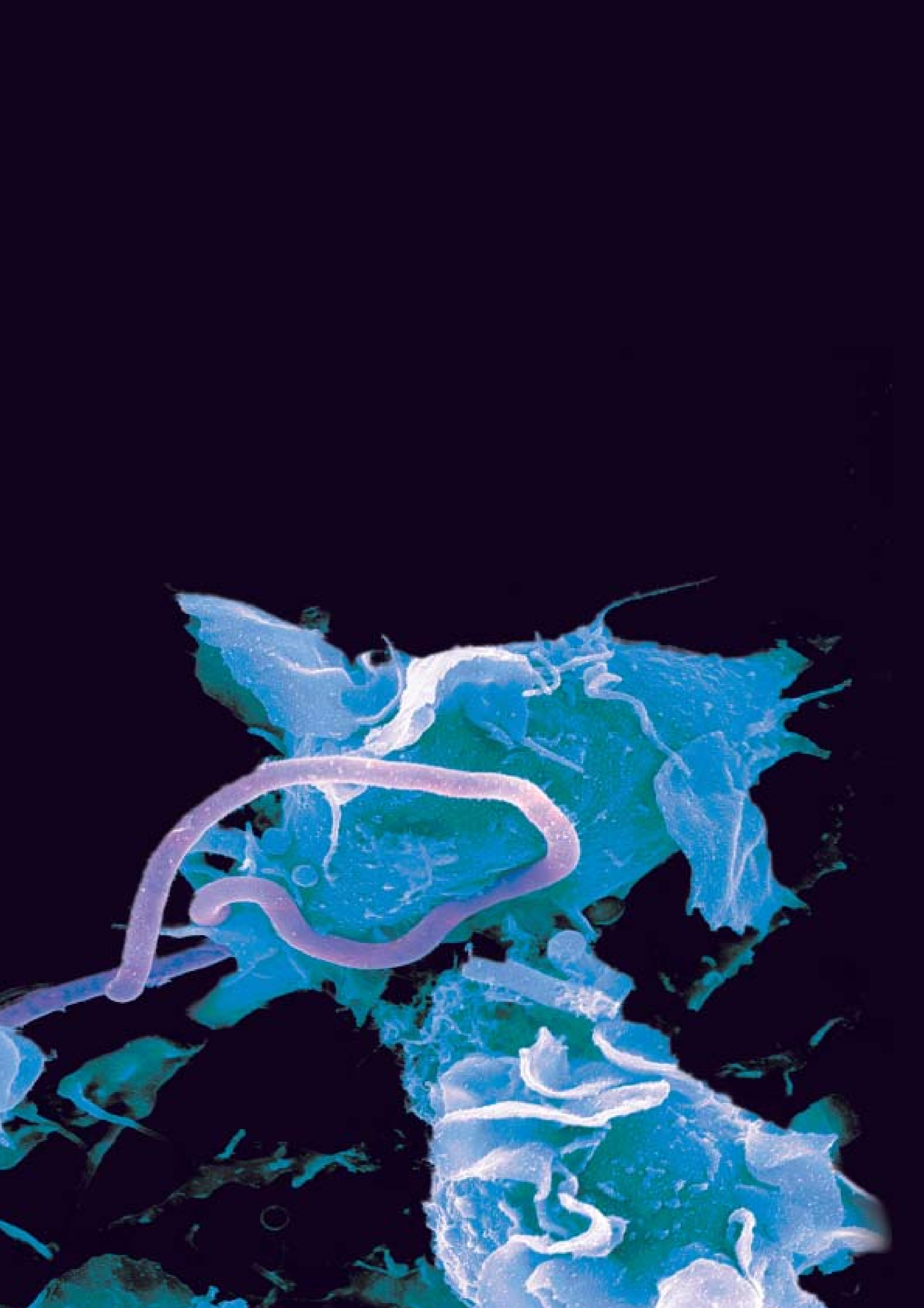
However, whilst Africa should rightly lead in these matters, it is important that the international community is also closely involved. Diseases can now travel the world in hours, and fighting them in Africa will also benefit countries around the world. Everyone will reap the rewards of working together to address these challenges.

Professor G J Gerwel
Chairperson, Nelson Mandela Foundation

This report has drawn together the many African strands of the Foresight project: Infectious Diseases: preparing for the future. In so doing, it has used information from many of the studies that were commissioned by the project, and the outcomes of several international workshops and surveys. It has also drawn on a submission by the project to the Commission for Africa.

The authors and the Office of Science and Innovation would like to acknowledge the valuable contribution of the many experts and stakeholders involved in the above. A list of those who have contributed directly or indirectly to this report is provided in Appendix B.

Contents



1 Introduction

The Foresight programme www.foresight.gov.uk is managed by the UK Office of Science and Innovation (OSI) under the direction of Sir David King, Chief Scientific Adviser to the UK Government. Foresight runs three or four major projects on a rolling basis and uses them to mine into the very best science. The objective is to inform policy makers about issues that could confront them in the future.

The current project, Infectious Diseases: preparing for the future, looks ahead 10–25 years. Its aim has been to assess the future threat of diseases in plants, animals and humans, and to develop a vision of how those challenges could be managed through new systems for disease detection, identification and monitoring (DIM). Africa has been a key consideration, in line with the priorities of the UK presidencies of the G8 and EU in 2005. This report brings together all of the African strands of the project.

The project has involved over 300 leading experts and stakeholders from nearly 30 countries across the world, including individuals from leading international organisations such as the African Union (AU), NEPAD, the World Health Organization (WHO), the Food and Agriculture Organization (FAO), the World Organization for Animal Health (OIE (Office Internationale des Épizooties)), the World Bank, the Bill and Melinda Gates Foundation, the Wellcome Trust and the Gatsby Foundation. By adopting a broad approach and drawing on this wealth of expertise, the project has produced fresh thinking and new perspectives.

This report begins by briefly reviewing the current impact of infectious diseases in Africa (Chapter 2), both in terms of human health and economic development. Chapter 3 then assesses how the threat could evolve in the future. Both existing diseases and the emergence of entirely new and unknown pathogens are considered, and the principle factors that will drive changes in the threat are then explored. The impact of climate change on infectious diseases is considered separately in Chapter 4, where a longer-term view is taken (75 years).

Having assessed the future threat, the contexts for future disease management are explored. Firstly, systems of culture and governance are explored in Chapter 5. These are important if new DIM systems are to be workable and efficient. Future strategies for disease management are then explored in Chapter 6 – recognising that advances in areas such as vaccines and prophylactics might themselves transform how we tackle diseases. Next, Chapter 7 considers how future science and technology could yield new DIM systems that are relevant to the future needs of Africa, and appropriate to the African context.

The report concludes by discussing what could usefully be done at the strategic level to meet the future challenge of infectious diseases. This draws heavily on a pan-African workshop which the authors organised with the OST in Entebbe in August 2005. The key proposal of the many leading African and international experts present at that event, was the need for Africans to take the lead in developing a pan-African Vision and Strategy for the Management of Infectious Diseases, covering plants, animals and humans. This ambitious but exciting concept is explored in Chapter 8 as a means to stimulate further discussion and debate by policy makers.

2 The scourge of disease in Africa

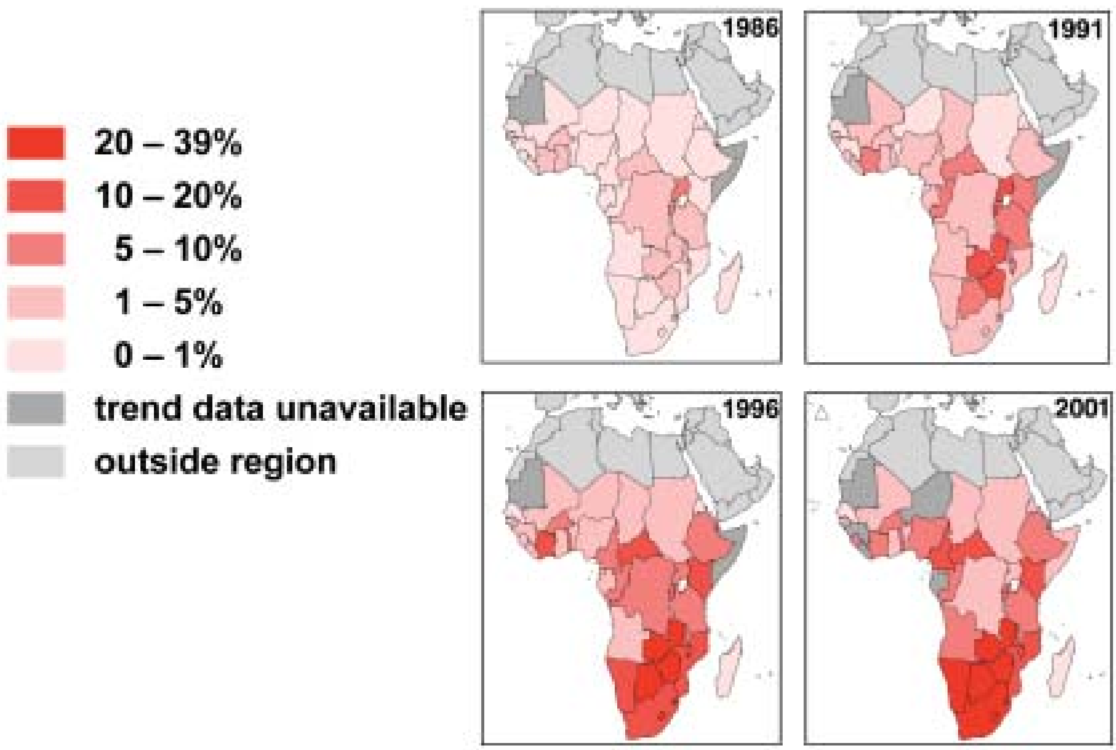
This chapter briefly considers the present-day risks of infectious diseases in Africa. Diseases in humans, animals and plants are considered in turn.

2 The scourge of disease in Africa

The importance of infectious diseases to Africa could not be greater. By attacking crops, livestock and people, they cause starvation, illness and death, they impair economic development and, at worst, can destabilise entire countries. By interacting with each other and with society in complex ways, they create a vicious spiral of decline.

Of the human diseases in Africa, HIV constitutes a ‘time bomb’. The estimated 26 million people now infected are likely to develop AIDS over the next decade. The effects of other diseases such as malaria and tuberculosis, which are already severe, will be amplified by the large numbers of people with suppressed immune systems. Women will be disproportionately affected, and life expectancy, already reduced to around 40 years in some countries with high HIV prevalence, will further decline. And just as greater demands are placed on healthcare and social welfare systems, the economic performance of countries will be compromised by an increasingly debilitated workforce.

Fig 2.1 HIV prevalence in adults in sub-Saharan Africa, 1986–2001

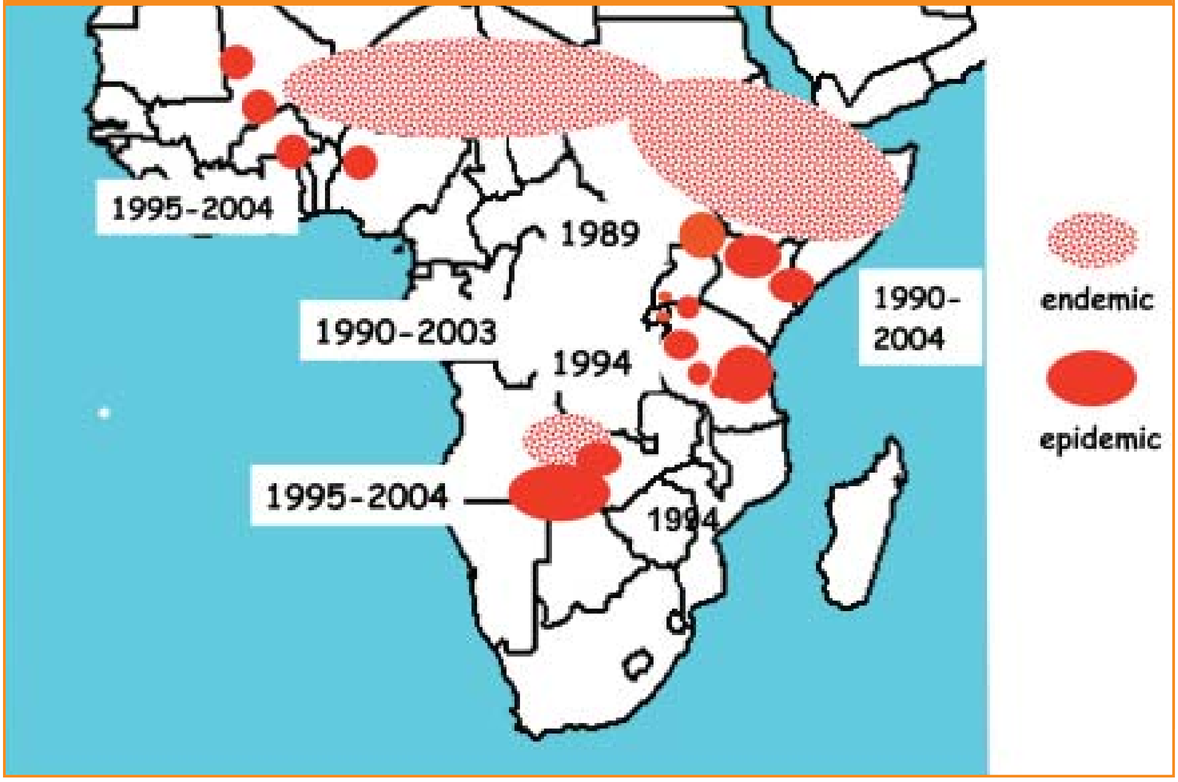


Livestock agriculture is the most important industry across sub-Saharan Africa, and disease is its biggest constraint. Overall, the industry represents 25% of the gross domestic product (GDP) of the region, and, in certain countries, provides enough stock for export. However, compared with other parts of the world, sub-Saharan Africa has the heaviest burden of infectious diseases of animals –

12 of the 15 diseases that were formerly considered by the OIE as the most contagious are found in Africa. By contrast, all 15 are exotic (i.e. foreign) to the UK. Furthermore, the spread of livestock diseases in Africa has worsened in recent years. For example, contagious bovine pleuropneumonia (CBPP), which was reasonably controlled in the 1970s and 1980s, has again become widespread. Serious animal diseases are also the most important impediment to international market access for African livestock commodities. However, while the threat from many diseases remains huge, there are some success stories – the near elimination of rinderpest being a notable example.

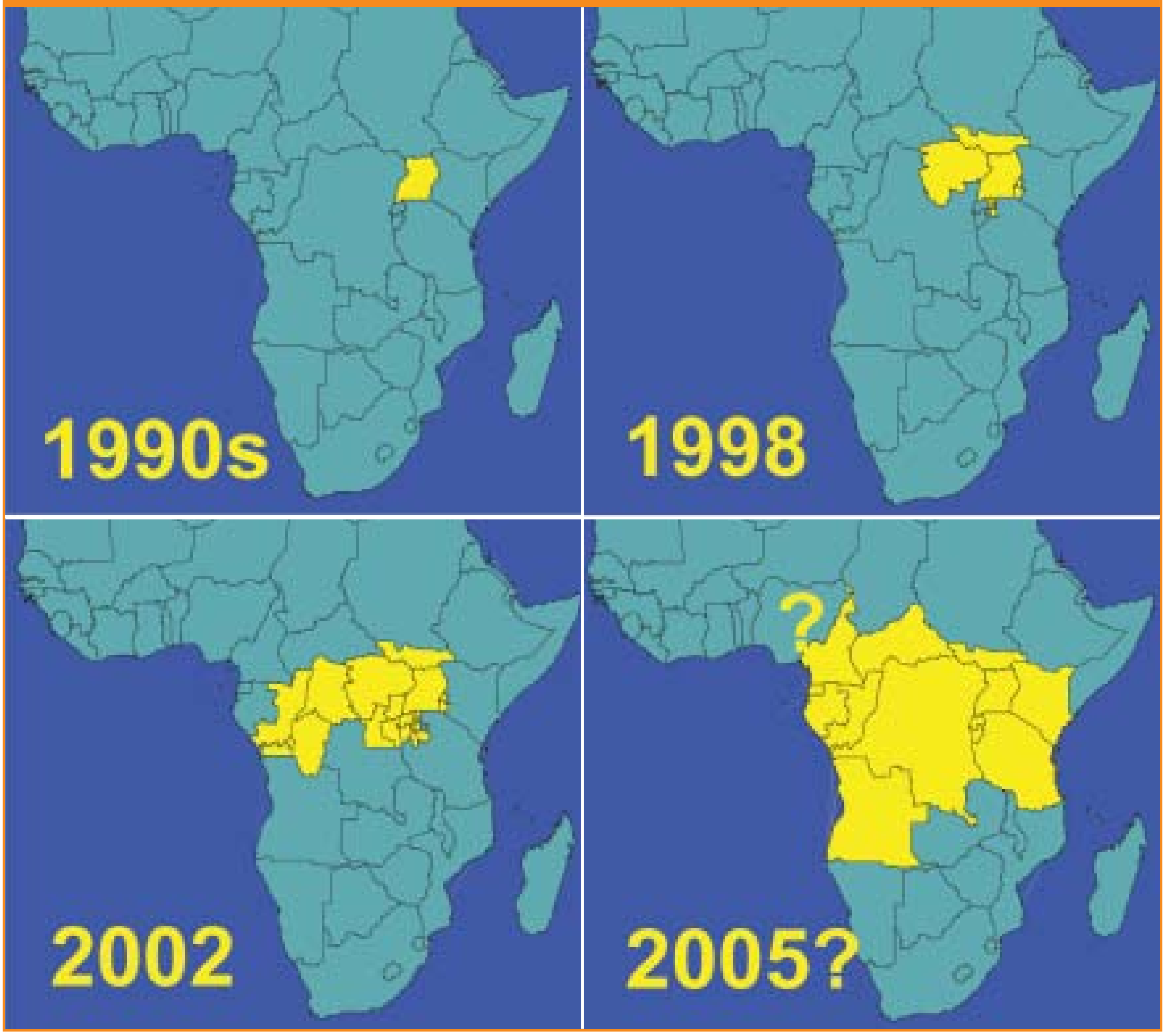
Fig 2.2 The distribution of contagious bovine pleuropneumonia (CBPP) in Africa, illustrating the worsening situation since 1990

Source: Dr William Amanfu, FAO Animal Health, FAO, Rome



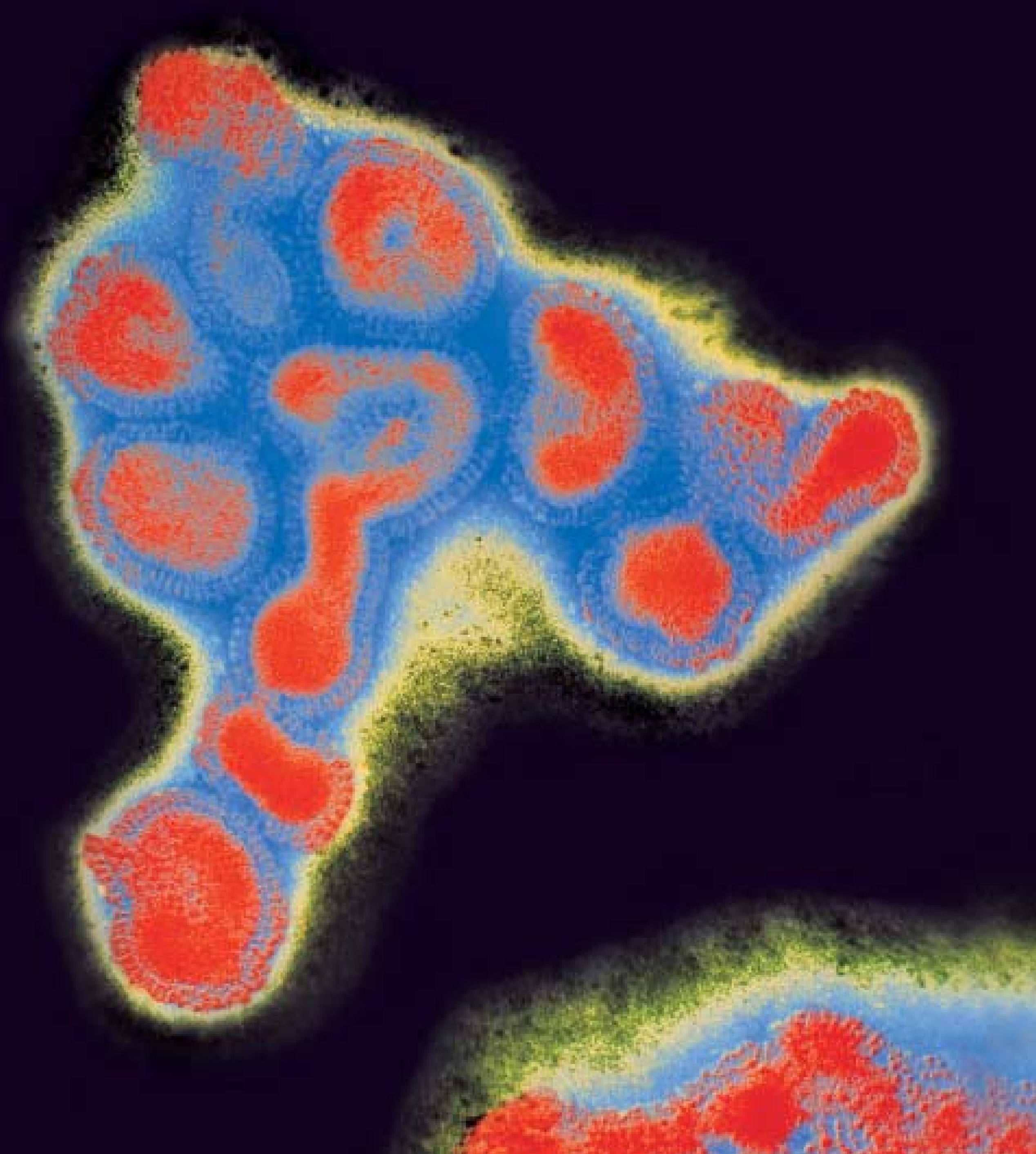
Crop diseases and pests are major threats to African food security. Resistant varieties are the only realistic control, and long delays in developing these makes early detection and eradication of new diseases particularly important. However, as in the management of animal diseases, there have been some recent successes. Cassava mosaic disease (CMD), for example, attacks one of the most important subsistence crops in sub-Saharan Africa and a particularly severe form of the disease was identified in Uganda in 1988. Since then it has attacked large tracts of eastern and central Africa, affecting millions of people who depend on the crop for survival – particularly in times of drought. However, rapid mobilisation of mosaic-resistant varieties, aided by biotechnology, and action at both local and international levels has now helped to control the disease in many places.

Fig 2.3 The spread of CMD in the Great Lakes region



Arguably, the greatest threat in Africa does not stem from any single disease, but from the combined effect of the wide range of diseases in humans, crops and animals which interact with societies, the natural environment and with each other. These interactions are many and complex and can produce a spiral of social, economic and environmental decline. Understanding these interactions will be vital in developing cost-effective strategies to break out of the trend.

3 Future disease risks and drivers for change in Africa



3 Future disease risks and drivers for change in Africa

The starting point for the Foresight project was to assess the future threats of infectious disease and the factors that are driving changes in risk.

This chapter looks 10–25 years into the future and considers the threat of infectious diseases in Africa for humans, animals and plants in turn. In each case, important future diseases are identified and the key drivers of change are discussed. The findings for the three kingdoms are then compared in order to draw out common trends.

First, however, the chapter introduces the risk model that has been used throughout the work.

3 Future disease risks and drivers for change in Africa

3a Introduction

This chapter looks ahead 10–25 years and presents information on the future patterns of risk in infectious diseases in Africa. It also discusses the most important factors that are likely to drive changes in risk levels (‘drivers’). The future risks and drivers are considered for humans, animals and plants in turn, and the chapter concludes by drawing together common strands from across the three kingdoms. The work draws on:

- the results of a major workshop of African experts held in Entebbe in August 2005 (see project report A4 – a full list of all project reports is provided in Appendix C)
- information from a major consultation exercise that has been undertaken within the Foresight project, and which has involved 80 infectious disease experts from Africa and the UK (T3)
- reviews and modelling studies from around 25 leading experts (T5.1–T5.12, T8.1–T8.11)
- a survey of emerging and re-emerging human pathogens (T16).

The consideration of risks and their drivers throughout the project was undertaken within the framework of a common model, developed by the Innogen Centre in Edinburgh. This model is explained in more detail and the various terms defined in report T1.

First some definitions:

- *disease risk:* the product of the probability of a disease event happening and the magnitude of its impact
- *drivers:* social, economic or physical factors that affect disease outcomes, either by changing the behaviour of disease ‘sources’ or ‘pathways’, or by acting directly on ‘outcomes’
- *disease sources:* phenomena or biological events that: give rise to potential new diseases; enable existing diseases to become more harmful; enable existing diseases to infect new hosts; or enable existing diseases to spread to new areas
- *disease pathways:* mechanisms or routes by which a disease organism can transfer from one host to another, within or between species
- *outcomes:* plants and animals at the individual, community and ecosystem or farming system level, and humans at individual and societal levels that are affected by infectious diseases.

Fig 3.1 The model of infectious disease risks that has been used in the Foresight project

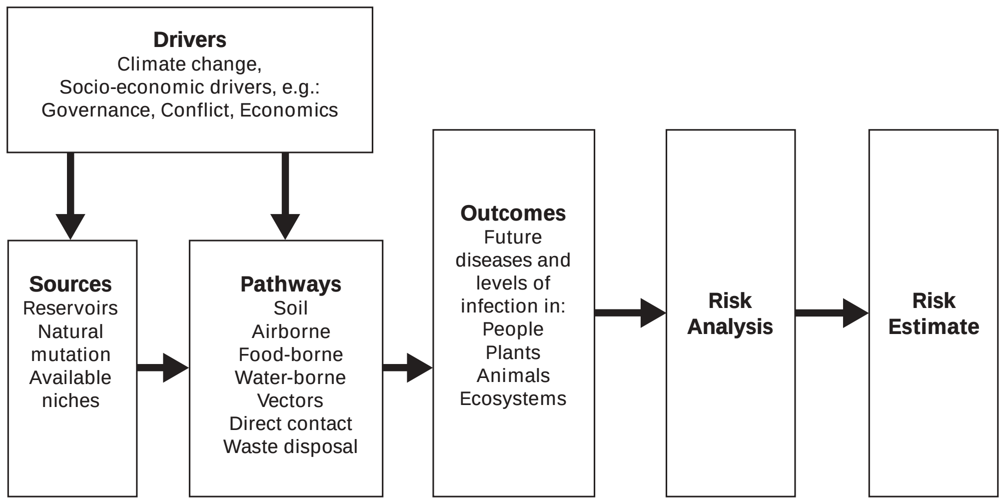


Figure 3.1 provides a graphical representation of the risk model and how its various components (i.e. drivers, sources and pathways) act to bring about disease outcomes and risk.

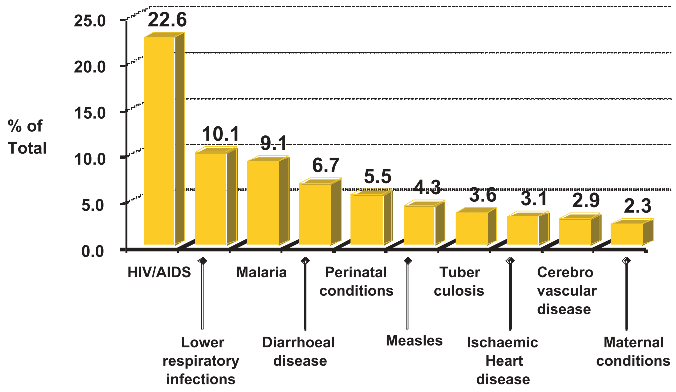
3b Future human disease risks in Africa

Drivers

The most remarkable change in Africa in the last 30 years has been the interaction of the environment and human behaviour, with the resultant increase or perseverance of the old diseases (Figure 3.2).

Fig 3.2 Africa in 2000: the leading causes of death

Source: World Health Report, 2001, Geneva, World Health Organization



There are three major processes that are currently taking place in Africa which are likely to be of critical importance in the emergence of 'new' clinical syndromes in humans. These are: (i) human behaviour; (ii) the effects of civil wars; and (iii) pressure for the emergence of virulent organisms.

(i) Human behaviour:

Human behaviour is and will be the single most important variable in the genesis of new clinical syndromes. Observation of demographic trends in the Africa continent suggests that African populations are growing, driven by high fertility rates. This has several effects, namely (a) the need for more land; (b) the need for food; and (c) human movement for jobs and/or resettlement in new areas.

In an effort to obtain new land, man is increasingly becoming exposed to new environments, such as forests, swamps and caves. This raises the likelihood of exposure to 'new' infectious agents in those environments, and could result in the emergence of new clinical syndromes.

The ever-growing demand for food, as populations expand, increases the chances of food being obtained from the wild. This is demonstrated in certain areas in Africa where the local populations are increasingly turning to wild game for food. This leads to exposure to infectious agents that are circulating in animals, and will be a source of new clinical syndromes in humans.

Africa still has a large migratory labour force. In addition, many of the cities in Africa are still relatively new and their populations are set to grow further. In this setting, there is an increased efficiency of transmission of infectious agents from populations that have been exposed to infectious agents as they mix with other segments of the population.

The increasing movement of objects and goods will also result in the emergence of 'new' infections in different parts of the world – as they carry with them micro-organisms that can survive in new or changing environments.

(ii) Civil wars and displaced populations

Many African countries are experiencing civil wars. This has mainly been due to problems of governance in Africa. The result can be the displacement of large populations within the country, or migration to large refugee camps in another country. This sudden increase in numbers of people living closely together, coupled with a breakdown of health services, can mean an increase in the transmission of diverse infectious diseases. Under these conditions, new clinical syndromes that have been transmitted at low frequency, and which might have gone unnoticed, can suddenly emerge as a critical mass of infection as realised in a refugee camp. Worse still, there may be no surveillance system in place or clinical services to detect the problem early. This will make the epidemic worse.

Fig 3.3 Forced migration of refugees, temporarily settled in unoccupied land near the Nile, led to an outbreak of huge skin ulcers. This was due to an organism related to the leprosy bacillus, new to that area, and blocked half the surgical beds of the nearby hospital

(iii) Emergence of new virulent organisms

There has been a significant increase in the use of antibiotics in many parts of Africa. This is usually because of: poor prescription habits; too many pharmacies that can provide over-the-counter medication (i.e. without a prescription); and the large number of patients who can't afford the cost of a full-course antibiotic prescription.

The net result is that abuse of antibiotics is now widespread. This will tend to exert selective pressure on many microbes, which could lead to the emergence of more virulent strains than is currently being experienced. This could already be happening, although we are not sure as there is no systematic surveillance in place to detect trends.

The most important drivers of risk in human diseases in sub-Saharan Africa in the next 10–15 years

The attendees at the Entebbe workshop identified the following:

- health system incapacity
- inappropriate drug use (relating to prescribing practices, drug use and compliance)
- human behaviour, including sexual behaviour, migration and urbanisation.

Future disease risks

A number of new clinical syndromes due to new infectious agents have been identified in Africa in the last 30 years, e.g. Marburg fever, acute haemorrhagic fevers, Ebola fever, AIDS. It is highly likely that there are ‘new’ clinical syndromes, attributable to new infectious agents, yet to be found. A key message is that we should expect a succession of new diseases to emerge in the future.

Apart from HIV, throughout this period, malaria, tuberculosis and acute respiratory disease have been the major cause of morbidity and mortality (Figure 3.2). The Entebbe workshop considered that these would continue in importance. Overall, the experts considered the most important human disease risks for Africa in the next 10–15 years to be:

- HIV/AIDS
- malaria
- respiratory illness (e.g. tuberculosis, acute respiratory illness, influenza).

Although these were considered ‘old’ or current disease problems, the incidence and impact of these infections are increasing.

Other important infectious diseases considered to be major components of future disease risk included:

- *zoonoses.* Most of the new and emerging infections are zoonoses.

- *vector-borne diseases.* This category includes malaria and zoonoses, but also other significant increasing infections not included elsewhere, such as dengue virus.
- *'neglected diseases' e.g. filariasis, leishmaniasis, trypanosomiasis.* These are increasing in morbidity and mortality, but control and available treatments are decreasing. They are often poorly monitored, and investment in these infections is low.
- *diseases originating in non-human primates.* These were the source of HIV, recently identified Simian immunodeficiency viruses and some outbreaks of viral haemorrhagic fevers. Since contact with these animals is increasing, there could be potential for an HIV-like agent emerging in the future. Although these diseases fall within the zoonoses category, the subgroup of infections from non-human primates are considered so significant that they warrant a special category.
- *viral haemorrhagic fevers (VHFs).* This group of infections is producing larger and more frequent outbreaks in some of the more inaccessible parts of Africa. Treatment is not available for many types of VHFs, and there is a high secondary spread to close contacts, especially healthcare workers. However, it is felt that, although they have a high mortality and thus tend to be self-limited, they could mutate to less virulent strains that could produce chronic health problems.
- *sexually transmitted diseases.* These will continue to be a serious public health problem, especially as they facilitate the transmission or acquisition of other diseases.
- *bioterrorism*. Although this was discussed, it was thought that, given their current problems, this was a relatively low priority for most African nations.

Drug resistance was felt to be a major problem in future, relevant to many of the infectious diseases outlined above.

There was also a feeling that completely new infections might arise, given that the pressures and drivers that facilitated many of the newer infections such as HIV would still be operating. The key implication of this is that policies for the management of infectious diseases in the future need to be flexible and adaptable to entirely new threats – as well as continuing to deal with major existing diseases that are expected to retain importance.

However, because of the underlying weaknesses in the DIM of infectious diseases in Africa, there is a real risk that, were a new or exotic infection to be introduced in tropical sub-Saharan Africa, it would take a long time to: detect and identify it as different from other common causes of fever and disease; recognise it as new or exotic; and mount an effective disease emergency response. In the modern globalised world characterised by rapid travel and movement of food commodities (especially those of animal origin), such a scenario cannot be regarded as merely theoretical. It is fortuitous that SARS (severe acute respiratory syndrome) did not reach Africa. And at the time of writing, one of the concerns about the threat of an avian influenza (AI) epidemic is that the surveillance systems in Africa are not sufficiently robust to enable early detection of any incursion of AI in poultry or wild birds – see Section 3a of this report.

3c Future animal disease risks in Africa

Drivers

The incidence of infectious animal diseases in sub-Saharan Africa is worse now than 30 years ago. For example, in 1969 Tanzania had eliminated rinderpest and contagious bovine pleuropneumonia (CBPP) and had tick and tick-borne diseases under control through nationwide dipping schemes. The country was beginning to plan for foot-and-mouth disease (FMD) controlled zones in order to be able to enter the formal regional and international livestock commodity market chain. The situation now is that the Tanzanian veterinary services have been dominated by rinderpest activities since the 1980s (although there have been only two incursions of rinderpest since the mid-1960s); CBPP, which re-entered the country in the early 1990s, has now become endemic in many districts of Tanzania. The dipping scheme collapsed in the 1980s and now tick-borne diseases (especially East Coast fever (ECF) – Theileriosis) account for some 70% of all cattle deaths in the country. So Tanzania never progressed to the stage of starting progressive and co-ordinated FMD control. Yet this is a country that has been peaceful and has never experienced any wide-scale civil strife. The reasons for the deteriorating situation of infectious diseases (i.e. the ‘drivers’) in Tanzanian, and in most of sub-Saharan Africa include:

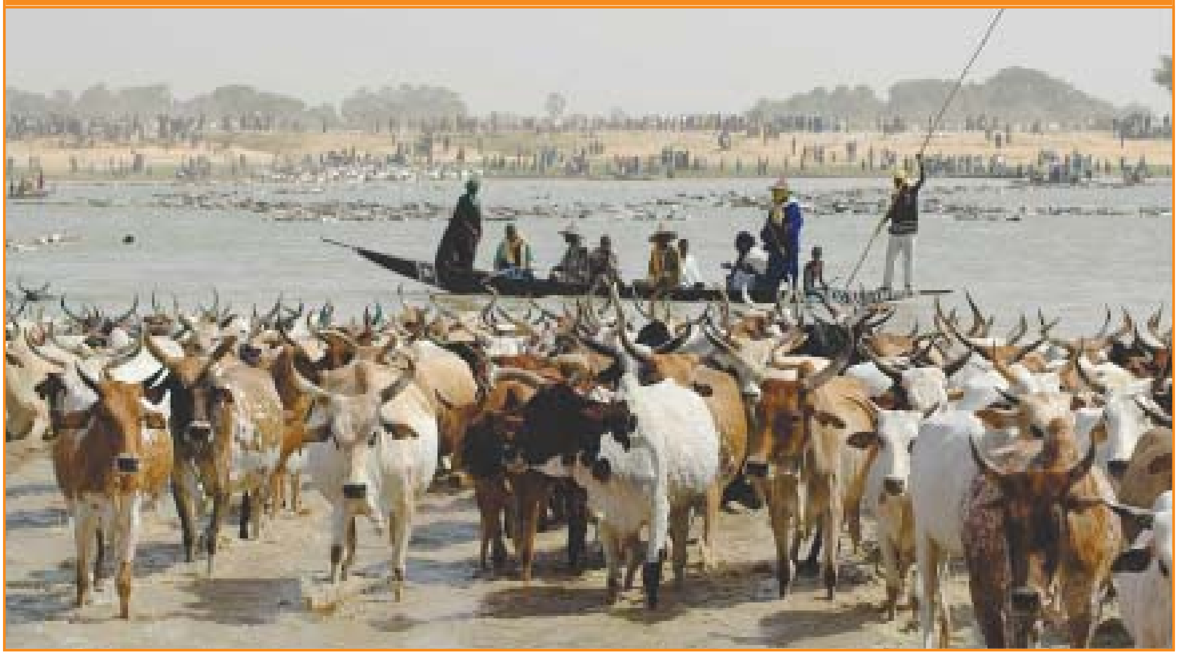
- weaknesses in the national budget
- constant policy and structural changes
- donor-driven structural adjustment policies which initially appeared to brigade all animal health activities together as primarily a private agricultural technical service to the farming community
- consequential weakness in the national veterinary services
- even weaker capacity for sustained laboratory diagnostic services and capacity for the DIM of infectious diseases
- weak livestock farming industry with little political influence and thereby no bargaining power in lobbying for an efficient animal health service
- grossly inadequate private service providers for the livestock sector, especially for animal health
- inadequate incentives for access to formal livestock markets
- uncontrolled animal movement.

In countries where there has been civil strife, the spread of animal diseases has been even worse.

Animal movement is a major factor in the spread of diseases, and has features that are particular to sub-Saharan Africa, driven by farming systems, trade, culture and social habits. It can occur in several forms, including:

- trade – regulated and unregulated
- communal grazing – agro-pastoralists
- transhumance – pastoralists
- human migrations
- wild animal migrations
- marine fish migrations
- family gifts and dowries – live animals.

Fig 3.4 Transhumance crossing the Bani tributary of the Niger River at Djénné, Mali. During November and December after the crop harvesting period, herdsmen and their cattle from Niger, Mali, Burkina Faso and Mauritania congregate at the Djénné, Sofara or Diafarabé crossing points in migration from north Sahel to the flooded pastures of the Niger River and its tributaries.
Source: Dr Bouback Seck, Mali.



Consequently, in the recent past, there have been disturbing examples of the spread of several important diseases in sub-Saharan Africa, including FMD, CBPP, African swine fever (ASF), bovine tuberculosis in livestock and wildlife animals, peste de petits ruminants (PPR) and the weather-dependent diseases such as Rift Valley fever (RVF), bluetongue and the vector-borne haemoparasitic diseases.

The exception to this generalisation has been the southern countries of the Southern African Development Community (SADC), i.e. Namibia, Botswana, South Africa, Lesotho and Swaziland and the island countries of Madagascar, Mauritius, Comoro and Seychelles. The southern SADC countries have a vibrant export trade in livestock commodities and there is therefore an internal demand for high animal health standards.

On the positive side, however, is the control of rinderpest. This disease has now been eliminated from most of Africa, as well as in Asia and the Middle East. Unfortunately, the last residual focus of rinderpest risk in the world is in sub-Saharan Africa, namely in the southern Somali ecosystem. Unless this disease is now eliminated verifiably, it could erupt and spread in future, negating the recent successes of the global rinderpest eradication programme.

The future trend in sub-Saharan Africa for animal disease risk and spread will depend on whether there will be:

- innovative schemes for stimulating the access of African livestock commodities to formal markets. At the moment, the majority of livestock farmers in sub-Saharan Africa are agro-pastoral and pastoral communities. Unless their commodity is part of the formal market chain, they will have little stake in either DIM systems or co-ordinated programmes for animal disease control, except for those diseases that threaten livestock life
- agreement on the part of governments and the international donor community that infectious animal diseases threaten a common or public good
- innovative schemes for enhancing the effectiveness of DIM for both animal and human infectious diseases
- schemes for stimulating rural private veterinary practices and primary animal healthcare.

While the above weaknesses in the national veterinary services, laboratory services, private veterinary service provision and the livestock industry remain unchanged, there is a grave risk that disease spread could worsen.

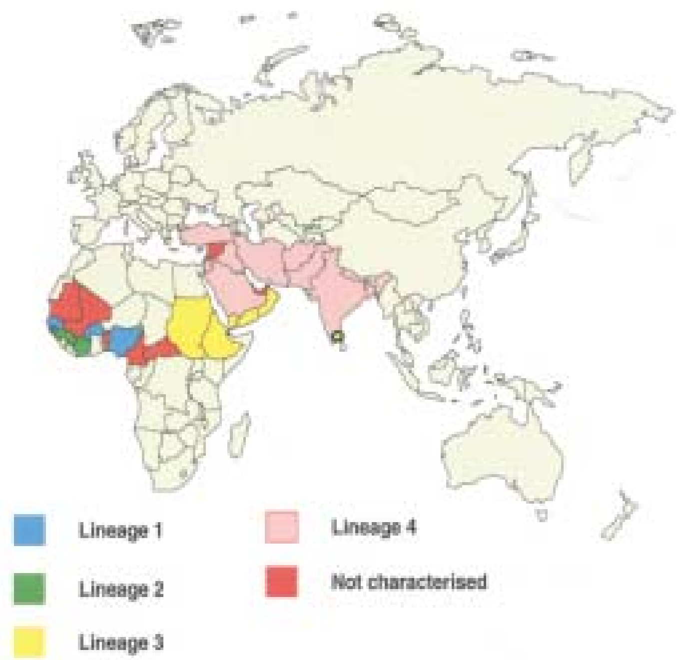
The most important drivers of risk in animal diseases in sub-Saharan Africa in the next 10–15 years

The attendees at the Entebbe workshop were asked to identify the three most important factors they thought would affect future risk of animal diseases. They identified:

- movement of animals and animal products, including the globalisation of trade
- socio-economic factors, particularly poverty-related issues
- the urbanisation and intensification of animal agriculture, especially aquaculture and increased monogastric and poultry production.

Antimicrobial resistance was also identified as an important factor but was considered to be a 'source' rather than a 'driver'.

Fig 3.5 Peste des petits ruminants (PPR) is an acute, contagious, pneumo-enteric disease of small ruminants (sheep and goats). First seen in Côte d'Ivoire in 1942, it has since spread gradually to the rest of west Africa and the Horn of Africa. So far, it has never been recognised in the wildlife ecosystems of eastern and southern Africa. The experts at the Entebbe workshop regarded PPR as a potential disease risk of the future.



Future disease risks

This assessment of future animal disease risks is based on the collective opinion of the leading experts who participated in the Entebbe workshop. The most likely risks and disease problems in sub-Saharan Africa in the next 10–15 years are summarised in Table 3.1, along with the justification for their selection and the most likely risk drivers for each exemplar:

Table 3.1 Future animal disease risks in Africa

Category	Exemplars	Justification	Driver
Transboundary animal diseases/m Major epidemic diseases that limit market access and/or trade	Foot-and-mouth disease (FMD)	Easily transmissible and greatest animal disease impediment to market access. Africa has the most complex serotype and topotype distribution in the world	Animal movement and globalisation of trade
	Peste des Petits Ruminants (PPR) (see Figure 3.5)	Slow spread over 40 years from west Africa to eastern Africa. Now present also in the Middle East and parts of Asia. Potential risk for further geographical spread to eastern and southern Africa; potential risk of infection of vast wildlife populations of eastern and southern Africa and change in host range to include cattle within the next 10–15 years. Currently there is no specific information on these risks	Animal movement and regional trade Poverty and socio-economic factors
	Contagious bovine pleuropneumonia (CBPP)	Serious potential for spread to free areas of southern Africa; inadequacy of current DIM and control tools	Animal movement and regional trade
Vector-borne/associated diseases	Haemorrhagic fevers		
	• African swine fever (ASF)	No vaccine developed so far; little ongoing research for either DIM or control tools. Disease likely to be a major threat to expanding peri-urban pig farming	Urbanisation and intensification of animal agriculture
	• Wildlife-derived haemorrhagic fevers	Greater human–wildlife interface foreseen in the next 10–15 years	Poverty and socio-economic factors
	• Aquatic haemorrhagic diseases	Increased aquaculture and movement of breeding stocks will enhance potential for spread of diseases	Urbanisation and intensification of animal agriculture
Zoonoses	HIV-related infections	Immuno-compromised individuals in livestock-dependent communities will have increased susceptibility to bovine tuberculosis, brucellosis and cysticercosis. So far, this risk has not been adequately assessed	Poverty and socio-economic factors Urbanisation and intensification of animal agriculture
	Avian influenza	Lack of knowledge of circulating influenza viruses in wild birds including those migrating in and out of Africa. Poor primary animal and human healthcare is likely to lead to misdiagnosis in the early stages	Animal movement and globalisation of trade Urbanisation and intensification of animal agriculture

3d Future plant disease risks in Africa

Drivers

As in the case of animal diseases, many drivers will affect future disease risks. The following discusses some of the most important.

Global policy on poverty reduction and sustainable economic growth. This will be a major driver affecting disease outcomes in many direct and indirect ways. The current global and regional policy focus on the reduction of poverty (e.g. through the Millennium Development Goals, the Commission for Africa Report, and NEPAD) place great emphasis on wealth generation. NEPAD has placed agriculture at the forefront of poverty eradication and through its CAADP, the organisation aims to achieve agricultural-led development with the goal of eliminating hunger, reducing poverty and food insecurity and leading to the expansion of exports and higher economic growth. Achieving this goal will mean greater investment in agriculture and agricultural research and technology; the intensification and commercialisation of farming; and greater trade in agriculture commodities and products. These will demand a shift to high-value crops, the introduction and deployment of new crops and high-performing varieties such as horticultural crops, fruits and vegetables, internationally tradable cereals and legumes such as rice, maize, beans and groundnuts, and trade in ornamentals and spices. The intensification of farming will result in specialisation, loss of crop genetic diversity and uniformity of crop species and varieties, which may make them more vulnerable to diseases epidemics. Greater trade in agricultural commodities and products will result in greater risks of disease introduction and spread. These factors will be crucial in driving changes in future disease risks in Africa.

Regional integration. This will facilitate and increase the movement of crops and crop products within Africa. Regionalisation, for instance, in the creation of a common seed policy across the East African Community (EAC), will mean the elimination of barriers to seed movement between these countries. This may increase disease risks. Further, due to economic incentives, investors will be encouraged to open new areas for production, specifically where it is most cost-effective. Again, this will increase the potential risk of disease introduction.

Changing agronomic practices. Here, changes will alter the host–pathogen equilibrium and, depending on the direction to which the equilibrium is tipped, may increase or decrease disease risks.

Environmental degradation. This includes the loss of biodiversity and loss of soil fertility due to intensive cultivation. Loss of biodiversity will bring about uniformity of plant species, increasing their vulnerability to disease pathogens and facilitating the spread of disease. It may also enable weak pathogens or minor diseases to gain importance. Similarly, loss of fertility will result in less vigorous plants that could be highly susceptible to weaker pathogens. A notable example is the emergence of root rot of *Phaseolus* beans, caused by otherwise weak parasitic fungi, *Pythium* spp and *Fusarium* spp, which thrive on beans in areas of low soil fertility.

Fig 3.6 Bean root rot: the top photograph shows a farmer's field in the Kabale district of south-western Uganda, with scientists from the region brainstorming how to address the disease. The middle photograph shows a crop of intermediate susceptibility and the bottom photograph shows a healthy crop.

All pictures were taken in 1999.

Global warming. This will operate through new or better-adapted vector or pathogen species, biotypes or strains. The new vector types may become more efficient in disease transmission or vectors may transmit a disease that they had not transmitted before. New strains of pathogens could become more virulent or may be easily transmissible by vectors. All these factors will increase disease risks.

Civil strife. This will drive outbreaks of disease where any capacity and infrastructure to prevent and control diseases has broken down. Further, refugees fleeing strife areas will typically carry plant materials, which could introduce disease into new areas. In addition, the movement of people due to strife or for economic reasons will also contribute to the movement of crops and disease. The increasing movement of food aid may continue to bring in new pathogens, and accidental introduction by researchers bringing in new germplasms may also result in new diseases.

Institutional factors, including capacity for prevention and control of disease, and policy and regulatory frameworks. A lack of capacity will increase the risk of diseases and, where policies and regulatory frameworks for disease DIM and control are poor, these will also have a substantial effect on the disease situation.

Intentional introductions. In future, Africa cannot be immune to the risk of intentional introduction of plant diseases to undermine food security and stability. Every effort must be made to prevent this.

The most important drivers of risk in plant diseases in sub-Saharan Africa in the next 10–15 years

The attendees at the Entebbe workshop identified the following:

- changing agronomic practices
- changing or new crops
- cross-border movement of people and agricultural commodities.

Future disease risks

Plant diseases may be fungal, viral, bacterial or phytoplasma in nature. It is unlikely that any one of these taxonomic classes will cause substantially greater risks than the others in the next 10–15 years. So future risks were therefore assessed as a function of the different ways in which new diseases arise, how they act and how they spread.

Firstly, new diseases in Africa will arise either as new encounter,[1] re-encounter,[2] or co-evolved[3] diseases. With the increasing emphasis on the commercialisation of agriculture as a means to eradicate poverty, Africa has and will be very dependent on introduced crops, in contrast to other continents. Consequently, re-encounter and encounter diseases are likely to pose greater risks in Africa in the future. The introduction of new crops or new strains of crops into Africa to increase or diversify agricultural production would favour these types of disease problems.

[1] A new-encounter disease occurs when a pathogen that previously existed on another (e.g. native) plant switches to and causes disease in a plant that has been introduced to the area, the introduced plant having had no contact with the pathogen before. Such examples are cocoa swollen shoot disease and the African CMD. New-encounter disease can also occur when an introduced agent becomes a pathogen and causes disease on an existing plant species.

[2] A re-encounter disease occurs when a host plant is geographically separated from its native pathogen and re-establishes contact after a long time, e.g. when an introduced crop is established in Africa and a disease from the same crop in its area of origin is later introduced. The disease may be particularly severe if the plant has loss resistance over time.

[3] A co-evolution disease occurs when a native or long-established disease on an African plant or crop evolves into a new and more virulent form, possibly as a result of the recombination of different disease strains. Examples are UgV, the virulent strain of east African CMD.

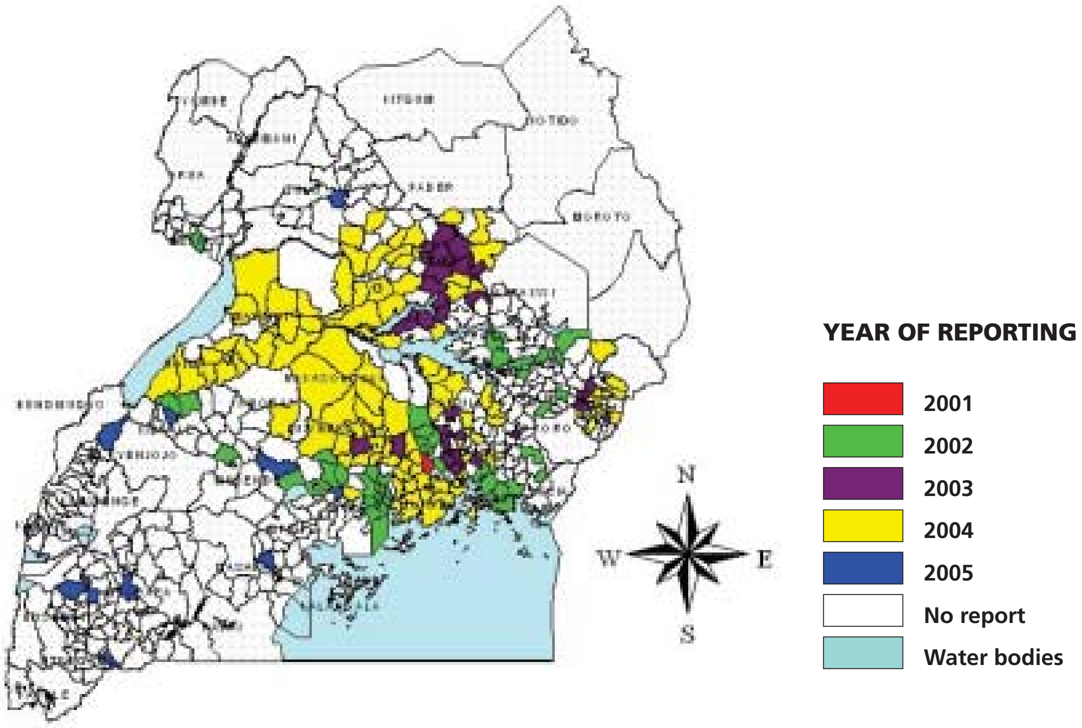
Based on the properties of disease, three important classes of disease can be identified:

- *Air-borne, mostly fungal,* diseases are likely to be some of the most important diseases in Africa in the future and the ones that cause the greatest risks. This is because the spores of such diseases can be carried over long distances by wind or jet currents and their spread can be very rapid so as to overwhelm any limited capacity to contain them, for example, using fungicides or deploying resistant varieties. Rust diseases, such as those on maize or soybean, are transmitted in this way. Also, coffee rust, Hemelia vastatrix, was carried from the west coast of Africa to eastern Brazil by air.
- *Vector-borne, mostly viral, diseases* may be of growing importance and could pose greater risks as vector populations may grow or change as crop intensification increases and other agronomic and climatic changes occur.
- *Seed-borne diseases,* mainly fungal, bacterial and viral in nature, will be more important and could cause greater risks in future. This will result from the current drive towards the intensification and commercialisation of agriculture and the increasing trade in agricultural commodities and products. Such activities will stimulate the introduction of new and better-performing crops species and varieties and the increasing trade in crop commodities and products within and across Africa. Vegetatively propagated crops are included in this category. For instance, it is now clear that a lack of local understanding that coffee wilt was a seed-borne disease contributed greatly to its spread through new plantings in the Great Lakes region of Africa.

Other categories of diseases are soil-borne and water-borne diseases. Because of their slow dispersal mechanisms, these are likely to be less important and could pose lesser risks compared to those described above.

In conclusion, the major risks for plant diseases in the next 10–15 years are likely to arise from (a) air-borne pathogens; (b) seed-borne pathogens; and (c) vector-borne pathogens, while the main drivers are likely to be (a) changing agronomic practices; (b) changing or new crops; and (c) cross-border movement of people and agricultural commodities. In all cases, early detection and early response to stop the spread of disease are crucial elements in disease risk management. Figure 3.7 illustrates the spread of banana wilt disease in Uganda from a focus that was not eliminated when first detected in 2001.

Fig 3.7 The progressive spread of banana wilt disease in Uganda since 2001



3e Common trends in disease risks and drivers

Having considered risks and drivers for plant, animal and human diseases in turn, this section now looks across the three to draw out common aspects. This consideration is enriched by drawing on a survey of 80 experts (T3), which compared the situation in Africa with that in the UK. Some comparison with the UK is therefore included in the following where it is deemed to add additional insights.

Firstly, there was a clear consensus on two aspects of the future threat:

- *Many current major infectious disease problems are expected still to be serious problems in 10–25 years' time:* e.g. HIV/AIDS in humans and FMD in animals. This shows that the development of new DIM systems to meet tomorrow's threats will also have substantial relevance to the present day.
- *There is a significant likelihood that some infectious diseases that will be major problems in 10–25 years are not currently known at all.* The experts consistently stressed this view, commenting that predicting future infectious disease risks was therefore extremely difficult. As an indication, new research commissioned for the project (T16) has shown that 38 new (or newly recognised) human pathogens have been reported within the last 25 years (including HIV and SARS Coronavirus). Also, some 75% of emerging infectious diseases of humans (including HIV, SARS, variant Creutzfeldt-Jakob Disease (vCJD), food-borne infections, AI) have an animal origin. One corollary of this is that it is important to emphasise the diversity of future risks (and of sources, drivers and pathways of future risks).

The second point raises a key issue for policy makers: if we are to expect a succession of new diseases to emerge in the future, should our policies for disease management be mostly reactive, or should we instead develop policies that are adaptable and flexible with regard to the evolving situation?

There was a strong consensus that effective systems of the surveillance, investigation and reporting of infectious disease incidence should play a crucial role both in managing existing diseases and in contributing to a flexible and adaptable approach to new and emerging diseases. A second underpinning factor should be capacity building to promote the availability of expertise and trained personnel in Africa.

Changes in **disease sources** were seen as important determinants of future disease risks in animals, plants and humans in Africa and the UK. In particular:

- Natural genetic change, geographical extension of pathogens, increased pathogen resistance to microbicides, and the emergence of new diseases from other species reservoirs were found to be consistently important across animals, plants and humans, with perceived risks being somewhat greater in 2030 than in 2015.
- The emergence of new disease vectors, failure of vaccines to continue to protect against diseases, and decreased immuno-competence of target populations were generally not perceived as important when compared with other sources of risk.
- There was little difference between the UK and Africa in perceived overall risks generated by changes in sources.

Changes in **pathways** (as opposed to changes mediated via drivers) were seen as much less important generators of disease risks across all categories than were changes in sources. Of those that were important:

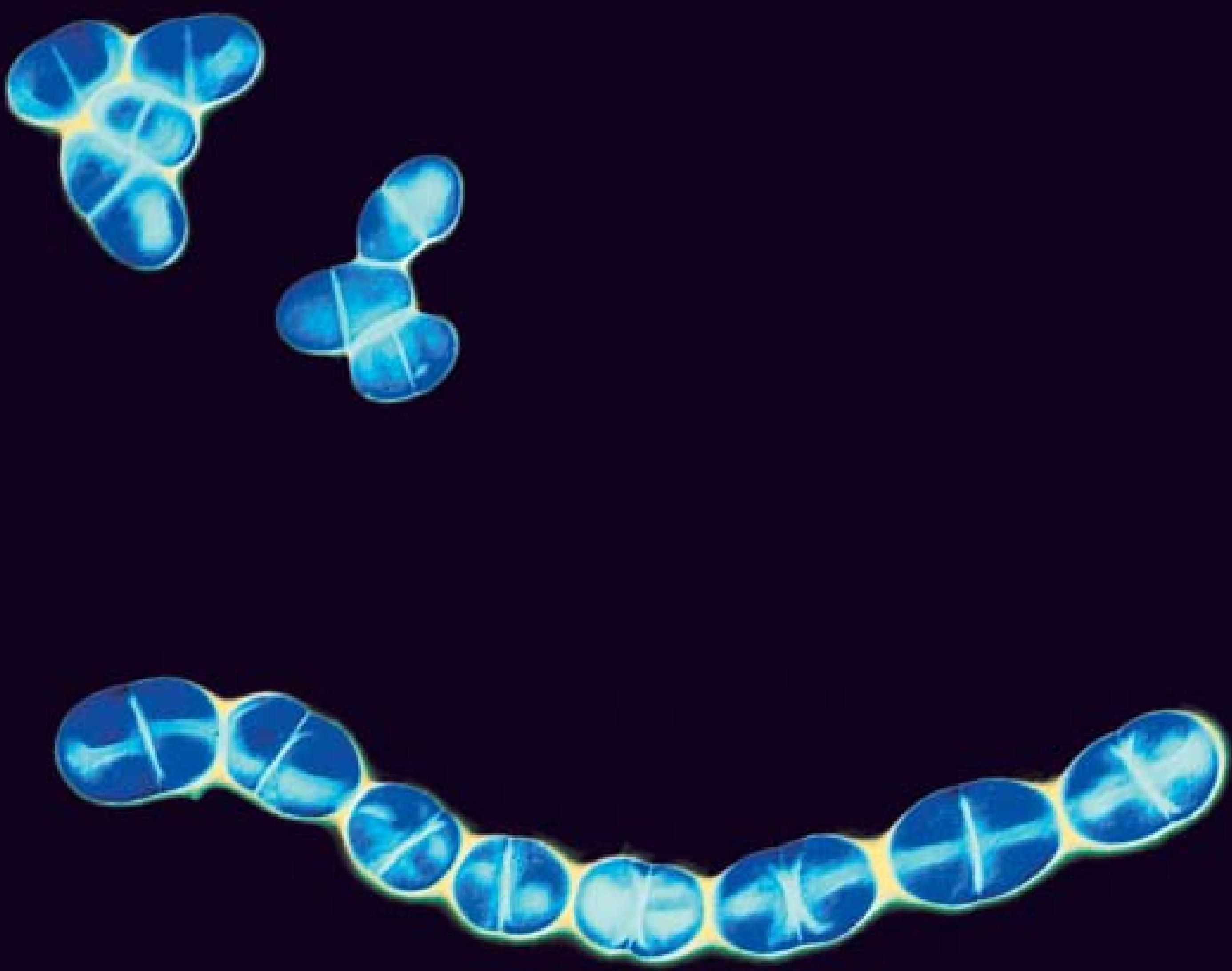
- In Africa, airborne pathways were seen as important for both plants and humans, and water-borne for humans.
- Increased disease-vector populations were important for plants in Africa – in comparison, they were important for both plants and animals in the UK.
- Increased host-to-host transmission due to increased density of host populations was seen as important for animals, plants and humans in Africa, but not at all important in the UK.

There were few differences in predictions related to disease pathways between 2015 and 2030.

A wide range of possible disease **drivers** was considered under the general headings of ‘legislation and systems of government’; ‘technology and innovation’; ‘conflict and war’; ‘economic factors’; ‘human activity and social pressures’; and ‘climate change’.

- Across the board, many more drivers were considered more important in Africa than in the UK. This implies that policies for disease management in Africa face a greater challenge, since they need to take account of a wider diversity of factors.
- In Africa, under ‘legislation and systems of government’ and ‘conflict and war’, many respondents predicted lower risks arising from these drivers in 2030 than in 2015, possibly reflecting optimism about the future situation on the continent.
- Climate change (increased temperature, rainfall and drought) were all seen as important drivers for humans disease risks in Africa; only drought was highlighted for animals, and only temperature and rainfall for plants.

4 Impact of climate change on disease risk



4 Impact of climate change on disease risk

Climate change will have a profound effect on societies across Africa. This chapter looks at the potential implications for infectious diseases. In so doing, it mainly focuses on direct effects – such as changes in the range of vectors.

While the rest of this report looks ahead 10–25 years, a 10–75-year horizon has been used in this chapter. This recognises the longer-term nature of climate change.

Firstly, the changing climate in Africa is discussed, followed by case examples of how this change could affect specific diseases in humans, animals and plants.

4 Impact of climate change on disease risk

The Foresight project commissioned three detailed reviews of the impact of climate change on infectious diseases in plants, animals and humans (T7.1–T7.3). These have also been enriched by certain modelling studies (T8). In this chapter, we have drawn on the parts of those papers that are most pertinent to Africa.

4a African climate change

Global climate change is now widely accepted, given the considerable weight of scientific research that has analysed the situation. In its third assessment report, the Intergovernmental Panel on Climate Change (IPCC) estimated that by 2100 the most probable outcome will be an increase in global mean temperature of 1.4–5.8°C, significant changes in precipitation and a greater frequency of extreme weather events.

Africa is a part of this change. Most of the current models indicate that the overall scenario is one of rising temperatures and changes in rainfall patterns, with more prolonged and frequent drought and flooding.

The size and geographical diversity of sub-Saharan Africa make climate change predictions particularly challenging. However, most of the current climate models[4] indicate that the overall scenario is one of rising temperatures and changes in rainfall patterns, with more prolonged and frequent drought and flooding. Mean temperatures over land areas are expected to increase by an average of around 1–2°C by 2020 (relative to the 1961–1990 baseline), with the largest increases occurring in southern Africa. By 2080, mean temperatures are expected to increase by about 1.7–6ºC in southern Africa, 1.3–4.5ºC in eastern Africa and 1.7–5.5ºC in western Africa. There is less agreement between the various climate models for rainfall than for temperature. However, most predict a decrease in rainfall for southern Africa of approximately 5% by 2020 and 10% by 2050. Similar decreases are also anticipated in parts of the Horn of Africa, with some areas in eastern Africa likely to receive a significant increase in rainfall.

These changes will have profound implications as they interact with African societies. They will create opportunities for some, but challenges for others. For example, patterns of agriculture and land use will alter as the viability of crops and livestock production is affected in different areas. Indeed, climate change could provide fresh impetus for conflict and migration as people and societies struggle to adapt to the evolving situation and contest scarce resources – such as water in times of drought.

[4] Global Circulation Models currently used include the Hadley Centre Model (HadCM3), www.metoffice.com/research/hadleycentre/models/HadCM3.html, and Community Climate Systems Model (CCSM) www.cgd.ucar.edu/csm/.

Chapter 3 has already shown that some of these possible consequences, for example, conflict and migration, are important drivers for the risk of infectious diseases. This means that climate change could have a substantial *indirect* effect on disease, working through these intermediate drivers. However, the extent will depend on many complex and uncertain factors such as the ability of different societies to adapt to the change, and their inclination to work together to address the challenges.

4b Impact on human diseases

As mentioned above, droughts and floods resulting from climate change could result in high levels of displacement of human populations, thereby promoting the spread of infectious diseases to new areas and exposing the migrating population to new pathogens.

However, climate change will also be instrumental in altering the range of existing diseases, particularly those that are vector-borne. The changes for these will be similar to those for animal diseases, as discussed in 4c. For example, the emergence of highland malaria in eastern and central Africa in the last 20 years has clearly illustrated the effect of climatic change on the spread of disease in new geographical areas. As highland areas tend to get warmer, malaria has spread in these new areas, finding non-immune populations, which has resulted in high mortality and morbidity. Further, Africa is experiencing severe prolonged droughts, resulting in severe malnutrition and the depression of immunity in affected populations. This has the effect of increasing the prevalence of infectious diseases, particularly respiratory infections. Conversely, periods of high rainfall would promote epidemics of water-borne diseases, particularly cholera.

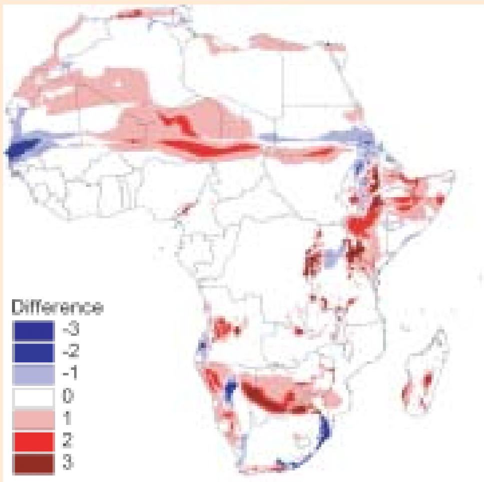
The key message is that environmental and climatic changes affect disease risks through diverse mechanisms and are already affecting the distribution of human diseases.

Fig 4.1 The complex effects of environmental changes. A new dam built in west Africa initiates a chain of events that leads to an epidemic of schistosomiasis.

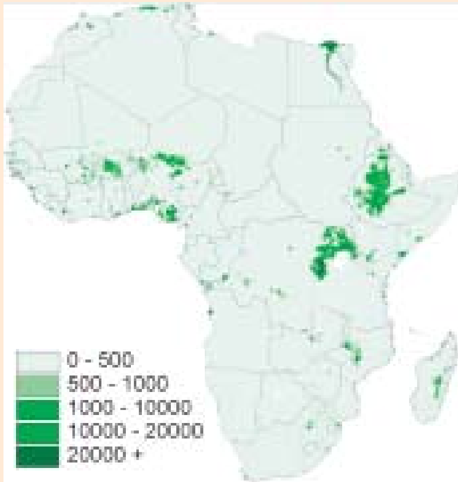
Malaria in sub-Saharan Africa

Predicted climate change alone is estimated to increase the human population at risk (PAR) of malaria in Africa by 13% by 2015 and 14.5% by 2030. Human population growth, however, is predicted to increase PAR by a much greater amount (22% by 2015 and 61% by 2030), indicating that climate change is just one of several drivers of change in the risk of infectious disease.

a)



b)



Change in fuzzy climate suitability class (red = more suitable; blue = less suitable) across Africa between 2005 and 2030 as a result of climate change (Figure a) and projected population growth over the same period (Figure b). The combination of maps allows us to visualise the population at risk of malaria and how it may change in the next 25 years (see T8.2 for full details and T5.8 for further discussion).

4c Impact on animal diseases

In the future, Africa is expected to get warmer, with some regions predicted to become drier, some wetter and others more seasonally variable. Livestock production in most of sub-Saharan Africa is determined by moisture, and these changes to the continent's climate could have dramatic effects on the distribution of animals as well as infectious diseases.

Warming, and changes in the distribution of rainfall in Africa will lead to changes in the spatial or temporal distributions of those diseases sensitive to moisture, such as anthrax, blackleg, dermatophilosis, haemorrhagic septicaemia, PPR, haemonchosis and vector-borne diseases. These diseases may decline in some areas and spread to others. This is shown clearly by climate-driven models of disease vectors in Africa.

Some global climate models predict that the El Niño Southern Oscillation (ENSO) will occur more frequently in future. This could also have consequential implications for African livestock diseases, as demonstrated by the ENSO which occurred in 1998. After drought in 1997, the 1998 ENSO brought excessive rainfall to east Africa and an 'explosion' in many diseases, notably RVF and bluetongue, transmitted by mosquitoes and biting midges respectively.
The combination of drought and rainfall, brought by ENSO, has also been linked to large epidemics of African horse sickness in the Republic of South Africa.

Irrespective of ENSO, it is widely predicted that climate extremes (e.g., drought, floods) will become more frequent. It is possible, therefore, that significant epizootics of certain vector-borne diseases will become more common in parts of Africa:

- *Culicoides imicola and bluetongue.* Bluetongue is a disease which for a long time was considered to be confined to Africa. However, in the last 50 years, it has increasingly been recognised wherever substantial populations of ruminants occur in the tropical and sub-tropical regions of the world roughly between 40°N and 35°S. Since 1999, the northern limit of the spread of both the vector, *Culicoides imicola*, and bluetongue itself has extended into southern Europe.

Fig 4.2 Distribution of bluetongue virus and its vector *Culicoides imicola* – in 1999 and in 2003

Source: Professor Philip Mellor, IAH, Pirbright

- *Tsetse.* Tsetse-transmitted trypanosomosis is one of the greatest disease constraints on livestock production in a large part of sub-Saharan Africa. The many species of tsetse, each with its own climatic requirements, are classified into three groups: savannah (*morsitans* group), riverine (*fusca* group) and forest (*palpalis* group). The probability of the presence or absence of each group in grid cells across sub-Saharan Africa has been modelled in terms of the current length of the growing period (LGP), a composite of temperature and moisture. Threshold values of LGP for a group's presence or absence were found, and future distributions of habitat suitable for each group were predicted for future LGP scenarios. By 2050, climate-change-driven decline in habitat suitability is predicted for all three groups in parts of their northern and southern fronts, whereas increases in habitat suitability are predicted in parts of east Africa. Additionally, there is predicted to be an increase in habitat suitability for the *morsitans* group along its southern front in west Africa.

  A model of the current distribution in southern Africa of a single tsetse species, *Glossina morsitans*, based on a number of climate variables, was used to predict future distributions of the species, again for the 2050s. A net decline in habitat suitability for this species in southern Africa was predicted, but with localised gains in some, particularly highland, areas.

- *Ticks.* Ticks transmit many important livestock diseases in Africa and, like tsetse, impose significant constraints on productivity. A model similar to that for *Glossina morsitans* was developed for the brown-ear tick, *Rhipicephalus appendiculatus*, the primary vector of ECF in eastern and southern Africa. By the 2050s, suitable habitat is predicted to largely disappear from the south-eastern part of its range (south-eastern Zimbabwe and southern Mozambique) but newly permissive areas are expected to appear in more western and central parts of southern Africa.

These modelling exercises provide quantitative support – and spatiotemporal detail – to our intuition. Moisture stress, exacerbated by high temperature, limits the distribution of many disease vectors in Africa. A general decline in habitat suitability for disease vectors may be witnessed in the hotter and drier southern Africa of the future, but with a possible increase in highland areas that are currently too cold. Distributional limits may be relaxed in east Africa and Sahelian west Africa, as increased rain falls during the current December/January hot season, and in central Africa and south-west Africa, which are predicted to get more rainfall during two seasons.

Similar predictions would tend to be made for all moisture-limited disease agents, but with important complexities. Fascioliasis in Africa is caused by two species, *Fasciola hepatica* (transmitted primarily by the lymnaeid snail vector, *Galba truncatula*) and F. *gigantica* (transmitted primarily by the lymnaeid *Radix natalensis*). *Galba truncatula* prefers colder temperatures and small, temporary water bodies, while *R. natalensis* prefers warmer temperatures and large, deep, permanent water bodies. *Fascioliasis hepatica* may increase in areas of Africa which experience more rainfall. Both snails (and parasites) might be expected to decline in areas that become hotter and drier. However, in such regions, *Fascioliasis gigantica* could, perhaps, increase if more dams or reservoirs are constructed to help maintain the water supply.

Finally, the rinderpest epidemic in Kenya and Tanzania in 1997, attributed to the response of pastoralist cattle owners to drought, provides an important lesson: climate-change-driven alterations to livestock husbandry in Africa, if they occur, could have many indirect and unpredictable impacts on infectious animal disease in the continent.

4d Impact on plant diseases

Impact of climate change on crop performance

The climate changes described in 4a will have significant impacts on crops, crop diseases and insect vectors. Some crops are currently grown under conditions that are close to their maximum temperature tolerance. Where this is combined with significant water stress, crop yields, which are already low, will be increasingly difficult to maintain. Thus, the most serious effects of climate change on agricultural production in sub-Saharan Africa are likely to occur in arid and semi-arid regions. In these areas, the predominant crops are maize, sorghum, cassava, sweet potatoes, cowpeas and groundnuts. These are subsistence crops and are therefore important for food security. Some, such as groundnut and maize, are also sold for cash and this can provide a vital source of income for poor families. Consequently, the impact of climate change on these crops could have a big impact on food security and income of rural poor.

Climate change and plant disease

Plant diseases have had major impacts on agricultural productivity throughout history, and major outbreaks have sometimes had devastating effects on human societies. A good example is the potato famine that occurred in Ireland in the 19th century, which resulted from severe epidemics of potato late blight caused by the fungal pathogen *Phytophthora infestans*.

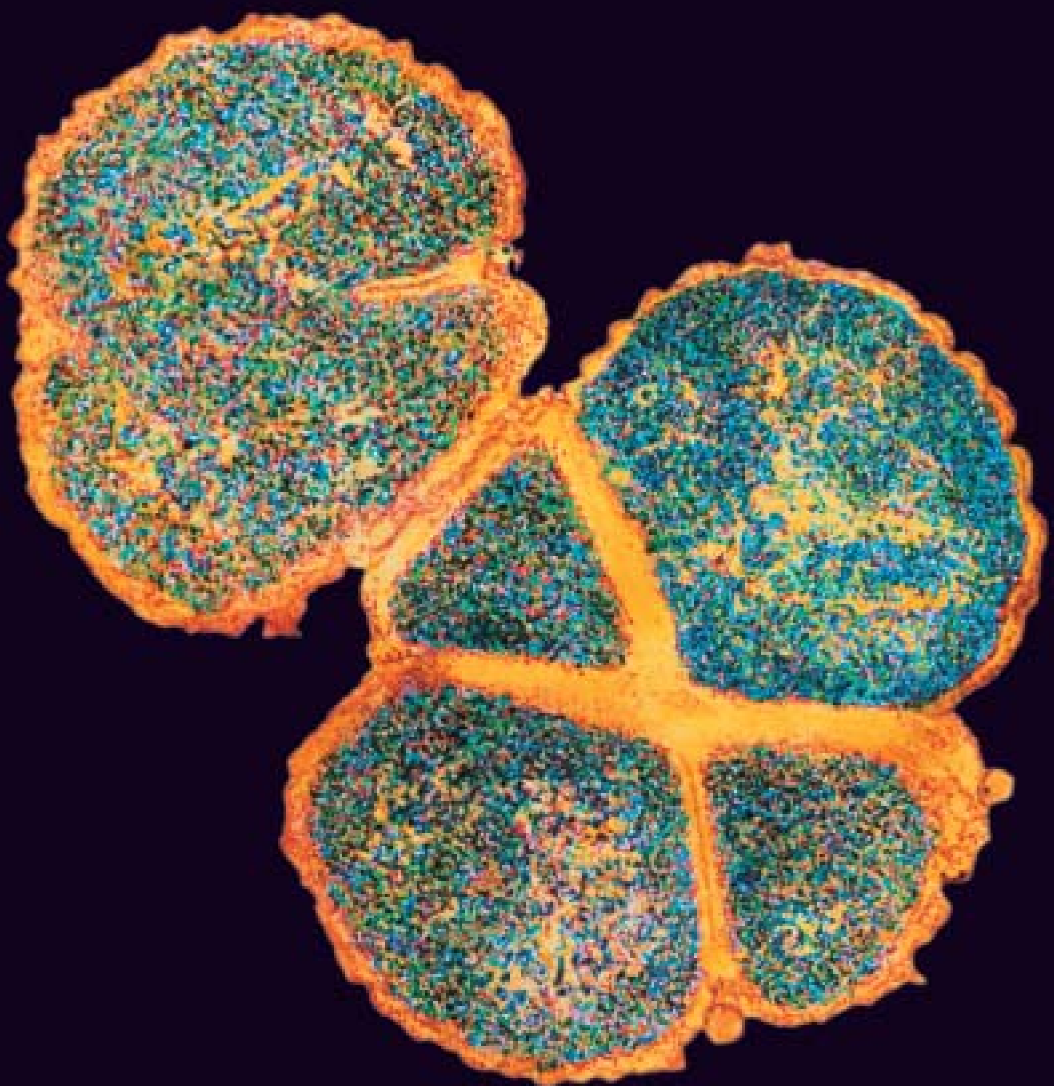
The distribution, incidence and severity of plant diseases is influenced by many interacting factors, including environmental conditions of which climate is the most important factor, and has a major effect on the development of plant diseases. To illustrate this point, potential effects of climate change on some key plant diseases in these marginal agricultural systems were considered by the Foresight project. A large proportion of damaging plant diseases in these marginal ecosystems are caused by viruses, and the majority of these are vector-borne. Cowpea mosaic and groundnut rosette diseases are transmitted by aphids; as is sweet potato feathery mottle virus, which combines with the whitefly-borne sweet potato chlorotic stunt virus (SPCSV) to cause the sweet potato virus disease complex. CMD and SPCSV are transmitted by whiteflies, *B. tabaci*, and the disease is also propagated through infected planting material. Maize streak disease is transmitted by leafhoppers, *Cicadulina* spp. Currently, abundance of each of these disease vectors is associated with higher than average temperature and rainfall. It might be expected that future temperature increases would favour greater vector abundance, but this may not occur in areas where rainfall declines. Reduced rainfall would have a greater impact on aphids and leafhoppers than on whiteflies. Thus, the picture is complicated and will also be influenced by other factors. Increased vector abundance may be offset by a decreased rate of pathogen development, particularly under the temperature increase projections at the upper end of the scale for the 2080s scenario. It is also likely that ongoing resistance breeding programmes will lead to the development of improved resistant or tolerant varieties. This would also work to reduce virus disease levels and their impacts on yield, food security and the income of the rural poor.

Fig 4.3 Climate change will particularly affect vector-borne virus diseases in subsistence crops. Ongoing resistance breeding programmes will help to offset the affects. Here, a farmer in Ugada enjoys bountiful harvest of cassava roots from mosiac-disease-resistant cassava variety Nase 4 (SS 4) developed by NARO, Uganda.

Most of the other important crop diseases in the arid and semi-arid ecosystems are fungal in nature. Two of the most damaging fungal diseases – southern leaf blight, caused by *Helminthosporium maydis*, and northern leaf blight, caused by *H. turcicum* – can be highly damaging to both maize and sorghum. These diseases require moist and humid conditions for optimum development and it is likely that their distribution will change according to future rainfall distribution patterns. Sorghum head smut, caused by *Sporisorium holci-sorghi*, is a soil-borne pathogen that is likely to be favoured by hotter and drier conditions. These conditions will lead to more rapid pathogen development and generally an environment more conducive to pathogen survival and increase. In areas where maize is replaced by sorghum, some of which are already marginal for maize cultivation, sorghum head smut is likely to become a more serious constraint to crop production.

In conclusion, future climate change is likely to affect the performance of a number of crops and the incidence and severity of some plant diseases in Africa. The geographical distribution of some plant hosts and disease pathogens will alter as a result of future changes in the climate. This effect is likely to be strongest in areas of significant water stress. This will bring about significant impacts on crop yields, food security and the income of the rural poor. The need is therefore urgent for Africa and partners to begin to deal with this problem now.

5 Culture and governance: contrasting sub-Saharan Africa with the UK and China



5 Culture and governance: contrasting sub-Saharan Africa with the UK and China

Having identified the diseases that could be important in the future (Chapter 3), this chapter considers the systems of culture and governance within which those diseases would need to be managed. This is important if new DIM systems are to be workable and effective.

As before, humans, animals and plants are considered in turn. However, since many diseases are global in nature and will need to be tackled internationally, the situation in sub-Saharan Africa is compared with two contrasting geographical regions – China and the UK. Public attitudes to risk are discussed separately in view of their particular importance in managing diseases.

Finally, issues of culture and governance in relation to humans, animals and plants are compared in order to draw out common issues for future consideration.

5 Culture and governance: contrasting sub-Saharan Africa with the UK and China

By nature, infectious diseases spread from individual to individual and from area to area. Their importance lies in their propensity to affect communities, herds, flocks, plant clusters causing outbreaks of illness, death, poor growth and/or productivity. Therefore, their detection and management are strongly linked with societal attitudes, culture, anthropology, farming systems, community participation and, above all, governance. Indeed, the need for the co-ordinated management of infectious diseases was the historical basis for organised medical and veterinary professional training, for setting up public sector health systems and for setting up such international agencies as the WHO, the OIE, the IPPC and the Animal Health Unit of the FAO.

This chapter examines the impact of culture and governance on the DIM of infectious diseases as well as their management. It takes an African perspective, but compares Africa's situation with that of the UK and of China. This comparison helps to expose the diversity of local cultural systems with which international and global responses to diseases need to interface. It also exposes the strengths and weaknesses of differing approaches to governance, although it is recognised that these operate under very different constraints in different countries. The material in this section is drawn from the studies on culture and governance (D4.1–D4.3); a study on the public perception of risk (D7), the Entebbe workshop (A4) from literature analysis as well as personal experiences.

The initial sections examine the impact of culture and governance separately on animal, plant and human diseases. This is followed by an examination of African anthropological perception of disease risk. The chapter concludes with an examination of culture and governance issues common to the management of infectious diseases of animals, plants and humans.

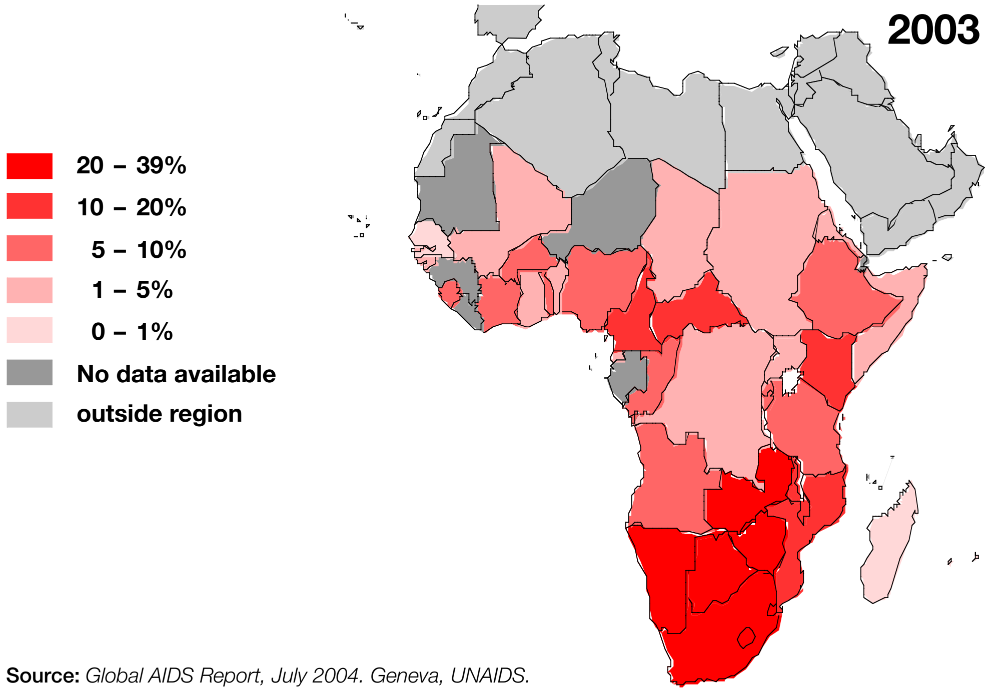
5a Specific issues for human diseases

In order to illustrate some of the most significant current influences of culture and governance on the DIM of infectious diseases, two examples have been selected from Africa and, by way of contrast, one example has been selected from China (SARS) and on from the UK (food-borne disease).

HIV infection in Africa

In recent years, HIV infection in Africa has demonstrated the importance and impact of culture and governance on the control of human diseases:

Fig 5.1 HIV prevalence in adults in sub-Saharan Africa, end 2003



Source: *Global AIDS Report, July 2004. Geneva, UNAIDS.*

Governance

In the last 20 years, we have learned that good political leadership, at least with respect to HIV epidemic, has a major impact on the control of the epidemic. The experience of Uganda can be used to illustrate the point. When the president of Uganda came to power in 1986, the HIV prevalence in Uganda among antenatal attendants stood at 32%. Currently, it is estimated at 6%. This has been attributed to, among others things, the fact that President Museveni has been very open about HIV infection in Uganda and invested a lot of time educating the masses about HIV infection in every speech he made. This created an environment in which the Government was visibly treating HIV infection as a priority and was consequently able to attract large amounts of financial and human resources to take forward prevention of and research into HIV. In addition, it developed a model where both government and non-governmental organisations (NGOs) were able to talk and work together in a multi-sectoral approach. It is clear that in those African countries where there has been a strong political commitment to confront the HIV/AIDS problem, great strides have been taken in controlling the epidemic.

Cultural practices

There are many sexual and cultural practices in Africa. Some facilitate the spread of HIV. Among those that increase the spread are widow inheritance, the sharing of wives among relatives, the culture of having multiple partners at once, and traditional practices involving cutting skin (especially in the face) with unsterile and shared instruments. The need to identify the occurrence of these cultural practices and to educate the populations about them is paramount. Changing such behaviours isn't easy and in most cases would involve completely giving up the practices, which would be particularly difficult to achieve in rural areas.

However, there are also practices that reduce spread of HIV. For example, being a virgin at your wedding is highly prized and there are calls to return to this practice. More generally, people delaying the age at which they first have sex is often seen as a sign of behaviour change that will also reduce HIV infection, especially in young people.

Meningitis in sub-Saharan Africa

Serious seasonal meningococcal meningitis outbreaks occur in sub-Saharan Africa from November to June, affecting thousands of patients and resulting in a high death toll. This case study explores factors affecting the timely detection and investigation of such seasonal epidemics.

All physicians in the country are well aware of the seasonal nature of meningococcal epidemics. The disease is under mandatory notification, as recommended by the WHO regional office, and patient care guidelines are available in most facilities. Physicians often use presumptive antibiotic treatment for meningitis because of a lack of laboratory confirmation. Cases are registered on the hospital logbook and reported to the district public health authority on a weekly basis, giving the total number of cases cared for in the previous week in two age categories, under five and five years and over.

Even if hospital-based clinicians can detect an increase in cases seeking medical care, public health interventions are triggered by district-level incidence calculations in accordance with national guidelines. Thus, primary care providers are not in a position to trigger an alert.

The investigative response to an alert consists of sending appropriate sampling equipment and transport media to hospitals in the district to enable the collection of samples so that the circulating strain can be determined. Often stocks of such equipment are kept at district level and shortages are not uncommon.

The timeliness of the investigation is crucial in order to allow an effective response. A seasonal epidemic may sweep across districts in a few weeks, and the success of a mass campaign relies on an early mass vaccination before the epidemic peaks. Delays can occur when hospital doctors are overwhelmed with other clinical obligations in poorly staffed health centres. In addition, some hospital doctors are also involved in concomitant private practice. Samples need to be promptly processed by a reference laboratory and transportation remains an issue in many districts.

If the alert threshold is sustained for two weeks in a row, a mass campaign should be launched once the circulating strain has been identified. District commissioners are informed but are sometimes reluctant to intervene because of the implications of such a decision in districts affected by political unrest.

Vaccine stocks are usually kept centrally or at provincial level and have to be kept refrigerated. Black market sales of vaccine is not unusual since vaccination is a requirement for attending the Hajj pilgrimage. It has been documented that at times vaccines have been faked or repackaged after use with inactive products. In addition, social and religious unrest in some areas has resulted in the population lacking trust in vaccination following suggestions that injections could be used to poison or sterilise them.

International NGOs have long provided support to these countries in responding to meningococcal seasonal epidemics.

We can conclude that the threat posed by seasonal epidemics of meningococcal meningitis is well known in these countries and perceived as important. Recognition of the threat, however, doesn't necessarily impact on timely identification and response. The main factors influencing the detection and investigation of meningococcal outbreaks in sub-Saharan African countries relate to:

- delays in the decision-making process
- a lack of resources and motivation from the public health staff
- the potential political or religious impact on acknowledging the epidemic.

While health is generally identified as a public good, governance is challenged by the lack of resources, the sensitivity of minorities and weakness in relation to corruption. In addition, public health governance relies heavily on international agencies and NGOs, which results in a lack of investment by national authorities.

China: SARS

SARS represents a newly recognised disease that apparently started in China. The earliest local event that might reasonably have been considered a significant public health event took place on 15 December 2002, when a patient from Shenzhen was admitted to hospital in Guangdong Province with severe pneumonia. In the following days, several additional patients were admitted and six physicians and nurses in the hospital presented with respiratory symptoms. The Department of Health of Guangdong province despatched a team of epidemiologists, microbiologists and infectious disease specialists to investigate the outbreak. The investigation attributed the outbreak to atypical pneumonia and recommended infection control measures to prevent further transmission.

In mid-January 2003, family and hospital clusters of similar severe pneumonia were detected in Zhongshan City. The Guangdong Centre for Disease Control carried out a field survey and a preliminary report was presented to health authorities of an outbreak of respiratory infection of unknown origin (not a reportable disease at that time in China). The report estimated the incubation period to range from 1 to 11 days, and suspected the transmission to be either from person to person or through indirect contact. The causative pathogen was unknown. A request was sent to the China Centre for Disease Control in Beijing to assist in the investigation of this outbreak of unknown origin and a Beijing team visited Guangdong.

Even though there was a mechanism in place to report a public health emergency, this was not triggered in a timely way. Physicians had never encountered such an emerging disease, and lacked experience in responding appropriately. At this stage, they were not able to assess the magnitude of the threat. Delays in the implementation of preventive measures resulted in a failure to control the spread of the disease in the community.

A threat to governance: the temptation to conceal information

In February 2003, the disease peaked in Guangdong province, with 10–15 new cases admitted daily. On 9 February, the WHO issued a global alert from its Geneva headquarters reporting the occurrence of more than 300 cases of SARS, with the main focus being reports from Vietnam. By the end of February, 789 cases had occurred in Guangdong province, and cases were reported from Hong Kong, Vietnam, Singapore and Canada. In March 2003, travellers returning from Guangdong spread the disease to Shanxi, Beijing, Guangxi and Hunan provinces. From March to mid-April 2003, SARS spread rapidly in Beijing and the northern provinces of China.

A challenge for governance: the need for national co-ordination

In April, 2003, large Chinese teams were dispatched to the provinces to undertake further investigations. National authorities probably realised the extent of the problem after an international alert was issued, along with a travel advisory notice to the province. Because of delays in communications, timely epidemiological information was not available at national level. In mid-April 2003, a consultation with all the provincial health authorities was undertaken, which showed that other provinces were facing a similar increase in cases of severe acute respiratory syndrome. The State Council reviewed reports from the provinces and realised that the Ministry of Health had not communicated information about the extent of the epidemic. Furthermore, it was apparent that the control measures had not been effective in preventing the spread of the disease.

It was decided that co-ordination of the investigation and response was a national priority, but the task proved to be difficult in the absence of procedures for implementation. This deficiency resulted in discrepant information being released from different sources and provinces. Variing case definitions were used in the provinces, sometimes in an attempt to lower the magnitude of the problem, despite the fact that country leaders had issued directives to ensure that no under-reporting took place.

A switch of governance: the involvement of the Communist Party

Because of these failures and specifically the under-reporting in Beijing, the Minister of Health and the Deputy Mayor of Beijing were dismissed from their positions and the State Council took control. The Chinese Communist Party organisation was used to launch mass intervention and ensure that national decisions were translated into local actions and policies. SARS was included in the public health law as a reportable disease, national guidelines were issued, and some theatres and other recreational facilities closed down. It was announced that treatment of people with SARS would be free and a new hospital for SARS patients was built in eight days. Millions of residents were mobilised to clean private and public facilities and attend public health lectures. A ‘patriotic public health campaign’ was launched. Overall, these measures were accepted by a population inclined to comply with party regulations. Information was still generally controlled at national level in order to minimise the political impact of the outbreak and to ensure stability. However, these belated control measures were too late to prevent the impact on international trade and travel as the problem had already become a global governance issue.

The number of cases started to decrease towards the end of May 2003 as strict control measures were implemented and guidelines developed. By the end of June 2003, the SARS epidemic was under control in China as the switch of governance approach resulted in the implementation of effective control measures.

The main factors producing delays in the detection and investigation of SARS were related to: (i) an approach targeting individual patients rather than communities; (ii) the lack of tools allowing the monitoring of the epidemiological situation, notably there being no formal cluster detection and reporting system; (iii) a dilution of the chain of responsibility; (iv) a lack of horizontal and vertical communication; (v) a denial of the magnitude of the problem; (vi) a weak co-ordination mechanism at national level, with a small and underpowered Ministry of Health with low status among national bodies; and (vii) a general neglect of public health as local, provincial and national functions.

After large epidemics in the first part of the 20th century had largely been controlled, health and healthcare gradually lost their recognition as a public good in the country. The main governance issues were related to the weak articulation between local and national bodies, resulting in poor information sharing. Co-ordination was complicated by the complexity of the healthcare system, with district and provincial bodies (governorates and mayors) and a national Centre for Disease Control under different structures and a lack of any overriding public health system. A switch of governance was required to control the outbreak, but this happened late in the course of the epidemic. Furthermore, the vertical governance approach of the national authorities, linked to the former International Health Regulations, conflicted with the global governance approach of the competent international organisations.

United Kingdom: food-borne disease

Food-borne disease remains a major cause of morbidity in the UK and other industrialised countries. It is estimated that food-borne infections in the UK probably affect at least 1.3 million people a year and cause about 500 deaths. A study of all infectious intestinal disease (IID) suggested that the annual cost to the country was in the order of £750 million. The timely DIM of food-borne infections and their causation is vital for the effective control of common sources of infection and the identification of contributory factors in food production, distribution and preparation. When foods of animal origin are implicated, DIM is particularly challenging because of the many agencies and services that have to be involved at local, national and international levels.

The requirements for effective DIM include a good, open working relationship between clinicians, microbiologists and public health staff, a laboratory capacity to detect and characterise the germs, a robust surveillance system and a responsive epidemiological service to identify and investigate unusual patterns of disease in a timely manner. Furthermore, once food-borne disease is suspected, the Health Protection Agency (HPA) has to work in close collaboration with the environmental health officers in local government departments and with the State Veterinary Service. When significant outbreaks are detected, the involvement of central government departments – the Department of Health, the Department for Environment, Food and Rural Affairs, and the Food Standards Agency – is required.

In the UK, there have been recent organisational changes at both national and local levels, so the boundaries of responsibilities among the different agencies are still evolving. The complexity of co-ordination is proving to be a challenging issue in governance at the local level as there are competing needs for curative services and public pressure to reduce hospital-acquired infection. At national level, the newly established Centre for Infections (CI) carries overall national responsibility for the surveillance of infectious diseases but its efficiency depends significantly on what happens at the local level.

Comparison and concluding remarks for human diseases

Overall, the influence of culture and governance on the DIM of human diseases in sub-Saharan Africa, China and the UK is summarised in Table 5.1. It is worth noting that the one particular factor that was identified by the survey respondante as having a consistently prominent influence in all three parts of the world was: 'religious or societal beliefs/concerns'. However, while this was ranked consistently highly in all three parts of the world, it does not necessarily imply that this is the single most important factor in any particular country.

Table 5.1: Comparison of the influence of governance and social factors on the DIM of infectious diseases in humans in the three case studies

Culture and governance issues		Sub-Saharan Africa	China	UK
Governance	International	+	+	+++
	Regional/supra-national groupings	++	+	++
	National	++	++	+++
	Local/provincial	++	+++	+++
	Ability to implement measures through legal or coercive measures	++	+++	+
	DIM interaction with control mechanisms	+	++	+++
	Investment in science and technology	+	++	+++
	Data-sharing culture	++	+	+++
Social aspects	Religious or societal beliefs/concerns	+++	+++	+++

Note: + suggests a limited influence and +++ a prominent influence currently; dark yellow shading indicates aspects most likely to be of greater importance in 10–25 years' time.

The Entebbe workshop (report A4) also examined culture and governance issues in the context of facilitating disease control programmes. The experts came to the view that in developing and implementing disease control policies, governments have placed far too little emphasis on the importance of culture in the successful implementation of programmes, despite this having a big influence on the success of programmes (as shown in Table 5.1).

Poor understanding and acceptance of new methods – for example, bed nets, new vaccinations – will lead to the failure of major programmes. Further, many African farmers believe disease and its effect on the crops in their fields to be brought about by witchcraft or by soil problems. This makes timely intervention immensely difficult. Participation by communities in developing disease control programmes will reduce this risk. The workshop concluded that there was a need for greater public education, sensitisation and greater involvement of and ownership by beneficiaries in infectious disease programmes right from the outset. In examining policy, capacity and governance across the continent, central Africa and the Horn of Africa were considered to have the greatest difficulty in addressing these needs, while South Africa had the highest, along with other SADC countries, with east and west Africa in an intermediate position.

5b Specific issues for animal diseases

Infectious animal diseases are gaining in importance beyond the objectives of animal welfare and farm income economics. Recent experiences with animal epidemics in areas previously considered free of them (e.g. the UK) have been very costly and disruptive, affecting not only the livestock industries but also the wider aspects of rural livelihoods and the rural economy. There is a realisation that animal diseases or infections increasingly have multi-sector effects, as they: (i) cause disease, suffering and death in animals (i.e. they affect animal health and welfare); (ii) cause disease or death in humans (i.e. they affect public health), as well as influencing perceptions related to the safety of food; (iii) result in trade restrictions; (iv) adversely affect rural incomes and livelihoods; (v) adversely affect non-livestock rural industries; (vi) have detrimental environmental effects; and (vii) adversely affect national economies for those countries with a heavy dependency on agriculture. Finally, project research has shown that some 75% of all new and emerging human infectious diseases of the last 25 years originated in animals.

The study of the interaction of culture and governance on the management of animal diseases has drawn on three categories of animal diseases as exemplars:

- FMD
- swine killers, i.e. ASF and classical swine fever (CSF)
- poultry killers, i.e. AI and Newcastle disease (ND).

Referring to Table 5.2, all three categories of disease are exotic to the UK. China experiences periodic outbreaks of FMD (types O, A and Asia-1), AI, ND and CSF. China has never experienced ASF. In contrast, sub-Saharan Africa has the heaviest burden of animal diseases, and all the exemplars, except AI and CSF, are endemic in most parts of sub-Saharan Africa. Furthermore, the region experiences six of the seven serotypes of FMD, three of which (SAT-1, SAT-2, and SAT-3) are indigenous to Africa. The presence of highly infectious animal diseases in endemic form in sub-Saharan Africa has been a primary impediment for international market access by African livestock commodities.

Table 5.2: Status of exemplar animal diseases

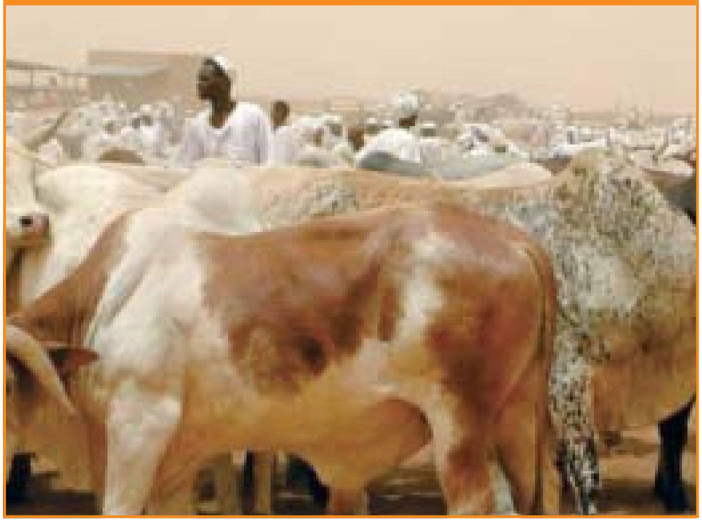
Exemplar disease	Sub-Saharan Africa	China	UK
FMD	Endemic – six of the seven serotypes	Controlled endemic	Exotic (2001); high national concern
Pig killer – CSF	Exotic (Madagascar and South Africa)	Controlled endemic	Exotic (2000)
Pig killer – ASF	Endemic – serious losses	Exotic (2000)	Exotic – never
Poultry killer – ND	Endemic – village poultry	Endemic – controlled on large production farms	Exotic (1997; 2005)
Poultry killer – Avian influenza	Exotic (South Africa H5N2)	Endemic – control measures; part of east Asian epidemic of H5N1	Exotic (1992)

Social and cultural attitudes

These diverge between sub-Saharan Africa, the UK and China, reflecting the divergences in the livestock farming systems.

- In **sub-Saharan Africa**, the agro-pastoralists and pastoralists are primarily concerned about animal diseases that affect the viability of their livestock (Figure 5.2). Because they are not deeply involved in formal trade, they tend to have relatively little concern for such non-killer diseases as FMD. Transhumance is a widespread practice in sub-Saharan Africa and this leads to the spread of infectious diseases. Another aspect that is peculiar to sub-Saharan Africa is the widespread practice of gift exchanges involving livestock. These have the potential to spread disease. The conservation and ranching of wildlife fauna is another special feature for the DIM of infectious animal disease in sub-Saharan Africa.

Fig 5.2 Omduran cattle in Sudan
Source: Dr Peter Roeder, FAO Animal Health, FAO, Rome



- In the **UK**, society increasingly demands high standards of livestock-derived commodities with respect to composition, safety and animal health. So the pressure for DIM is at farm and individual animal level. The farming community demands ‘zero tolerance’ of infectious diseases in order to protect profitability. Consumer pressure is such that people demand assurance of the quality and health safety on each purchase of a livestock-derived food package. In the UK, a large proportion of purchases are from supermarkets.
- In **China**, there is a co-existence of large-scale farming enterprises against a background of predominantly small-scale farming. This also reflects itself in the attitudes towards infectious diseases. Partly out of cultural custom and partly out of a desire to avoid livestock marketing and slaughtering taxes, a few of the backyard or small-scale producers in remote ethnic rural areas still sell locally and slaughter, at home, one pig at a time. Moreover, as part of their culture and tradition, the majority of Chinese prefer to buy live chicken rather than meat, especially frozen or processed meat. This increases the risk of spreading livestock diseases through markets and of spreading zoonoses, such as AI, to humans. However, in the urban centres, there is a growing demand for food safety and food quality. And the large-scale livestock farm enterprises in China are just as concerned about biosecurity as their counterparts in the UK.

Table 5.3: Societal attitudes to infectious disease

Attitude and drivers	Africa	UK	China
Societal tolerance of infectious diseases	Moderate	Near-zero	Variable
Driver for attitude	(Animal survival/viability)	Food safety and (animal) welfare	Economic return

Governance through state veterinary services

In the past, this has also varied between the UK, China and sub-Saharan Africa. However, there is now a growing acceptance in the three exemplar regions that the DIM of infectious diseases is a public good.

Table 5.4: Public v. private goods services (based on: Holden 1999[5]; Rivière-Cinnamond 2004)[6]

Public good service	Private good service
Epidemic or zoonotic disease control (surveillance, movement control, quarantine services)	Endemic disease control and prevention
Control of food-borne diseases	Clinical services and veterinary clinics
Some extension	Some extension
Some research	Some research
Diagnostic services for epidemic, zoonotic and food-borne diseases*	Diagnostic services (endemic infectious and non-infectious diseases)
	Vaccine production
Tsetse control on communal land using traps. Targets or aerial spraying	Dips

**Deduced from the identification of surveillance as a public good service*

- In the **UK**, the DIM of infectious animal diseases has always been accepted to be a public good service. The control of such diseases is regulated by enforceable legislation.
- In **China**, most veterinarians are employed by the state and the responsibility for infectious diseases lies with the state. Implementation at grassroots level, however, relies heavily on sub-professional cadres, including the ‘barefoot’ veterinarians. There is extensive and unregulated movement of livestock commodities between provinces and sometimes across international borders among common ethnic groups. Such movement has been associated with the inter-provincial or cross-border spread of each of the three indicator diseases (FMD, CSF and AI). The control of such diseases is based on legislation and planned vaccination campaigns.

[5] Holden, S. (1999) The economics of the delivery of veterinary services. Rev sci tech Off int Epiz 18, 425–439.

[6] Rivière-Cinnamond, A. (2004) *A public choice approach to the economic analysis of animal healthcare systems*. PLPI Working Paper No. 11. Pro-Poor Livestock Policy Facility. Rome: FAO.

- In **sub-Saharan Africa**, veterinary services have been in a state of flux in the last 20 years. They have been dominated by the lack of financial and human resources, a weak livestock industry, a weak regulatory framework and too frequent organisational or structural changes imposed by donors or national political systems, or necessitated by natural or man-made disasters like civil strife and the devastating impact of HIV/AIDS. There is a growing realisation that some of the structural adjustment programmes did not take the public or common good aspects in animal health services sufficiently into consideration. DIM, however, will need to be regarded not merely as a national public good but also as an international public good.

In recent years, the attitude of the professionals and governments in sub-Saharan Africa has shown:

An increasing tendency towards:

- syndrome-based diagnosis only
- acceptance of ill health as common
- acceptance of sub-optimal performance/productivity as inevitable
- reactive treatments and vaccinations

A decreasing emphasis on:

- disease management
- surveillance and planning for a response to the outcomes of surveillance
- infectious disease outbreaks as emergencies – local or national prevention.

Animal health service delivery in sub-Saharan Africa is predominantly in the hands of sub-professional, trained personnel, whereas in the UK it is almost entirely delivered by veterinarians. Accordingly, the demands for DIM systems in sub-Saharan Africa may differ from those in the UK as a reflection of the cadre of personnel who will use them.

Table 5.5 shows how the delivery of animal health services differs between sub-Saharan Africa, China and the UK.

Fig 5.3 In Africa, vaccinations and other animal health activities are based on communal approaches. Vaccination is undertaken by veterinary technicians or auxiliaries. Future DIM systems should also target ready usability by sub-professional personnel.

Photo: FMD vaccination and surveillance in Zimbabwe –Dr Fred Musisi, FAO.

Table 5.5: A comparison of animal health service delivery capacity (FAO/OIE 2003)

Criteria	Sub-Saharan Africa	China	UK
Veterinarian: technician	1:3 (plus many more auxiliaries)	1:2 (plus many more barefoot veterinarians)	13:1 (no auxiliaries)
Veterinarian: livestock unit	1:15,704	1:3,788	1:390
Veterinary employment Non-governmental: state	53:47 (Tanzania)	12:88	93:7

Special considerations for infectious diseases of aquatic animals

For aquatic animal (mainly fish) diseases, the following are key culture and governance issues:

a Fishing is a harvesting of natural resources on which many communities depend for a livelihood. This raises the issue of promoting profitable and responsible artisan fishing within a sustainable livelihood framework.

b A major concern is the balance between the interests of large- and small-scale artisan fishing. At the global level, the issues of responsible fishing are being addressed, largely by the Kyoto Declaration and Plan of Action through the co-ordinating forum of the FAO of the UN.

c Aquaculture is a growing practice in sub-Saharan Africa, although it is still relatively poorly developed compared with China and Asia. As has happened with other forms of animal agriculture (e.g. broiler poultry), such intensification often leads to infectious diseases resulting in high rates of mortality and a serious constraint to production. Sustainable development of aquaculture requires DIM, as well as improved biosecurity and disease control policies. Accordingly, the DIM of infectious fish diseases is likely to assume greater importance in the future, with the expansion of aquaculture.

d In many countries in sub-Saharan Africa, the capacity for specific-agent diagnosis and monitoring of infectious fish diseases is limited. Laboratories for such work often operate at levels which are well below their counterparts for terrestrial animal diseases. There is a case for promoting synergy between the two.

e Government has a key role in the regulation of fish movement – in particular the introduction of exotic species – to prevent the introduction and spread of exotic diseases. DIM is fundamental to demonstrating freedom from exotic pathogens and to the early detection of new and emerging diseases.

f With respect to international standards, the OIE has a specific Aquatic Animal Health Standards Commission whose responsibility includes the production of the *Manual of Diagnostic Tests for Aquatic Animals and the Code for Aquatic Animal Health*. Issues of food safety are covered by the *Codex Alimentarius*.

Key issues for future consideration for animal diseases

a Stimulating the demand for DIM at the local level through progressively promoting livestock as a formally tradable commodity at local, national, regional and ultimately international level.

b Promoting livestock farmer training school schemes in order to stimulate both technology uptake and the concept of livestock farming as a business. Pastoral and agro-pastoral communities would be interested in the DIM of infectious diseases if they can associate that with market access and enhanced income from their livestock commodities.

c Promoting primary animal healthcare at village level and rural private veterinary practices through financial incentives and government contracts for publicly funded, public good services, including those targeted at improving DIM.

d Promoting primary diagnostic or veterinary investigation centres at sub-national level and low-cost technologies for DIM that are appropriate for such laboratories.

e Promoting DIM projects based on the concept of virtual centres of networks across administrative and disciplinary/professional boundaries with south–south and north–south collaborative research programmes or smart partnerships.

f Giving specific attention to effective DIM systems that are readily applicable to infectious animal diseases in the rich and diverse wildlife fauna of sub-Saharan Africa.

g Promoting the concept of national institutes of infectious diseases applying common technologies and facilities for human, animal health (i.e. both terrestrial and aquatic animals) and plant infectious diseases.

h At the global level, promoting the proposed joint FAO–OIE–WHO global early warning system for infectious animal diseases and zoonoses.

Overall, the influence of culture and governance on animal diseases in sub-Saharan Africa, China and the UK is summarised in Table 5.6.

Table 5.6: The influence of culture and governance on various aspects of DIM of infectious animal diseases – a comparison

	Culture and governance issues	Sub-Saharan Africa	China	UK
Governance	International – OIE Code	++	+++	++++
	National	++	+++	++++
	Local	+++	+++	++++
	Ability to implement measures through legal or coercive means	++	+++	++++
	Interaction with control mechanisms (e.g. culling, vaccination)	++	+++	++++
	Subsidy	+	++	++++
	Data sharing	++	++	+++
	External (regional or donor) funding	+++	+	+
	Policy determination by external agencies (regional, donor, international agencies)	+++	+	+
Social and cultural aspects	Value-based judgements	+	+++	++++
	Societal attitudes to the disease	++	+++	++++
	Societal attitudes to managing the disease through DIM	++	+++	++++
	Internal and cross-border intra-regional movement (transhumance or trade) in disease spread	++++	+++	+
	Intercontinental risk of spread	++	+++	++++
	Religious attitudes to DIM measures	++	+	+
	Attitudes to animals/humans welfare/contact	++	++	++++
	Epidemic or vector-borne killer diseases	++++	++++	++++
	Epidemic trade-limiting, non-killer diseases	++	+++	++++
	Productivity limiting diseases	++	+++	++++
	Zoonotic diseases	++	+++	++++

+ = lowest influence	*++*	*+++*	*++++ = highest influence*

[7] By official definition, the term 'surveillance' means an official process to collect and record data on pest occurrence or absence by survey, monitoring or other procedures. Guidelines for such surveillance or monitoring are provided in the international standard for phytosanitary measures (ISPM) No. 6. In this terminology, a survey occurs over a defined period of time to determine characteristics of a population of pests of concern or to learn what pests occur within a specific area. Monitoring is an ongoing process. While these terms are employed more loosely in this report, to match with the studies on animal and human health, in all cases surveillance and monitoring tap into various sources of information to obtain the best information on pests of concern.

5c Specific issues for plant diseases

Culture – defined as 'the arts, customs, social institutions etc. of a particular group or nations' – and governance – 'the activity or manner of controlling or directing the public affairs of a society, a nation or country' – have a significant influence on the DIM[7] and control of infectious plant diseases in Africa. Their influence is particularly great when plant diseases of crops threaten domestic food security, or internal and export trade and economic growth – many African economies are dependent on trade in crop produce and associated products.

To set the scene, this section begins with two exemplars of diseases from the Great Lakes region which vividly demonstrate the impact of culture and governance on the DIM of plant infectious diseases.

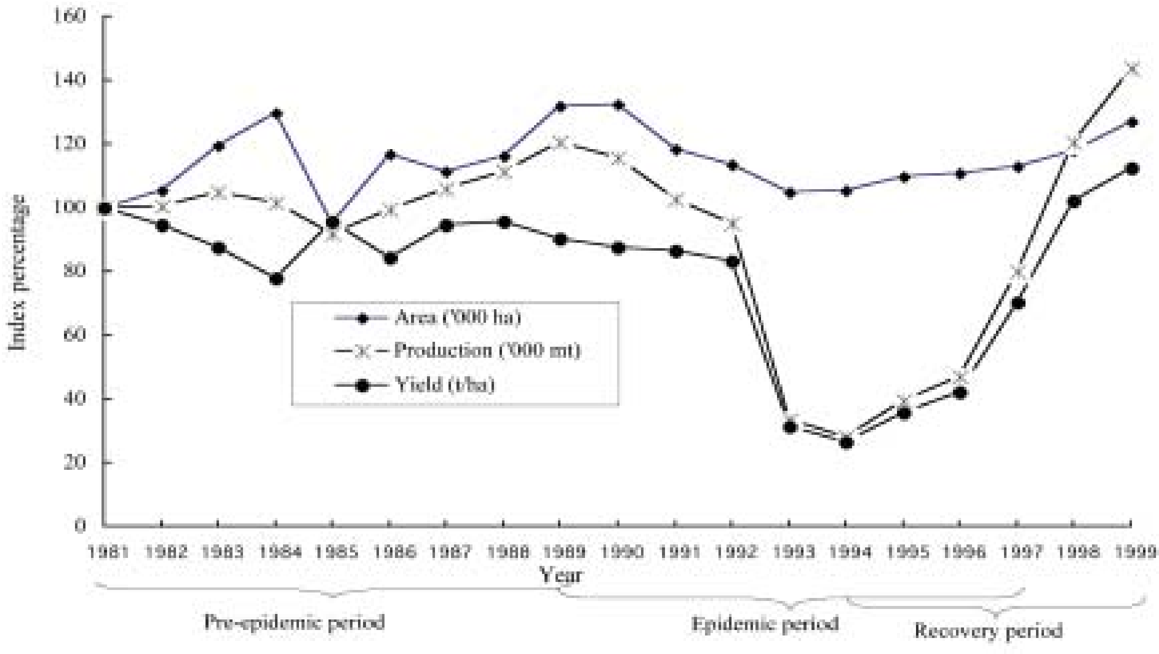
CMD pandemic in the Great Lakes region

Cassava has, for a long time, been a major food crop and source of prosperity in Africa. Prior to 1988, CMD had remained minor and endemic, hardly causing any serious concern. However, the situation changed drastically in 1988 with the appearance of a severe and epidemic form of the disease, initially in Uganda. The CMD epidemic led to an almost virtual elimination of the crop in most areas of the country, as all the available varieties were susceptible. In Kumi district, for instance, the area planted with cassava decreased from 30,000 hectares in 1990 to less than 3,000 in 1996. Similar decreases occurred in Soroti and many other districts of the country. The decline was felt most severely in 1993 and 1994, when total production and yield in the country declined by about 90%. Since 1989, CMD has spread to other parts of eastern and central Africa, affecting millions of people who, particularly in times of drought, depend on cassava for survival.

Conservative estimates indicate that annually from 1993, the epidemic in Uganda caused a loss of over 60,000 hectares of cassava, equivalent to over 600,000 metric tonnes (US$60 million) of fresh cassava roots in the country. This also resulted in massive food shortages and starvation in some districts, especially in the east and north of Uganda, where in 1994 unconfirmed reports estimated that 3,000 people had died of starvation as a result of famine caused by the epidemic.

The CMD outbreak was unprecedented and took everybody by surprise. The institutional arrangements (the cassava research programme) to deal with the problem were weak as the epidemic occurred soon after civil strife in eastern Uganda. The budgetary support to deal with the problem was minimal when the epidemic struck. Nevertheless, the Government was able to respond quite quickly and invested a total of US$2.5 million in controlling the disease over a ten-year period beginning 1989. The problem was effectively brought down and food security restored within ten years after marshalling adequate support and international collaboration.

Fig 5.4 Trends in production, area and yield of cassava in Uganda, 1981–1999 (base = 1981)



Coffee wilt disease in the Democratic Republic of Congo (DRC)

This disease (see Figure 5.5) is caused by the fungus *Gibberella xylarioides*. The disease was first observed in the Central African Republic in 1927, and spread, destroying large areas of coffee production in west and central Africa. Its impact was subsequently been reduced to a minor level by the use of *robusta* coffee resistant varieties and by uprooting and burning infected trees, followed by a two-year fallow period. Coffee wilt resurfaced as a serious disease, however, in abandoned coffee farms in the 1970s and in plantations in the 1980s in the DRC and spread quickly to Uganda, perhaps due to people fleeing from the conflict zones in the DRC during the war periods. Even with the quarantine facilities in Uganda, the informal trade sector and exchange of plant material made it difficult to monitor the movement of plant materials between the DRC and Uganda.

Fig 5.5 Progression of coffee wilt disease (clockwise from top left), from wilting; to dieback on one side of a coffee stem; to total tree death; and death of several or all coffee bushes in a farm leaving only stumps

Although coffee is the most important cash crop, a major source of household income, and is fundamental to the livelihoods of those in more than 20 African countries, coffee wilt disease has become rampant and little attention has been paid by national governments to managing the problem. It took too long from the time of recognition to the detection, identification and surveillance of the subsequent disease spread. Initially, this was due to the challenge of conducting any surveillance in areas in conflict. Yet there was also a lack of preparedness and absence of an early warning system to trigger response in the neighbouring areas. Existing institutions dedicated to coffee research supported its DIM after the initial discovery of the disease. However, even after the disease was identified, the lag time in response suggests a lack of technical and institutional capacity and a lack of an adequate strategy and plan to deal with the problem. Inadequate budgetary support has also been a problem.

There are many other examples, such as cocoa swollen shoot virus disease in west Africa in the 1950s and 1960s and the current ravages of banana Xanthomonas wilt disease in east Africa, that have been greatly influenced by culture and governance. In such cases, governments and the public alike have always reacted only when such plant disease epidemics have struck – a time when it is already too late for effective damage control. This contrasts markedly with the situations in China and the UK.

Components of governance that impinge on plant diseases

The examples described above show clearly that many factors greatly impinge on plant health governance in Africa. Some of these factors are briefly discussed below.

The absence of infectious diseases in government priority programmes has and will be a major hindrance to infectious plant disease control in Africa. Today, many African governments accord prevention and control of infectious diseases little or no priority in their national development programmes. This affects resource allocation in this very important area. To obtain effective results, a vision and commitment to promoting infectious disease surveillance and control are required from all governments in sub-Saharan Africa.

In addition, poor government policies, coupled with unsupportive legislation and regulatory frameworks and weak institutional arrangements adversely affect the infectious disease situation in Africa. At the moment, Africa often operates through a ‘rule of crisis’, characterised by reactive management of immediate problems. There is a lack of proactive strategy and planning for possible future problems. HIV/AIDS demonstrates this point very clearly, as do infectious plant and animal disease epidemics such as CMD, and coffee wilt and banana wilt diseases in the Great Lakes region. Continued poor disease control policies and a failure to develop improved ones will worsen the situation.

The poor regulation of pesticide use will facilitate the development of resistance and the loss of technology, thereby proliferating disease, as is the case with malaria in humans.

There is a need for Africans to assume leadership in infectious plant disease surveillance and control while working through smart partnerships that attract needed co-operation. Currently, Africans are passive, even on issues that greatly affect them, and are too often driven by donors. It is usual for African studies to be commissioned by donors and executed by western researchers. In many cases, African researchers play minor, supplementary roles. This has made it difficult to ensure continuity and the easy availability of data and information to others who need to use it.

The effective implementation of existing and new plant disease control policy and legislation is critical for infectious disease management in Africa. There have been many cases where government policies and programmes are not effectively implemented and this has affected the level of success in disease management. This can arise as a result of civil strife and wars, lack of institutional capacity, and inadequate resources.

Civil strife and wars are particularly important in Africa as they disrupt all programmes, destroy infrastructure and skilled human resources, and trigger massive human displacement through the movement of refugees across borders. This migration of refugees could introduce infectious plant diseases into new areas. Current widespread decentralisation of responsibility for plant disease control without the resources necessary to achieve this is another way in which policy makers fall short. Corruption in government also undermines plant disease control programmes as it deprives them of much-needed resources.

The co-ordination of infectious plant disease programmes is crucial. At the moment, many programmes are isolated and poorly co-ordinated, causing duplication in some cases. At the national level, more inter-sectoral and inter-ministerial co-operation and co-ordination is required to improve disease control. On the other hand, regional co-operation, and particularly networking of plant disease control operations, could greatly improve control by allowing concerted action and making optimal use of very limited human and other resources. A more strategic and co-ordinated approach to infectious disease management is critical if future risks are to be minimised.

Regional integration and globalisation are other major factors. New initiatives for regionalisation in Africa, aimed at improving economic growth, may have positive or negative effects on disease control. Removing regional trade restrictions (e.g. on moving seed within the East Africa Community) could make control more difficult. Failure to develop or implement the effective control of cross-border movement could greatly increase disease problems and detract from the benefits of trade. Globalisation will definitely increase trade in agricultural products and enhance the mobility of people across the world. The result could be a greater risk of introducing diseases to new areas.

Other challenges facing Africa include: (a) inadequate research into preventive methods for some diseases; (b) a lack of awareness and training among stakeholders; (c) difficulty in detecting latent diseases; and (d) overall lack of capability for DIM and the management of pathogens.

Capacity is a particularly relevant aspect of governance. It may be defined as ‘an ability to formulate and achieve relevant objectives, accomplish goals, and satisfy stakeholders’. It operates at individual, community, national and regional levels and involves human, physical and financial management. At the individual level, lack of skilled manpower to effectively deal with the problem has and will continue to affect the infectious plant diseases situation in Africa. Without more effort, there will be a shortage of skilled scientists, arising from insufficient training and a failure to retain trained personnel. Lack of support to African scientists has always led to most resources for African disease research going to scientists in developed countries. This has left African researchers frustrated and demoralised. At the community level, most Africans within the population are uninformed. Weak capacity will allow even manageable disease problems to escalate into epidemic proportions. Efforts will be needed to address these and related issues. For instance, education, sensitisation and creating awareness among local communities, the general public and other stakeholders are absolutely necessary to build their capacity to participate and contribute effectively to disease surveillance and control programmes. Furthermore, the power of religious and civil society organisations could be harnessed to improve capacity and participation at the community level. A strong infrastructure will bring about the effective management of disease problems.

The countries in sub-Saharan Africa do not have a comprehensive infrastructure. Sporadic high points are lost from the overall lack of framework for plant health so that new technologies will be difficult to adopt unless substantial support is given to those cultural and governance areas directly related to the application of the technology in question. Clearly, any situation involving the effects of war or natural disasters will prove an even more challenging environment for DIM. The most hopeful models for rapid improvement of the plant disease DIM system in that region for at least the next decade are to pool resources towards the creation of regional capacity and to create parallel systems funded by the export industry in the hope of getting by until the public sector system is improved. While this may seem pessimistic, one only has to consider the impact of a single technology – the mobile phone – to realise that technology can alter culture as often as culture affects adoption of technology.

Culture

In developing and implementing disease control policies, governments have placed far too little emphasis on the importance of culture. Yet culture has a big influence on their success.

The CMD pandemic is a good example. When the disease first hit some parts of Uganda in 1989, farmers believed that other farmers had bewitched their crops and that there was nothing they could do besides catching and punishing the witch. They further believed that the recommendations given by agricultural workers to select plant stems from healthy looking plants and to uproot any plants showing symptoms were inappropriate because traditionally their parents and grandparents would never have done this. They argued that their parents used to plant cassava stems collected from the field and the resulting plants would give good crop yields. To them, uprooting diseased plants was unethical because traditionally it was a bad omen to uproot any planted crop. They argued that even a diseased plant can give some yields, albeit a low one. These views had a big impact on the spread of the epidemic until the Government embarked on massive education and sensitisation campaigns. There have been similar experiences in the control of banana Xanthomonas wilt and coffee wilt, and many other crop diseases in Africa.

Sharing seeds is another important cultural factor in infectious disease spread. Traditionally, many rural African farmers use home-saved seeds and share these with relatives and friends. Such exchange of seeds can be an efficient method of disseminating seed-borne pathogens from one area to another and from season to season. Poor understanding and acceptance of new plant disease control methods is also a major factor because rural farmers believe in doing things the way their parents and grandparents always did. In addition, many African farmers believe that diseases and their effect on crops in their fields are either brought about by soil problems or by God and so there is nothing they could do to address the problem. This makes timely intervention immensely difficult.

Unless such issues are addressed, the influence of culture will lead to the failure of many plant disease programmes. Participation by communities in developing disease control programmes will reduce this risk. Nevertheless, better public education and sensitisation, as well as ensuring the effective involvement and greater ownership by the beneficiaries of infectious disease programmes right from the outset, should be mandatory elements of any programme.

Contrasting examples from the UK and China

In the UK, the Government accords priority status to plant health so that policies, regulations, standards and effective institutional arrangements and linkages to handle the plant health issues are in place and effective. The national and regional governments institute contingency plans and fund annual inter-institutional surveillance programmes, each backed by an effective lesson-learning exercise; collaboration; and information flow to all stakeholders. A common EU strategy and decentralisation of plant health governance under the guidance of a single central UK authority, supported by competent scientific institutions, promotes open and rapid communication among member countries, and quick response and containment of outbreaks. Further, in the UK, plans, procedures and protocols for possible disease outbreaks are prepared well in advance.

In China, the Government implements a decentralised and effective system of plant health governance and management and has strict regulatory, surveillance and monitoring systems backed by plans to contain new outbreaks. A decentralised plant protection system backed by effective research programmes enhances the efficiency and effectiveness of the system.

An examination of societal attitudes to crop agriculture in sub-Saharan Africa compared with those in the UK and China reveals some telling contrasts. For example, in the UK, the main driver is increasingly that of rural biodiversity and quality of rural life. In China, it is production targets and commerce. In sub-Saharan Africa, the primary driver is household food security with low-level targets for productivity. The net result is that African government policies pay inadequate attention to the prevention of disease spread.

Overall, the influence of culture and governance on the DIM of plants is summarised in Table 5.7, which compares the situation in Africa with that in China and the UK.

Table 5.7: The influence of culture and governance on various aspects of DIM of plant disease – a comparison

	Culture and governance issues	Sub-Saharan Africa (countries studied)	China	UK
Governance	International	++	+	+
	Regional	++	+	+++
	National	+++	+++	+++
	Local	+	++	+
	Ability to implement measures through legal or coercive means	++	++	++
	Interaction with control mechanisms	+	++	++
	Production subsidy	+	+	++
	Data sharing	++	+++	+++
Social aspects	Value-based judgements	+++	+++	++
	Societal attitudes to the host plant	+++	+++	+++
	Societal attitudes to managing the disease through DIM (recognition of public good)	++	+	++
	Religious attitudes to DIM measures	+	+	+
	Attitudes towards natural environment	++	+	+++

Notes: + suggests a limited influence and +++ a prominent influence; yellow shading indicates aspects predicted to be of greater importance in the next 10–25 years; grey shading indicates aspects perceived to be of decreasing influence in the next 10–25 years, though they could remain important.

5d Public perceptions of health risks – anthropological perspectives from Africa

Africanist anthropology can shed light on public understandings of and responses to the risk of infectious diseases and DIM by exploring various cultural and social factors that influence notions of disease and disease control. This section first examines understandings of person, body and sickness; cultures in Africa differ and change in regard to these concepts, which results in views of infectious diseases that tend to be at variance with a scientific model of 'risk'. The section continues then with an examination of societal and historical factors that shape responses to the control of disease risks through DIM in contemporary Africa.

Personhood and body

African personhood has often been described in contrast to western individualism. While this generalisation is contradicted by the universal role of individualism as ideology and lifestyle in the present globalised world, African ethnographic evidence suggests that there are indeed alternatives to an exclusive focus on the individual in the sense of a singular, bounded person, endowed with autonomous will and agency. The person may instead be constituted by relations with others, produced through kinship and other forms of substantial relatedness, and through flows of substance that link one person with others and with the environment, which often embodies ancestors and the past. Such 'non-western' understandings of personhood tend to value relations over boundaries and regard the person as a 'dividual' entity of sorts, and overlapping with other persons rather than being autonomous and indivisible. This notion of continuity and mutual extension of persons often includes the non-human environment as well as crops and livestock.

These observations convey a message concerning perceptions of risk: if one does not understand the person as a bounded, autonomous individual, a crucial condition of the notion of risk perception as an individual choice between avoiding or approaching a potential threat is not given. If the person is not the central locus of control and agency, adversity is not experienced, anticipated and countered in relation to single persons, but to a network of social relations. This leads to an emphasis on different threats (threatened relations rather than bodies) and countermeasures (ritual rather than vaccination).

Sickness

Non-individual models of personhood have implications for how people understand their bodies. An idealised individual body, as in a biomedical textbook, is an autonomous and indivisible organic unit that depends for its well-being on completeness and boundedness. Infringed boundaries equal sickness, which is countered with drugs such as antibiotics, which aim at eliminating pathogens and re-establishing firm boundaries around body and person. A 'dividual' body depends by contrast on its interfusion with other persons and bodies – relations with living and dead people, often embodied by land or material objects. Its well-being depends on flows between self and others, across porous boundaries. Sickness is in turn understood in terms of blocked pathways between inside and outside or between living and dead persons, and treatment aims at opening up the body, re-establishing relations.

For a composite body comprising different agents and continuous with others across its body boundaries, the risk of infectious disease may not be a priority. Many people entertain biomedical ideas of infection alongside 'non-western' understandings of sickness, producing complex patterns of practice. Most Africans know about HIV/AIDS, but many have priorities other than risk avoidance: the production of persons and of sociality. This often requires unprotected sexual intercourse, among other forms of physical communion. Another example is malaria: although most African mothers know about malaria, many are more concerned with the influences of other humans, social relations and the environment on their children's health. Even if one knows about infections, concerns with personhood might motivate action.

Difference and change in models of person and sickness

Cultural ideas about the person often exercise less influence on risk perceptions and behaviour than do mundane everyday constraints: people are exposed to HIV due to economic deprivation rather than cultural beliefs. Apart from this economic question, there is more than one culture in any modern social situation. Everywhere in Africa, biomedicine is present in the form of widely desired pharmaceuticals. Capitalism, the dominant economic form in most African societies, transports its own particular form of individualism and related notions of the body and sickness. A third important cultural force that propagates a different concept of the person and of her body – self-discipline and containment – is of course religion, i.e. Christianity or Islam.

Memories of DIM

Infectious disease research and control has been a continuous project since colonial occupation, which has shaped western medicine and has produced long-term memories and locally specific histories in Africa. DIM has been, and sometimes still is, the main source of biomedical care. These historical experiences have left positive memories of controlled diseases and new opportunities and negative ones of intrusive, forceful approaches and economic and power differences. While the formal ethics of disease control have been improved since colonial occupation, the continuing socio-economic differences within which disease control is situated remain a source of contention about resources and benefits.

For example, colonial veterinary and conservationist policies such as destocking are widely remembered as unjust and motivated by the colonial occupants' interests, and, like land reform policies, have often exacerbated economic hardship and differentiation. Such memories, along with more positive ones, continue to shape African thinking and responses to, for example, livestock health interventions.

Such memories are critical for notions of risk, disease and the DIM of infectious disease. Surveillance and control technologies are not simply welcomed but questioned by Africans in a broader frame than one could anticipate, and technologies of surveillance and disease control are surprisingly prominent in African memories. Interventions into African health have come and gone; surveillance and control has an ambivalent face in Africa; state and foreign powers have brought benefits and suffering. DIM has to find a place in a complex historical field.

Contemporary society

Public ambivalence towards DIM initiatives is exacerbated by the shape of most African states today and their relationships with their citizens. Some face unrest and external destabilisation; others have not recovered from economic restructuring; and even relatively stable states, with few exceptions, fail to deliver services to their people, notably in the field of health. The notion of the common good has been dissociated from the state, and trust in health interventions has been eroded. Foreign agencies have taken over some of the state's caring role and positive public perception, but their uncontrolled power and resources also cause ambivalence, as power does among the powerless.

The scepticism and unease of many ordinary Africans towards state and external agencies must be considered when introducing technological solutions to the continent's problems. No new measure, and no new agency bringing it, will simply be welcomed as an agent of public good.

Public debate on DIM

The ambivalence towards medical technologies and intervening agencies is reflected in public debates about disease, disease control and science in Africa, such as recent discussions in the newspapers of several countries about the alleged misconduct and exploitative research by foreign medical research units; rumours that AIDS is an American product to eradicate Africans and that free condoms are laced with HIV; or suspicions that blood taken by scientists to diagnose diseases is sold for personal profit. These debates and rumours present a continuum from political critique – why are scientific agendas often dominated by foreigners? – to occult explanations of economic difference – where does a scientist's relative wealth come from?

Irrespective of their 'rationality' by scientific standards, these rumours say something about African concerns with disease and medical technology in the context of an unequal world – a world that bears the traces of economic exploitation and abuse of power. These debates about history and politics deserve close scrutiny in different locations in Africa if we wish to design and implement appropriate and sustainable DIM measures there.

5e Key culture and governance issues for future consideration

The economic depression of the 1970s and 1980s in Africa, with the concomitant budgetary problems in the public sectors of many countries, culminated in major structural reforms of government systems. The main drive was to reduce state involvement in the provision of services and to shift the burden to individuals and the private sector. This led to an overall consideration of all health systems as a private-good service to be paid for by the individual beneficiaries, i.e. patients and farmers. So the management of infectious diseases as a public good became a marginal issue.

However, this adjustment now increasingly recognises the complementarity of public-good and private-good services, at least for both human and animal infectious disease management. Medical and veterinary services with distinct entities for infectious diseases, public health and zoonoses are becoming established in many countries. Plant protection, however, is still regarded mainly as a subsidiary activity to crop production in several African countries.

Overall, the impact of infectious diseases on society and on policies of governments and regional organisations appears to be underrated, although governments have shown strong support for such internationally co-ordinated programmes as the eradication of polio, rinderpest and CMD, as well as the current global initiative against HIV/AIDS, malaria and tuberculosis. An outcome of such a lack of clear policies for infectious diseases – in a continent that has the heaviest infectious disease burden – is the weakness in the institutions for the DIM and surveillance of infectious diseases and the epidemiological weakness in the definition of disease risk management strategies. Consequently, disease surveillance is not institutionalised as both a disease reporting system and a crucial component of disease risk management. Thus, the African experts observed at the Entebbe workshop (report A4) that for human and animal diseases, surveillance is often linked to specific disease control programmes/projects, while for plant diseases, co-ordinated regional surveillance and disease reporting are practically non-existent.

Fig 5.6 Community dialogue is an important component in surveillance and rural health delivery systems for human, plant and animal infectious diseases
Source: FAO photolibrary

Community awareness and participation as well as the promotion of community-based health delivery systems are likely to be important for the DIM and management of infectious diseases for all three sectors. This will be important, not merely from the perspective of cultural consciousness, but also from the perspective of efficiency of delivery of a system for DIM and disease risk management. Surveillance and health delivery in the next 15 years is likely to continue to be heavily dependent on sub-professional technicians, including community-based health workers. Therefore the importance of community dialogue cannot be over-emphasised (see Figure 5.6). Furthermore, for all three sectors, there is a strong case for promoting diagnostic or disease investigation centres at sub-national level and for promoting low-cost technologies for DIM that are appropriate for such laboratories and/or for point-of-contact/care diagnosis.

For both plant and animal diseases, it is important to link DIM and disease management systems visibly to such development goals as food security and poverty reduction through sustained marked access. In particular, the efficiency of uptake of DIM systems and disease reporting by livestock farmers will need to be perceived by society as progressively promoting livestock as a formally tradable commodity at local, national, regional and ultimately international level. So far, Africa is barely a participant in the international marketing of livestock commodities.

A consistent thread in the three sectors has been the institutional weakness in DIM for current technologies, which will become worse when the evolving technologies (Chapter 7) come on stream. The concept of national virtual centres for infectious diseases that links relevant institutions across administrative and sector lines, as well as the Pan-African Vision and Strategy for the Management of Infectious Diseases proposed in Chapter 8, raises issues for further consideration.

An aspect that may require deep analysis is the management of surveillance and disease risk management with respect to inter-species transmission between wild animals (terrestrial and aquatic), farmed animals (also terrestrial and aquatic) and humans. This is likely to be of increasing concern, especially in the face of the evidence that some 75% of emerging human infectious diseases originate in animals, as is the increasing concern for food safety. Nevertheless, it should be noted that, in Africa, the lack of a consistent surveillance programme for infectious diseases in wild animals, with a clear link to veterinary and medical systems, represents a major weakness in the understanding of inter-species disease transmission, and merits future consideration.

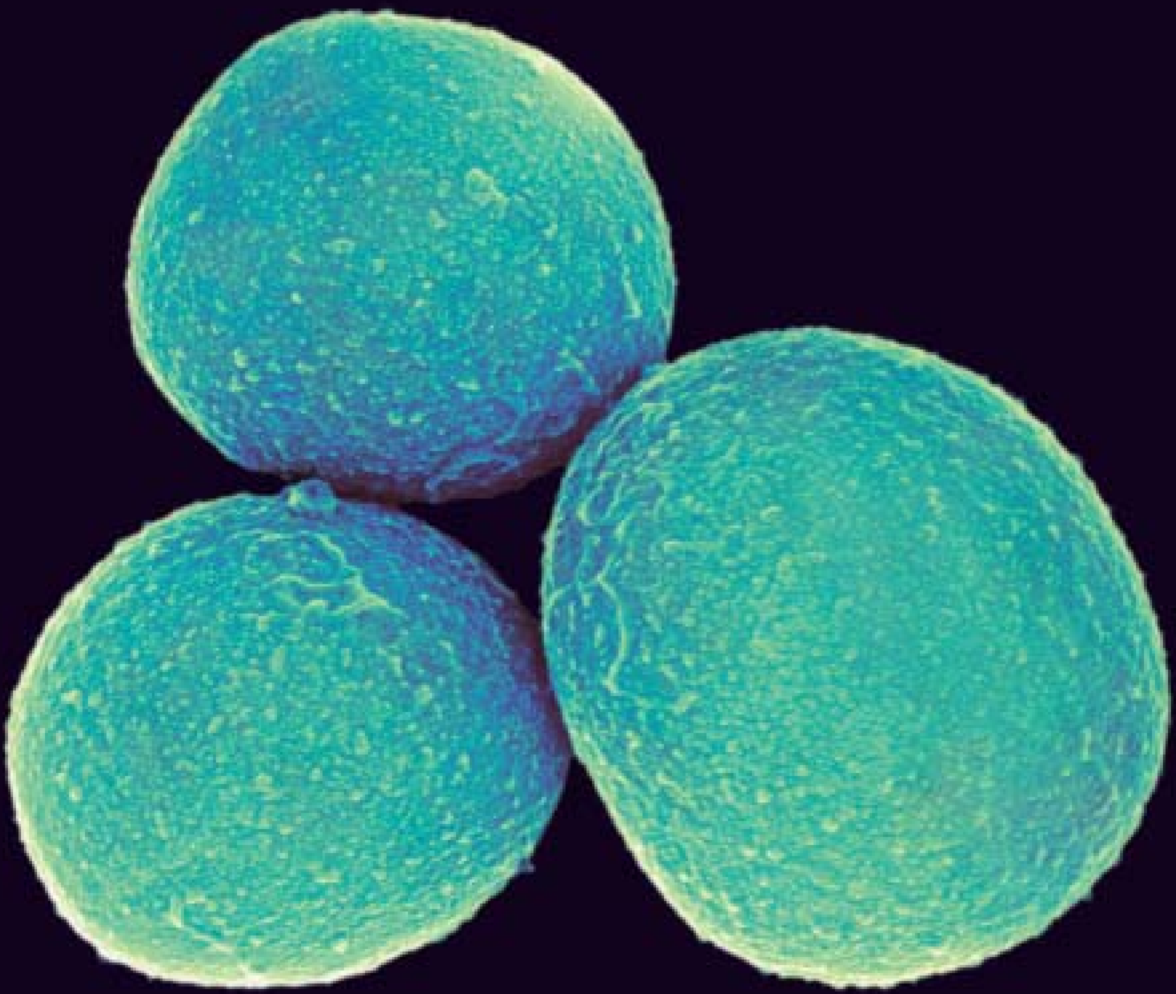
Governance at the global level will also impact on Africa. The renewed emphasis in the WHO on communicable diseases, including global disease alert and response systems, is encouraging. The OIE has also enhanced its focus on infectious diseases through its expanded mandate and strategic framework. Similarly, by introducing a high-priority programme on transboundary animal and plant diseases and pests (EMPRES), the FAO has also been raising the profile of infectious animal and plant diseases. The proposed FAO reform, which was approved by the FAO Conference in November 2005, envisages the establishment of a single major Technical Division to deal with the infectious diseases of animals and plants. This should help to improve international governance in the management of infectious diseases, although it is still unclear how much this new FAO division will also encompass the international surveillance of infectious diseases in wild animals.

The new joint initiatives by the FAO, the OIE and the WHO for a global early warning system for transboundary animal diseases and zoonoses and the initiative for the global framework for transboundary animal diseases (GF-TADs) are welcomed. Both improve the impact and effectiveness of international organisations not only in the management of infectious diseases but also in the governance systems, i.e. medical and veterinary services. However, ultimately the effectiveness of such global systems depends on what is done at the ground level by countries and regional organisations. This is yet another reason for further consideration of the concepts that are included in the proposed Pan-African Vision and Strategy for the Management of Infectious Diseases (see Chapter 8).

The new paradigm for the DIM of infectious diseases in Africa will inevitably involve the following aspects of governance:

- the need for more transparency and communication across agencies/ministries
- the need for taking information to the next levels: analysis, interpretation and finally policies
- the importance of stakeholder interest and involvement
- the value of advance planning and agile mechanisms for emergency funding
- the usefulness of reviewing experiences and lessons learned
- particularly important, the impact of power and resource distribution within institutions, so that all staff feel empowered to do their jobs.

6 Future control of infectious diseases in Africa



6 Future control of infectious diseases in Africa

Future systems for the DIM of diseases will need to be implemented within wider frameworks of disease control. This will be important in order to realise fully the systems' potential benefits. This chapter therefore takes a broad look at the future control of diseases in the public sector in Africa, and the factors that are likely to be important.

Future control strategies are considered for humans, animals and plants in turn. Common issues across the three kingdoms are then identified and discussed.

6 Future control of infectious diseases in Africa

As earlier chapters have shown, Africa is likely to continue to bear a heavy burden of today's major infectious diseases in the next 10–15 years. In addition, it will experience additional challenges of new and emerging diseases, the re-emergence of old diseases with enhanced virulence, and the threat of diseases from other parts of the world. Against this background, the management and control of infectious diseases are likely to be major pre-occupations of the public sector in Africa.

This chapter examines factors that are likely to influence the efficiency of disease management and control, and describes approaches that are likely to be common in the public sector management of infectious diseases.

6a Future control strategies for infectious human diseases

The project held a workshop to consider the future control of infectious human diseases in 10–25 years (report D3.3). The workshop took an international perspective, but particularly focused on the UK and sub-Saharan Africa as exemplars. It focused largely on technical control measures, such as vaccines and antimicrobials, but also considered societal and environmental control measures and factors that were considered important for the prevention of communicable diseases and the development and implementation of control measures (e.g. socio-economic development, universal education etc). The following builds on the outcomes of that workshop.

Control strategies in next 10–25 years and their likely impact

Both basic and technological control measures will be needed in the future. Basic control measures are mostly already available and could make a substantial contribution to the management of risk, especially in sub-Saharan Africa, but their effective implementation is also dependent on political, economic and cultural factors beyond the control of communicable disease and public health professionals. The basic primary control measures include:

- education
- clean water and sanitation
- hand hygiene
- condoms
- environmental
- restrictions on people or travel
- vaccination.

Vaccines

Vaccines are potentially the most promising strategy for controlling infectious diseases in Africa. They can technically be made against any antigen. However, the limiting factor for their use has been the lack of substantial financial resources needed to develop and test new vaccines using new innovative technologies. For example, there is the potential to develop more effective vaccines for vulnerable populations, such as young infants, against acute diarrhoeal diseases and for some healthcare-associated infections in in-patient populations. The impact of these vaccines would be substantial on infant mortality and morbidity.

In Africa, one of the limiting factors for effective vaccination is the maintenance of a cold chain against the backdrop of a poor infrastructure. The design of future vaccines should therefore address both the thermostability of the vaccine preparation and the induction of long-lasting immunity after a single application.

Early detection (diagnosis) and treatment

In many African populations, individuals present themselves to health facilities when their illness is advanced. Early detection and treatment is a fundamental strategy for the prevention of transmission of infectious diseases.

Diagnosis

Early accurate diagnosis is central to early treatment and therefore in reducing the probability of the transmission of diseases. It is therefore critical for the effective control of infectious diseases. The challenge in most parts of Africa for the last 50 years has been to improve the diagnostic capabilities of health facilities, particularly in rural settings where the bulk of the burden of disease lies. Easy-to-use and cheap diagnostics techniques have eluded us for tuberculosis and sexually transmitted diseases for the last 40 years, and this challenge will remain for the next 10–25 years. However, there is hope. New diagnostic techniques, particularly those based on DNA, eliminate the need to culture organisms in order to identify infectious agents. Cheap antibody/antigen-based diagnostic kits are increasingly being made available, e.g. Elispot/quantiferon testing for tuberculosis. Other possible tests are expected to be developed in the future. However, the key issues for Africa will be availability, cost, and the human resources needed to use the kits/equipment

Treatment

Most community-acquired infections will still be treatable with available antibiotics and it is not expected that there will be a ‘return to the pre-antibiotic era’. The impact of antimicrobials on the control of infectious diseases will depend on the disease, their appropriate use, and the link to diagnosis. In many parts of Africa, the antibiotics used are first- or second-generation penicillins.

In the next 10–25 years, an increasing number of micro-organisms will develop resistance to a wide range of the current antibiotics. This will mean that newer and more expensive antibiotics will be needed for treatment. This will present a problem to most governments as they will not be able to meet the cost of providing these services.

A second challenge is the development of drugs that reduce the period of treatment. These are needed in order to improve compliance and thus reduce the probability of resistant strains emerging. This will be particularly important for diseases like tuberculosis and sexually transmitted diseases.

There will also be a need for cheaper and widely available antiviral drugs to treat viral diseases. Currently, most health facilities in rural areas do not stock antiviral drugs due to their cost. However, viral illnesses are increasingly becoming prevalent, particularly as HIV seroprevalence increases in the populations. Of particular interest are herpes viruses, human papilloma and cytomegalovirus. In the next 15–25 years, the clinical importance of these viruses will increase and we need to meet that challenge.

Effective surveillance systems

The early detection of diseases through surveillance is critical for their cost-effective management. For example, such surveillance helps in the evaluation of intervention measures, thereby enabling limited resources to be targeted most effectively.

Surveillance for human infectious diseases in Africa is grossly impaired by a lack of systematic surveillance networks both within countries and regionally. The availability of financial and human resources are major constraints in this. Nevertheless, there are good surveillance networks for specific programmes such as the polio eradication programme. It makes sense to build on these successes wherever possible, rather than trying to build entirely new networks from scratch. However, so far there seems to be no indication from either national governments or the WHO that the polio network would be turned into a general baseline surveillance system. In this regard, it is worth noting that, on the veterinary side, the network that was set up for rinderpest surveillance is being transformed into an epidemio-surveillance network currently funded by the EU, with an expectation that the funding of the network will be taken over by national governments, both individually and collectively through the AU.

Another weakness in the surveillance of human infectious diseases is that few countries have fully fledged microbiological laboratories and fewer still have any capacity beyond their capital and other major cities. This means that rural public health is heavily compromised in many countries.

Clinical hospital service is the dominant thrust of the public sector medical services. Accordingly, the accompanying laboratory facilities tend to lay greater emphasis on clinical pathology than on microbiological and serological systems.

Generally, the diagnosis of infectious diseases is increasingly reliant on syndrome recognition rather than on specific laboratory-based diagnosis.

Current and future factors affecting the development and implementation of control measures in the next 10–25 years

In order to understand the factors that will affect control of infectious diseases in the next 10–25 years, we need to look back 25 years and see what has changed and what has not. This is best considered under the headings of socio-political changes and technical issues.

Socio-political changes

As in the last 25 years, the next 10–25 will still find Africa in the grip of poverty. Poverty is a major determinant of infectious disease and acts through a number of pathways. For example, it leads to a lack of education, and this in turn leads to lack of knowledge. Africa finds itself in a poverty trap that leads to high morbidity and mortality attributable to infectious diseases. However, there is evidence that good governance and accountability can offer hope in breaking this vicious circle. Already in several countries, improvements in governance have helped to attract both financial and human resources to help tackle economic problems. The result has been better social services such as education and health.

Lack of good governance is one of the factors that generates civil conflicts. In the last 30 years, Africa has witnessed an epidemic of regional and internal wars. These conflicts have a major impact on the emergence of 'new' diseases and the re-emergence of old ones. Conflicts generate increased intermingling of people and thus create a critical mass for infectious diseases to appear. In addition, the resultant breakdown in health facilities makes it very difficult to identify and monitor epidemics. In the next 10–25 years, if Africa manages to reduce the number of civil conflicts, it will go a long way in enabling more effective control and monitoring of infectious diseases.

In view of the fundamental role of infectious diseases in impeding economic and human development, there is a need to re-energise the political leadership to make public health – and infectious diseases in particular – a priority in their regions. This argues for a shift in financial resources towards public health in African countries. In the next 10–25 years, there is the need to invest massively in the public health sector after, effectively, so many years of neglect.

International co-operation is critical to the control of infectious diseases as, by nature, infectious diseases spread beyond international boundaries. It is in everyone's interest for African countries – and indeed non-African countries also – to be more forthcoming in the reporting of diseases of public health importance to enable regional and international monitoring and control.

Technical issues

The non-availability of human resources is identified as a significant limiting factor in the future implementation of disease control measures. Trained health workers, particularly laboratory technicians and health assistants, are critical to the early identification and treatment of diseases in rural areas of Africa. In addition, they will need a functioning infrastructure and the support of referral centres as backup. There is also a need for simple, cheap and easy-to-maintain equipment to facilitate laboratory diagnosis.

An issue of special consideration in the process of collecting laboratory specimens is the ethical challenges it poses. Use of personal information is often viewed with suspicion in Africa. Also, there is always an assumption that, if you collect samples, even if only for surveillance, care will be forthcoming. The issue of who would pay for the care and surveillance is crucial and is explored below.

Who would be most likely to 'pay' for these future control measures, who would benefit the most and who would be affected detrimentally?

The majority of African countries spend less than $20 per individual per year on healthcare. In addition, effective control measures will require the involvement of more that one country in a region. Together, this suggests that countries in Africa will need to actively develop within-country and within-region policies that encourage effective disease surveillance and control as well as the (financial) support of such measures by international organisations. In making the case for such international support, it should be noted that the surveillance and control of diseases at source in Africa will benefit other countries around the world in several ways, for example, by preventing the subsequent spread of pathogens to other parts of the world, or by enabling the maximum possible time to be applied to the development of control measures such as vaccines.

Partnerships with the private sector could also usefully be developed. Vaccine-producing companies always welcome large volumes of sales, although a challenge for Africa will be ensuring that the vaccines developed are of relevance to the most important diseases in Africa. In that respect, there is a case for promoting collaboration in the development and clinical trials of drug products that are of particular use to Africa.

Other issues of special consideration

In addition, the Entebbe workshop identified two further issues specifically relating to the control of infectious diseases in sub-Saharan Africa.

Firstly, while more money/aid is going into Africa than ever before, weak infrastructures are still a limiting factor for the effective delivery of services. Donor programmes, while needed, often lack proper co-ordination. They also tend to operate as vertical programmes, which limits the integration of services in existing healthcare structures. As a result, scarce resources are used inefficiently and divert activities from elsewhere. For example, hundreds of millions of US dollars are going into HIV antenatal treatment and yet, for one extra dollar per person, syphilis, from which many babies are dying, could also be treated. A lack of cross-communication and/or of programme integration is to blame. Well-meaning aid also turns local healthcare workers away from other control programmes. For example, many want to work in HIV programmes because they bring better salaries. The ideal is to have 'multiple disease' programmes.

Secondly, governments may have little control over public health because of the huge private healthcare sector. Despite technological advances, getting vaccines and drugs to those who need them is still a major issue in sub-Saharan Africa. Access to public health measures is still a big issue.

6b Future control strategies for infectious animal diseases

Future control strategies for animal disease are likely to be influenced by the following trends (see project reports D3.2 and A4):

a The movement of animals and of animal-derived commodities is a major factor in the spread of infections. Accordingly, with increased globalisation, infectious diseases are likely to be of growing global concern, wherever they occur. Also, they are likely to continue to be a major factor in trade regulatory measures. In Africa, animal movement due to traditional farming systems, transhumance, migrations and gift exchanges are likely to exacerbate disease spread.

b The most serious epidemic or TADs are generally endemic in developing countries. Sub-Saharan Africa probably has the highest infectious disease burden in the world. Twelve of the former fifteen OIE List A diseases (until May 2004) occur in this region and, of these, eight can be described as indigenous to Africa. For FMD, six of the seven serotypes (i.e. A, O, C, SAT-1, SAT-2 and SAT-3) occur in sub-Saharan Africa and three of these (SAT-1, SAT-2, SAT-3) are indigenous to the continent.

c The control of infectious diseases in sub-Saharan Africa has a link to the wider development goals of poverty reduction, food security and market access. There is a general consensus that livestock and the control of animal diseases can be a key pathway out of poverty for rural sub-Saharan Africa.

d The intensification of animal agriculture, including aquaculture, will lead to the increasing importance of otherwise low-pathogenicity diseases, either as productivity-limiting diseases or even as epidemic diseases. This, too, will be associated with an increasing number of emerging or re-emerging diseases.

e At the global level, approximately 75% of recent emerging human infectious diseases seem to have originated from an animal source. This trend is likely to continue and to be exacerbated by increasing human–animal (domestic or wildlife) contact and an expanding demand for foods of animal origin.

f The effective control of old and new zoonoses is likely to be demanded by society. This, in turn, will require better-integrated human and veterinary health systems for the DIM and strategic control of zoonoses than ever before.

g Environment-dependent, vector-borne diseases of animals and humans are likely to be of increasing importance as a result of climate change, and development programmes such as the construction of new large dams or agricultural and/or urban developments that encroach excessively on wildlife animal habitats or large human settlements that expand into rain forests.

Therefore, infectious animal disease control in sub-Saharan Africa is likely to be dominated by three thrusts:

- the control of epidemic or TADs
- the tactical control of zoonoses
- the control of vector-borne diseases within farming systems.

Transboundary animal diseases

Future control strategies for TADs in sub-Saharan Africa will probably be driven by two parallel objectives:

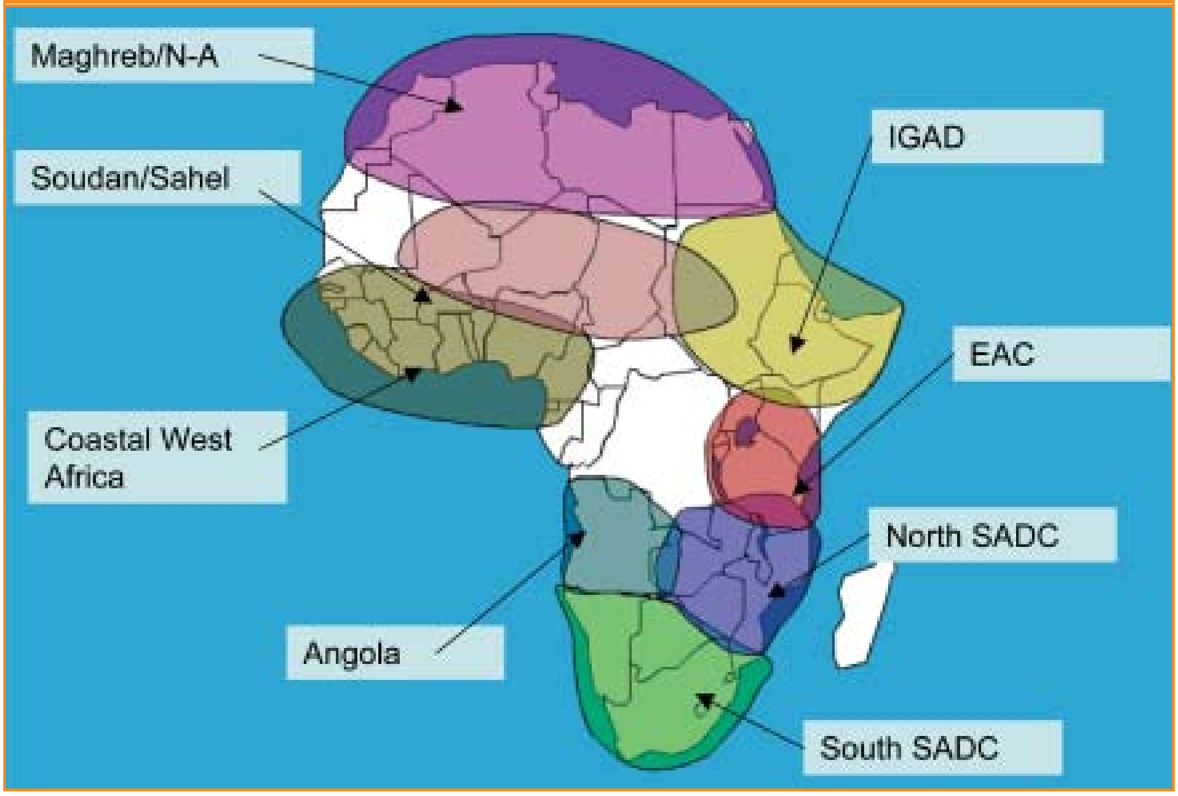
- boosting household income and local trade, which will focus on epidemic diseases of short-cycle stocks such as ND in village chickens, ASF, PPR and caprine pleuropneumonia (CCP) (see Figure 6.1)
- promoting access to the export market, which will focus on epidemic diseases of cattle and goats, such as FMD, CBPP, RVF, PPR and CCP.

Fig 6.1 The control of epidemics affecting household food security and income will depend on tactical interventions: ASF, PPR, and ND in poultry

For the objective relating to household income and local trade, the strategy is likely to be one of tactical interventions, area-wide at the level of village clusters. The DIM and disease control tools (e.g. vaccines) would need to be developed with this strategy in mind. These tools are likely to be applied by either the livestock owners or the primary animal healthcare personnel, such as community animal health workers under the direction of a private veterinarian (or veterinary technician) for the area. Such tools will therefore need to be affordable, robust and thermostable.

For the objective relating to exports, a range of strategic and tactical approaches will be necessary. The underlying concept, again, will be one of risk management to acceptable levels. The objective for strategic control will be to identify a small number of diseases whose surveillance and control would be based on agreements among clusters of countries, irrespective of whether control is to focus on zones within a country or across neighbouring countries. Increasingly, the co-ordination of surveillance and control operations will be on epidemiological clusters (see Figure 6.2 for an example of conjectured epidemiological clusters for FMD). Progressive control would need to be a long-term undertaking (15–20 years).

Fig 6.2 Epidemiological clustering may be a useful option for regional co-operation in the progressive control of FMD and other TADs. The map shows an attempt to cluster countries according to the known current (2005) FMD status.



Livestock farming in sub-Saharan Africa is dominated by agro-pastoral and pastoral systems, marked by transhumance and communal grazing. Therefore DIM and TAD control strategies will need to target homogeneously mixing livestock populations, which often transcend national borders. Another feature of sub-Saharan Africa in the future management of disease is the richness of the wildlife fauna, with the resultant risk of disease transmission between wild animals, livestock and humans (Figure 6.3).

Fig 6.3 The rich wildlife fauna of eastern and southern Africa is a source of biodiversity and tourism, but wildlife can also be a source of infection of livestock and people.

The control of TADs in sub-Saharan Africa is likely to be successful if linked to promoting local, regional and intercontinental trade in livestock commodities. This will involve risk management based on disease containment/control in live animals and the promotion of the export of livestock commodities processed in the producer countries of sub-Saharan Africa in such a way as to minimise the risk of such commodities transmitting infection.

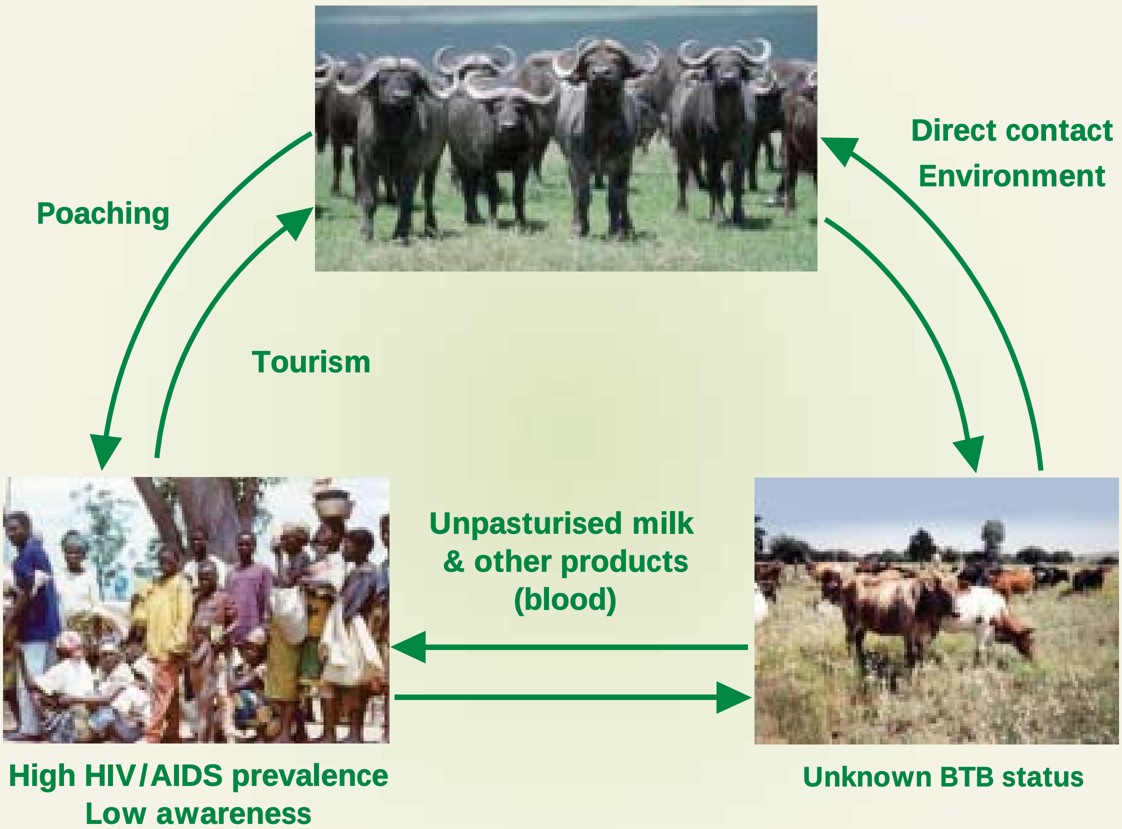
Zoonoses, food safety and emerging diseases

There is a general perception that the control of the traditional zoonoses is not getting adequate attention in sub-Saharan Africa following the many structural adjustments and organisational changes in veterinary services in many countries since the 1980s. There is also a perception that insufficient attention is being paid to the impact of zoonoses on the poor.

There appears to be inadequate targeted assessment of traditional zoonoses, such as bovine tuberculosis, brucellosis and cysticercosis as a complication in the HIV/AIDS complex among the agro-pastoral and pastoral communities. Figure 6.4 demonstrates the increasing concern regarding bovine tuberculosis as a potential complication in HIV/AIDS.

Fig 6.4 Bovine tuberculosis is an evolving zoonosis in Africa and is an example of disease transmission between farmed animals, wild animals and humans. Bovine tuberculosis is a potential complication for HIV infection in livestock-dependent rural communities in Africa.

Source: Dr Anita Michel, Onderstepoort Veterinary Institute, South Africa.



Therefore, in many countries, the starting point for addressing zoonoses could be:

a targeted surveys to establish the level of prevalence/risk of animal infections that threaten the health of agro-pastoral and pastoral communities – i.e. *risk assessment*

b to promote community-based preventive measures e.g. tactical vaccinations of at-risk animals or culling of infected animals – i.e. *risk management*

c to promote pro-poor processes for the preservation of animal products and thereby reduce the risk of food-borne infections among livestock-dependent communities – i.e. *risk mitigation*

d to develop, in collaboration with community public health programmes, an active awareness campaign for livestock-dependent communities on issues of public health including HIV/AIDS, infectious human diseases, zoonoses and food-borne infections/diseases – i.e. *risk communication*.

There is also a high risk of the emergence of drug-resistant infectious agents as a result of extensive usage of antimicrobials. It is therefore important to develop alternative control methods, and to support mechanisms for managing farmer access to antimicrobials.

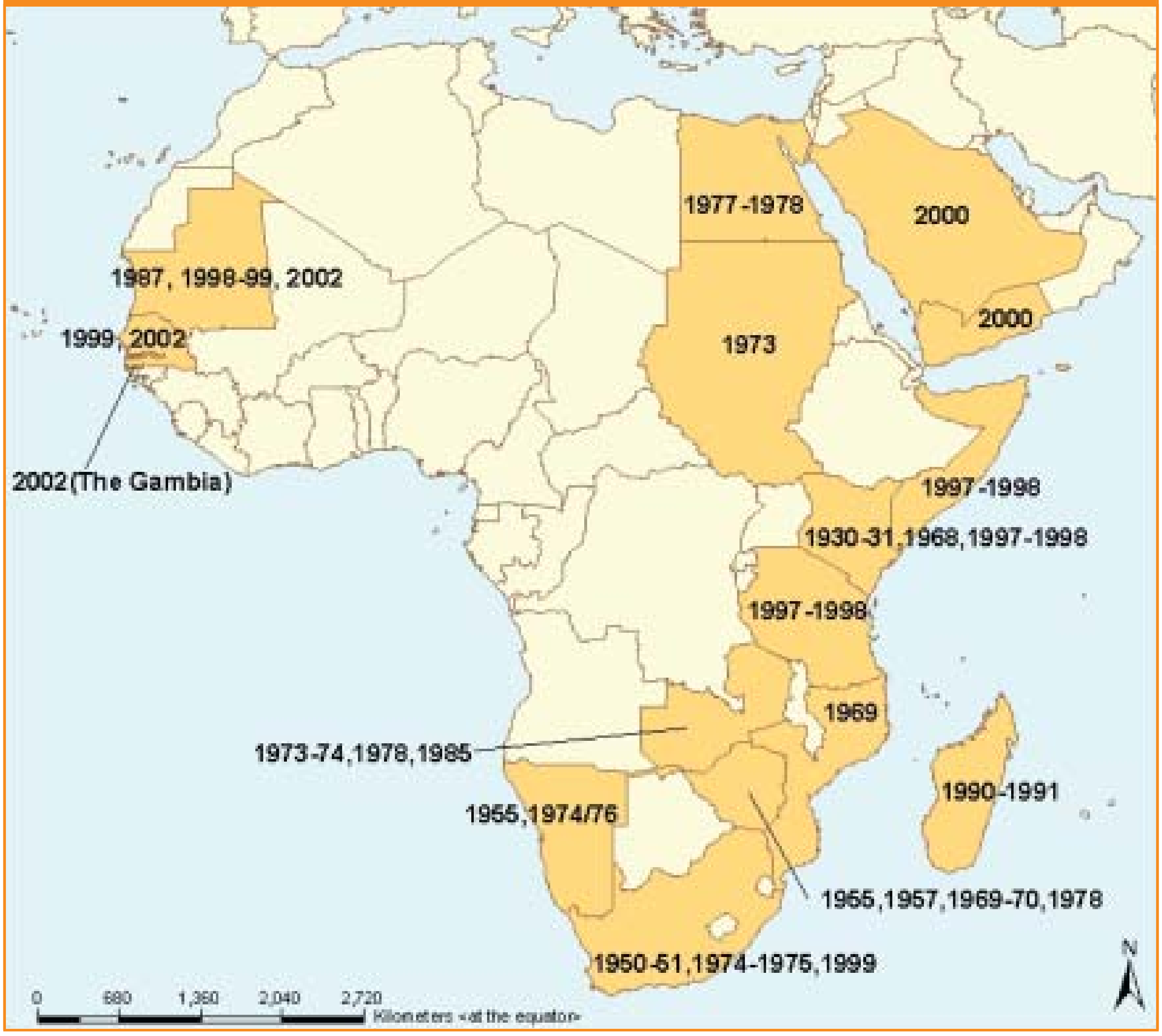
Vector-borne diseases

Vector-borne animal diseases in sub-Saharan Africa fall into three categories:

- viral diseases, the so-called arbo-viral diseases, such as bluetongue, RVF (Figure 6.5), African horse sickness and ASF. For convenience, diseases like lumpy skin diseases, which are probably mechanically transmitted by biting insect may be included into this category
- tsetse and trypanosomosis
- ticks and tick-borne diseases caused by protozoal or rickettsial organisms.

Predictive models based on remotely sensed environmental and epidemiological data will be used to generate spatio-temporal risk maps with which to target surveillance and to implement pre-emptive control measures.

Fig 6.5 The evolution of RVF distribution in Africa and the Middle East
Source: Dr Vincent Martin, FAO Animal Health, Rome.



Conclusion

So, overall, future animal disease control in sub-Saharan Africa is likely to focus on:

a the development of vaccine formulations that are designed to induce long-lasting herd immunity

b the fact that sub-Saharan Africa cannot eliminate all the highly contagious diseases concurrently. Therefore, the strategy will have to be one of prioritisation, identifying diseases of strategic importance for which co-ordinated programmes can be supported at the national or regional level

c the need for disease control to be targeted and driven by DIM objectives and based on epidemiological and socio-economic definitions, more than on blanket technology-driven interventions d research on several key diseases for which there are still no effective vaccines or safe affordable chemotherapy e.g. ASF, malignant catarrhal fever, trypanosomosis and Theileriosis. Hence the need for smart north–south partnerships in research

e linkage of disease control to progressive market access.

f a systematic study of the interaction and exchange of infections between humans, farmed animals and wildlife animals.

6c Future control strategies for infectious plant diseases

Infectious plant diseases are an important factor in agriculture in sub-Saharan Africa. The region depends on agriculture for about 70% of its total employment and about 25% for its GDP. The crop agriculture suffers a plethora of infectious diseases that significantly limit yields. There have been protracted efforts at country and regional levels to restrict the adverse effects of diseases on crops in sub-Saharan Africa. However, as discussed in Chapter 2, changing patterns of plant diseases arising from climatic and environmental changes, the commercialisation and intensification of agriculture, and the introduction and/or emergence of new diseases, vectors or strains, will pose greater risks to African crop agriculture by 2015 and 2030 unless adequate measures are taken to address the problems. This section discusses strategies and measures for the control of infectious plant diseases in sub-Saharan Africa, drawing on reports D3.1 and A4.

An effective quarantine system and regulatory framework

Quarantine i.e. the control of diseases by exclusion of pathogens, has been used effectively and successfully to manage infectious diseases in many parts of the world. However, in Africa quarantine systems are generally weak due to a lack of skilled personnel and inadequate infrastructure and funding. There is therefore a strong case for reassessing the level of investment in quarantine services in Africa, especially to build human and physical capacity to meet future phytosanitary challenges. A regional approach to quarantine services, such as the former East African Plant Quarantine Services, and a similar one that existed in west Africa, may be more feasible and cost-effective. The African plant protection services including quarantine systems should more effectively access and make use of the global plant diseases knowledge-base. Further, there should be an effective regulatory system for managing infectious diseases in Africa.

Disease, monitoring, surveillance and forecasting

It is almost impossible to prevent the introduction or emergence of new diseases or pathogen strains into sub-Saharan Africa. However, there is a strong case to invest in and intensify disease monitoring, surveillance, forecasting and prediction in order to stop pathogens becoming a major threat. The surveillance should increasingly employ modern robust and sensitive methods of biotechnology and optical methods. In addition, changes in the genetic structure of crops, pathogens and also the trends in environmental, policy and socio-economic factors over time need to be studied. Research on epidemiology and the control of plant diseases should receive increased emphasis to provide evidence that can be used for prediction and pre-emptive action. Input from farmers will be important. Robust and professional risk assessments will be required to guide the appropriate disease control strategies either at regional or continental levels. The current impact of plant diseases should be used as a template to design control strategies that increasingly apply cutting-edge science to reduce potential risks.

Understanding host–pathogen interaction and the emergence of races

Many plant pathogens exhibit variation as races and biotypes and can mutate to more virulent forms, often due to widespread use of single-gene resistances in widely grown crops. In order to ensure sustainable crop production, it will be important to predict the durability of deployed resistance genes through assessing the fitness of the corresponding pathogens. Pathogen fitness is a key driver in the evolution and stability of a pathosystem. Improved methodologies are needed to allow enhanced understanding of pathogenesis, genetic variation, and the triggers of change and drivers of epidemics in the development of improved resistance management strategies in future. In addition, the ongoing monitoring of changes in the pathogen will be necessary in order to develop strategies to manage pathogen change in the longer-term, and especially to prevent devastating epidemics.

Biological control

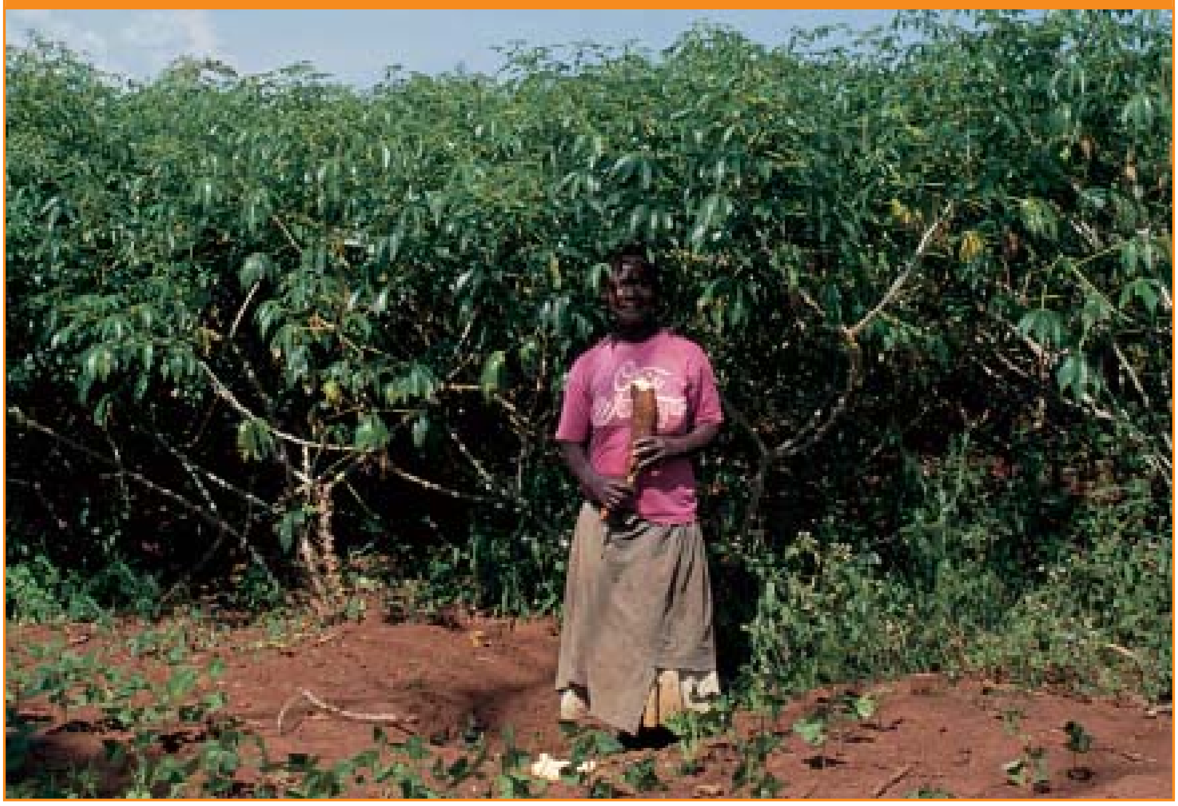
Biological control is potentially a sustainable solution for crop diseases in African agriculture since its effect is long-term and it has few, if any, undesirable side-effects. Biological control agents act against crop pathogens through different modes including antibiosis, competition and hyperparasitism. Crop and soil management practices such as minimum tillage, composting and cover crops can contribute significantly to the reduction in crop losses caused by soil-borne pathogens.

Host-plant resistance

African farmers have always welcomed improved varieties with genetic resistance. They favour host-plant resistance mainly because it is cost-effective and environmentally sound, but also because alternative disease control methods are unaffordable or less effective. For instance, it was estimated that, by 1998, 95,000 hectares were under mosaic-resistant cassava varieties that give an average yield increase of 10 tonnes per hectare. Genes conferring resistance to serious diseases have been transferred to some target food crops using conventional breeding (Figure 6.6b). Possibilities are now wider, given the new developments in genomic, genetic mapping and marker-assisted selection (MAS).

Fig 6.6a Cassava severely damaged by the virulent form of mosaic disease in Uganda at the height of the epidemic in the mid-1990s

Fig 6.6b Woman farmer in Uganda with a variety of cassava that is unaffected by CMD



Multiple or durable resistance would be preferable as single-gene (R genes) resistance normally breaks down due to changes in pathogen populations. Examples of previous effective resistance genes becoming ineffective and resulting in devastating epidemics can be traced for several crops in the world. This can be avoided by applying knowledge on the evolutionary potential of a pathogen. Genes that impose a high penalty on the adapting pathogen and genes transferred from outside the crop gene pool should help in developing more durable crop resistance. Consequently, widespread use of host-plant resistance alone will not, in the long run, be adequate to prevent big losses due to plant diseases in sub-Saharan Africa. Integrated management strategies will be necessary for controls that are more effective.

Transgenic resistance

The potential impact of novel resistance genes is expected to be important in Africa, where new approaches are desperately needed to increase and stabilise agricultural productivity. Already, several genetically modified (GM) crops have been commercialised in South Africa. Kenya is testing several GM crops, and Nigeria and Uganda are likely to follow shortly. Intensified research in biotechnology and biosafety and in the development and commercialisation of transgenic plants should be intensified.

Environmentally sound use of pesticide

There is growing international concern about the risks from acutely toxic pesticides in Africa. Although environmental concerns and regulatory pressures have resulted in the removal of many hazardous pesticides from the marketplace, chemicals will continue to play a role in pest management for the near future. This is partly because of the development of more environmentally benign ('softer') products such as oxadiazines (sodium channel blockers) and pyrazolines, but also because competitive alternatives are not yet available. Sub-Saharan Africa should rely on a range of environmentally friendly and safe pesticides with different modes of action to minimise cross-resistance. Comprehensive monitoring for breakdown of resistance to pesticides would be highly desirable, although it is expensive.

Plant activators

Plant activators, a new class of compounds that protects plants by activating their defence mechanisms, have potential for the future control of fungal and bacterial diseases. There is also a vast source of largely untapped naturally occurring organisms with the potential to provide new agrochemicals (as well as other antibiotic and chemotherapeutic agents), which have low mammalian toxicity and minor environmental impact. Sub-Saharan Africa should explore these potentials.

Integrated management of disease

Cultural control, including the use of crop rotation, removal of plant residues, manipulating planting dates, phytosanitation and rouging are widely applied in disease management in Africa. Where host-plant resistance has been integrated with these strategies, the efficacy of the approach in controlling the diseases has been greater. Future disease management strategies should therefore be integrated and built around host-plant resistance and the other activities mentioned above in order to achieve more effective controls.

Effective seed systems

Future strategies for controlling plant diseases can be divided into seed-based and knowledge-intensive (cultural, biological, chemical and integrated) strategies. Experience has shown that, in Africa, seed-based solutions to controlling plant diseases are significantly easier and more effective to implement than knowledge-intensive technologies. However, dissemination of disease-resistant crop varieties to smallholders can be grossly affected by ineffective seed systems. Appropriate policies and regulatory frameworks that support the production and marketing of quality seeds of improved varieties could usefully be developed and implemented at all levels. Village- and community-level seed production systems, usually supported by NGOs, have proven successful in Malawi, Kenya, Uganda and Tanzania. Similarly, private sector participation is crucial for sustainable seed systems in Africa.

6d Some common concepts in managing infectious diseases in Africa

During the 1970s and 1980s, the world health community was involved in the first ever eradication of an infectious disease, namely the global eradication of smallpox. This set the historical precedent that has given confidence to new programmes for both human and animal disease eradication strategies. These include the global polio eradication initiative (www.polioeradication.org/), the global measles control programme and the global rinderpest eradication programme (www.fao.org/ag/AGA/AGAH/EMPRES/grep/e_rinder1.htm). The current global initiative for HIV/AIDS, tuberculosis and malaria, the hemispheric plan for the eradication of FMD and canine rabies from the Americas also derive from the precedent set by the global eradication of smallpox.

Fig 6.7 Map of the progress of global rinderpest eradication
Source: Dr Peter Roeder, FAO Animal Health, Rome

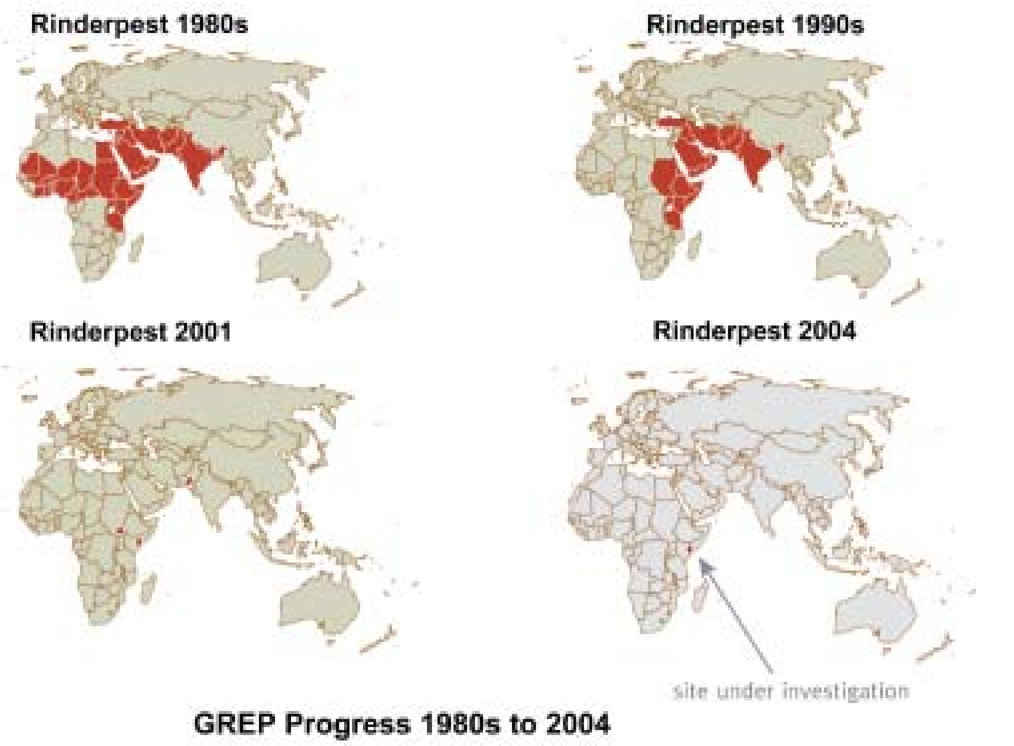
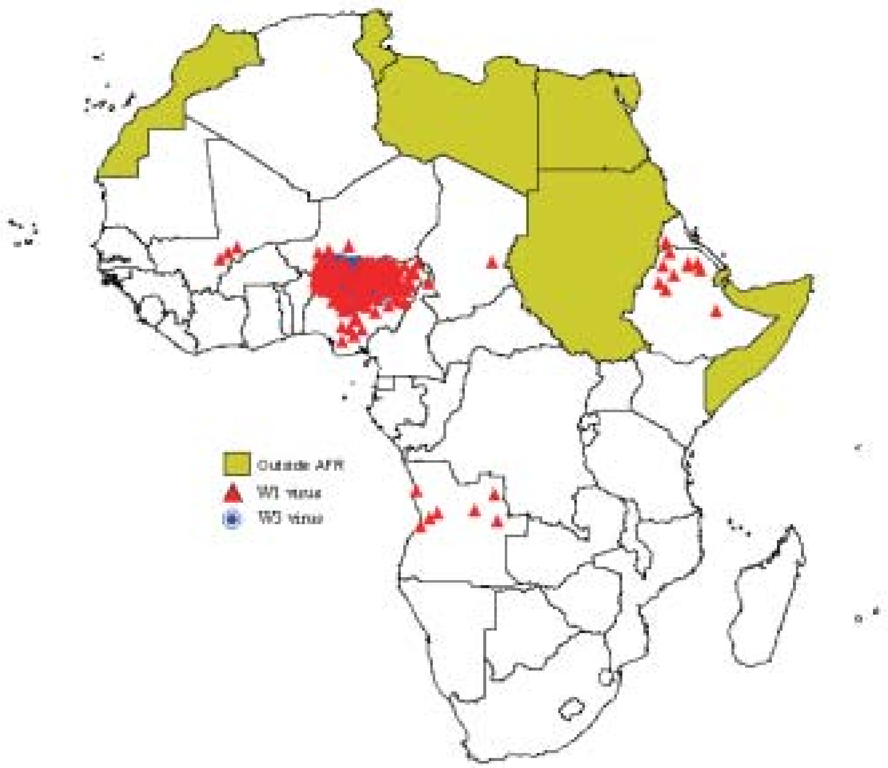


Fig 6.8 Wild polio in sub-Saharan Africa in 2005
Source: WHO, Geneva.



The lesson for Africa is that progressive control leading to the eradication of infectious diseases needs to be rooted in the desires of society and be part of national and regional policies. There is also a realisation that Africa could usefully approach the control of infectious diseases from a risk management perspective. There is therefore a growing body of opinion that considers it advisable to approach disease control in epidemiological clusters of countries rather than as isolated country initiatives or as pan-African approaches without any clustering. Each cluster or regional block could undertake an epidemiological and socio-economic categorisation of infectious diseases as follows:

- *Strategic diseases.* This would involve countries in the region agreeing to co-operate over the long term in the progressive control of a limited set of diseases, with a view to their elimination from the region.
- *Tactical diseases.* In this category, the objective would first of all be to establish a baseline of 'tolerable risk' and then to monitor the situation constantly so that when early warning signs indicated a significant deviation from the baseline, co-ordinated intervention systems could be deployed to contain the disease and prevent small outbreaks evolving into major epidemics.
- *Exotic or emerging diseases.* Three fundamental approaches are becoming increasingly necessary in this category. In summary, they are (a) a high degree of awareness of the incidence and dynamics of incidents that could potentially result in disease incursions into unaffected areas; (b) risk-based surveillance; and (c) a robust preparedness and contingency plan in the event of an incursion of such a disease.

Effective disease management under all three categories requires an effective DIM system as a primary prerequisite. Unfortunately, this is a commodity that is in short supply for Africa, where it is most needed. Further action is therefore required to strengthen this capacity – for generating disease data for international reporting; and importantly, for surveillance and early warning against the spread of disease and for disease risk management.

The following summarises the predicament:

- Today, only 5% of global scientists live and work in non-OECD (Organisation for Economic Co-operation and Development) countries, where 90% of the global population resides. Similarly, the total scientific resource for research and development in developing countries is only 4% of the total global investment.
- Without more effort, there will be a lack of skilled scientists, arising from a lack of training and failure to retain trained scientists. A lack of support for African scientists has always led to most resources for African disease research going to scientists in developed countries. This has left African scientists frustrated and demoralised.

- At the community level, most African populations are inadequately aware of infectious disease intricacies. Education, sensitisation and awareness creation in local communities, the general public and other stakeholders is vital in order to build their capacity to participate and contribute effectively to disease surveillance and control programmes. Furthermore, the power of religious and civil society organisations could be harnessed to improve capacity and participation at the community level.
- The current infrastructure such as laboratories, equipment and communication systems to support the implementation of infectious disease control strategies are already inadequate. This will get worse if no steps are taken to improve them.

Evolving international solidarity

While the recent past has witnessed a worsening situation in the spread of infectious diseases at global level and in Africa in particular, there are some new global initiatives that could help Africa address systematically the infectious disease burden. Apart from the major programmes like the Global Fund for HIV/AIDS, Tuberculosis and Malaria and the Gleneagles G8 Summit plan for supporting African development, the new enabling initiatives include:

- *the International Health Regulations (2005), recently passed by the WHO General Assembly:* These not only set out regulations for the global management of infectious diseases but *inter alia* urges the WHO to work closely, especially with the FAO and the OIE. They also encourage WHO member states to: build, strengthen and maintain the capacities required under the International Health Regulations (2005); mobilise the resources necessary for that purpose; and provide support to developing countries in the building, strengthening and maintenance of the public health capacities required under the International Health Regulations (2005).
- *the joint FAO–OIE GF-TADs initiative:* this advocates tackling infectious diseases at source, which generally means the international community supporting disease control initiatives in developing countries.
- the joint FAO–OIE–WHO global early warning system for transboundary animal diseases and zoonoses initiative (under development).

The FAO, the OIE and the WHO now advocate common basic principles for managing infectious diseases of humans, animals and plants:

- *early warning/alert systems* arising from the DIM and surveillance of diseases and infections
- *early reaction/response* based on a structured preparedness system and contingency planning not only for disease control operations but also for laboratory diagnostic and epidemiological surveillance services

- *enabling research*
- *the co-ordination of disease control strategies.*

It should be noted that the effectiveness of such a concept will largely depend on having effective systems for DIM in developing countries, especially sub-Saharan Africa. The three organisations further advocate the need for the international community to support the implementation of effective DIM systems in developing countries. In this regard, it makes sense to build on existing systems and networks where possible – particularly where these have enjoyed past success. Three examples are:

- the consolidation and further development of the nascent PACE epidemio-surveillance network for animal diseases. PACE evolved from rinderpest surveillance and has the potential to become the foundation for a major network for baseline animal disease surveillance and knowledge-based disease risk management strategies.
- the SADC epidemiology and laboratory networks, which could also provide a valuable resource on which to build further. Here, some consideration may need to be made towards their merger into an SADC surveillance network to encourage its work towards supporting disease risk management.
- the polio surveillance network, which also has the potential to be readapted and extended, rather than allowing it to fold up at the end of the polio campaign. The time is propitious now to start transforming this network into a baseline disease surveillance network for human infectious diseases.

On the plant side, there is an acute need for developing co-ordinated surveillance systems for plant pests and diseases.

The development of effective laboratory capacity and epidemiological surveillance programmes will determine Africa's capacity for the effective management of infectious diseases in humans, animals and plants. Thus, the present Foresight project points the way to the type of technologies and approaches that could help such a cause and reveals the challenges that will need to be addressed.

The main question, therefore, is how could managing the infectious diseases of humans, animals and plants in Africa be taken as a high-priority policy objective by African governments and institutions. African scientists meeting in Entebbe (report A4) concluded that Africa needed to consider developing a pan-African Vision and Strategy for the Management of Infectious Diseases – an idea which is explored further in Chapter 8.

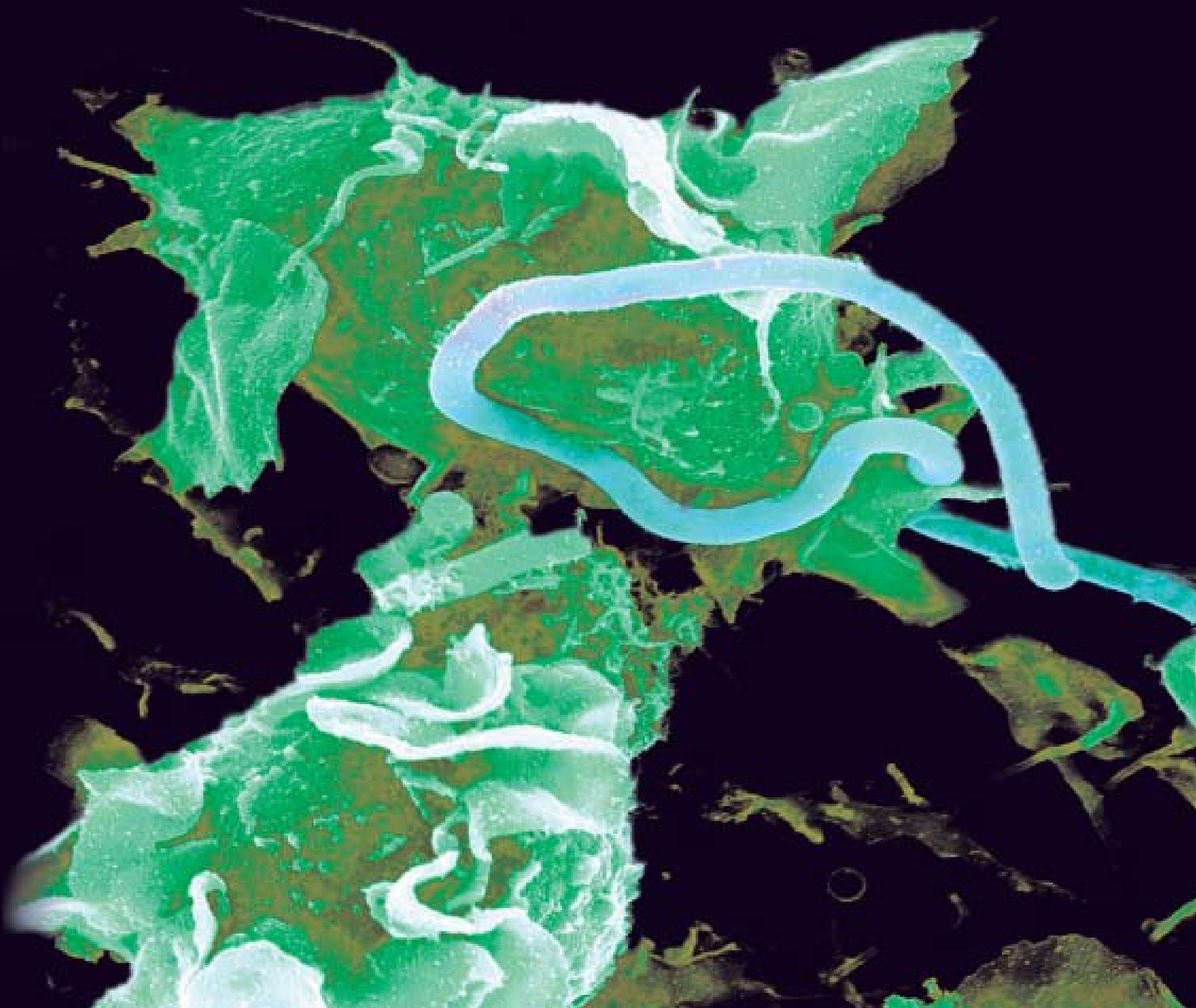
7 Future technology opportunities

7a Future technologies

7b Technology ‘user challenge’ domains

7c Some key target technologies for Africa

7d The operation of future DIM systems in African societies



7 Future technology opportunities

This chapter looks at future technology and how it could yield new systems for the DIM of diseases for Africa.

The project has reviewed ten key areas of science. Potential DIM technologies that could arise from these are discussed first. The identified technologies are then considered within a framework of four ‘user challenges’ – broad categories of future DIM systems. The most important potential advances in DIM systems for Africa are then identified, taking a 10–15-year time horizon.

The new DIM technology will need to operate in diverse systems of culture and governance within Africa. They also raise important questions of equity. Such issues are discussed at the end of the chapter.

7 Future technology opportunities

A substantial part of the Foresight project has considered developments in science and technology which could lead to new DIM systems. In particular, reviews of the state of the art in ten areas of science were commissioned (see project reports S1 and S3–S12). Clearly, not all technologies identified are immediately applicable under African conditions. However, it is important for African science policy makers to be aware of the type of technology that is evolving and into which Africa could usefully tap in order to successfully manage the infectious disease burden. This chapter therefore starts by reviewing the potential DIM technologies of the future.

7a Future technologies

Key future DIM technologies that have been identified from the ten areas of science review (S1, S3–S12) are:

- **Analysing nucleic acids or proteins to identify diseases**
  - With the continuing rapid improvements in portable genome sequencing technology, one can envisage the development of a rapid tool for such analyses. Ultimately this could even be non-invasive.
  - If the protein equivalent of real-time polymerase chain reaction (PCR) could be developed, it would be possible to trace reverse synthesis pathways to generate nucleic acid sequences. These could then be amplified to reveal specific proteins.
  - Another useful tool would be a method for detecting extremely low concentrations of proteins.
- **Detecting unknown diseases**
  - Genome-based technologies could be developed for recognising virulence genes in novel plant or animal hosts, even if the actual disease and the specificity of the observed virulence was unknown. Such a technology might work by characterising DNA or showing how certain genes are up- (or down-) regulated by virulent diseases. It may also give a clue to the identity of the disease.
- **Immunological signatures of susceptibility**
  - One can envisage sensitive biocompatible inserts in the cheek that measure chemicals associated with immune responses. This would generate a disease history for an individual – from natural infection to vaccination, as well as changes resulting from infection and disease. Further, this information could be automatically transmitted to a receiving point for collation. Not only would this monitor an individual's health and response to treatment, it would help us understand better the susceptibility of whole populations.

- The more that is understood out about innate immune systems and the chemical responses to pathogens, the more we will learn about signals that could be used to detect plant and animal infections or diseased tissues.

- **Measuring cells' responses to infection**
  - Real-time *in situ* measurement of the processes that take place in cells in response to disease-causing agents would be of great value. One approach could be nanoparticle bead biosensors, which are injected into the tissue of interest, such as lung or kidney, and then relay data to a hand-held device.
  - Another approach would be to engineer stem cells to respond robustly to infection and then encourage them to develop into the appropriate tissue type which is implanted into lung, kidney etc.

- **Automatic whole-blood analysis**
  - A hand-held device such as a mobile phone incorporating microfluidic technology that could analyse whole blood would be invaluable. A simple pinprick of blood would be fed into an intelligent data capturing system that provides on-the-spot analysis, or alternatively, transmits the measurements over a phone line to a remote station for analysis. A personal log of data is thus accumulated for long-term examination and analysis. Today's simcard needs to become a smartcard.
  - Central storage and analysis would enable accurate diagnoses to be made and facilitate real-time and long-term epidemiology over wide areas.

- **Smart swabs**
  - A routine procedure such as a simple swab could be transformed into a sophisticated technology for determining immunological or genetic status, or for sampling some other key parameter. Saliva or sputum swabs could be engineered to change colour in specific ways or to embody assays with some other readout capability that will identify a particular disease or range of diseases.
  - Already lateral flow (dipstick) tests are available for specific plant and human diseases using blood, urine and other samples. These are ideally suited for developing countries.

- **Sensitive sentinel organisms**
  - Living organisms – plants, insects, mammals – have very sensitive sensory apparatus for responding to diseases even before symptoms appear. Rather than replicate this natural technology by man-made electronics, it will be increasingly feasible to harness sentinel organisms as biosensors, perhaps in some organism/machine hybrid.

- Equivalents to traditional canaries in coalmines could be found for surveillance reporting, using animals that are particularly susceptible. Sentinel pets could be deployed to detect human pathogens, linking their sensitive sensing apparatus to some kind of reporting function. Similarly, the chemical signals of stress in insects might also be used as markers of specific diseases by training ‘bees’ to respond to particular markers.
- Plants may be genetically engineered to change colour when infected by pathogens. Also, insects that feed on blood could, in theory, be used to sample, collect and record from human populations.

- **Organ scanning devices**
  - Ultrasound or teraherz technology offers us the prospect of pocket-sized devices for scanning specific organs such as lung or liver. This non-invasive approach has high resolution and would be suitable for coupling to telemicroscopy systems linked to central analytical resources.
- **Non-specific surveillance**
  - Broad indicators of pathology – such as temperature and stress responses – could be detected by radiation using such techniques as thermal scanning and chemical analysis of stress hormones.
  - Skin plasters could also be engineered to measure chemical responses, innate inflammatory/stress markers or body temperature.
- **Sampling controlled airspaces**
  - The volatiles associated with illness and stress could be collected and analysed, especially in confined spaces such as aircraft, animal sheds, shipping containers and even airports. Linked to sensors (including novel biosensors), these would offer, using PCR, rapid, real-time surveillance that is either pathogen/antigen-specific or more broadly indicative of general health. Breath analysis could also be another possible avenue for exploration.
- **Remote sensing**
  - Satellites and aircraft can be used to monitor crops and plants, using measures of spectral reflectance to indicate the presence of diseases. Further, by placing engineered sentinel plants among crops or in natural ecosystems, it would be possible to remotely detect early stages of infection, and to track the subsequent progress of the disease across the landscape.
  - Remote sensing can also be deployed in conjunction with ‘smart dust’ – nanoparticles engineered to embody a capacity to measure and pinpoint disease over a broad area by means of biosensors linked to GIS.

7b Technology 'user challenge' domains

The above technologies have been further consolidated within the core Foresight project into four 'user challenges'. These user challenges are broad classes of future DIM systems, and have been considered in detail to analyse a wide range of issues such as their costs and benefits, barriers to their implementation, and how they would need to interface with systems of culture and governance.

The full details of the user challenge analysis is provided in reports D2 and D2.1–D2.4 and summarised in D1. However, the following draws out the key elements of relevance to African science policy makers:

- **User challenge 1: Data mining, collection and fusion**

  This strand examined novel information technology for the capture, analysis and modelling of data for the early detection of infectious disease events. It considered the ubiquitous, continuous and rapid automated capture and transmission of heterogeneous data to internationally networked data repositories. It also looked at the development of analytical and strategic systems to provide timely information to users and risk managers.

  Exploiting such systems for disease management in Africa will be a major challenge. The information systems that are currently used in Africa are geared towards disease reporting – there is little predictive modelling and data mining as a key component for disease management. Also universities, which generally have qualified personnel in data management, are seldom involved in issues of infectious diseases of national or regional strategic importance. Therefore, there will be need for a new paradigm in science management that involves African academic institutions in the mainstream of major infectious diseases; and a need for smart Africa–North partnerships and targeted capacity building in this area of infectious disease science that is relatively strange to Africa.

- **User challenge 2: Genomic and post-genomics for early detection and characterisation of new and emerging diseases**

  This user challenge concerns predominantly laboratory-based systems which could include central, regional and even mobile models. It focuses on the characterisation of new and emerging pathogens rather than on routine diagnostic laboratory functions.

  Two complementary approaches are envisaged. Firstly, host (immune) response signals in animals and humans would be interpreted to indicate likely causal agents and may also usefully give additional information as to the class of pathogen involved e.g. viral or bacterial etc. This approach may be less relevant to the characterisation of plant disease.

  The second approach would use pathogen genomics and bioinformatics to open up fresh opportunities to characterise new and emerging diseases.

Both approaches are likely to utilise sequencing- and array- (both nucleic acid and protein) based technologies.

The capacity for sub-Saharan Africa countries to operate such systems will be a challenge. To address this, it would be useful to promote the concepts of virtual centre research networks at national and regional levels, regional centres of excellence or centres of technology and smart Africa–UK/North partnerships as described further in the next chapter.

- **User challenge 3: Taking technology for identification and characterisation of infectious diseases to individuals by designing smart swabs, hand-held or portable devices that analyse fluids**

  Smart swabs and dipsticks offer the potential for rapid, easy-access diagnosis, and could be used by people with relatively low levels of training.

  Nanotechnology could also lead to new field-based, point-of-care (bedside, penside etc) systems for rapid diagnosis. Such devices might typically comprise a sensor module that detects and identifies one or more target pathogens. This might also be connected to a communications device to enable diagnostic information to be relayed to a central point. In so doing, it could provide information for use in user challenge 1 above.

  Such nanotechnology devices could be relatively easy to use, and indeed, the incorporation of the communicator could enable advice to be relayed back to the user. However, in an African context they raise substantial issues of cost. Another important issue would be whether manufacturers would develop sensor modules which targeted diseases of relevance to Africa.

- **User challenge 4: The use of non-invasive markers (electromagnetic radiation, volatiles) for high-throughput screening for infectious diseases – airports, livestock markets, containers**

  The aim of this user challenge is to examine the development systems rapidly, cost effectively and acceptably to detect, and identify, all known and unknown infectious diseases in high-throughput environments (e.g. airports, ports, train stations, etc.).

  This user challenge raises substantial issues for Africa relating to affordability, ethics and the possibility of exclusion. In particular, if such systems were unable to distinguish between prior exposure and infection, they could potentially result in the exclusion of Africans and African commodities because of prior exposure to some infection, rather than actually carrying infection. The smart partnership proposal (see Chapter 8) between African institutions and those in the UK and other developed countries might be a way to include Africa in the technological revolution. The equity issues that could be associated with this user challenge are further outlined below.

7c Some key target technologies for Africa

The attendees of the Entebbe workshop (report A4) were asked to identify some key areas of technology that could help to address Africa's need for disease management and which could form the targets for development in the shorter term. The experts found this subject to be extremely complex, needing a longer period of study and deep assessment – clearly a single workshop was insufficient in itself. However, the experts were able to produce some initial views, hoping that there would be another opportunity for more analysis in the future.

Their initial views relate to technology specifications for Africa's immediate needs over the next 10–15 years:

- **for human diseases**
  - hand-held point-of-care devices
  - breath analysis
  - drug resistance test systems
  - cd4 status test for HIV
- **for animal diseases**
  - simple, robust and cheap penside tests
  - systems for primary animal health workers/sub-national diagnostic laboratories
  - genomic identification systems at national level
  - the capability to distinguish vaccinated animals from infected animals
- **for plant diseases**
  - 'litmus' tests for known pathogens in the field
  - point-of-entry systems for known quarantine diseases
  - lab-based identification of new pathogens – this could use a genomic approach and be linked to regional monitoring
  - remote sensing using air samples.

7d The operation of future DIM systems in African societies

While technology is an important enabler for all of the user challenges, they need to be considered within the broader perspective of their use within society. This is particularly true for user challenge 3 – tools for individual, lay and community diagnosis.

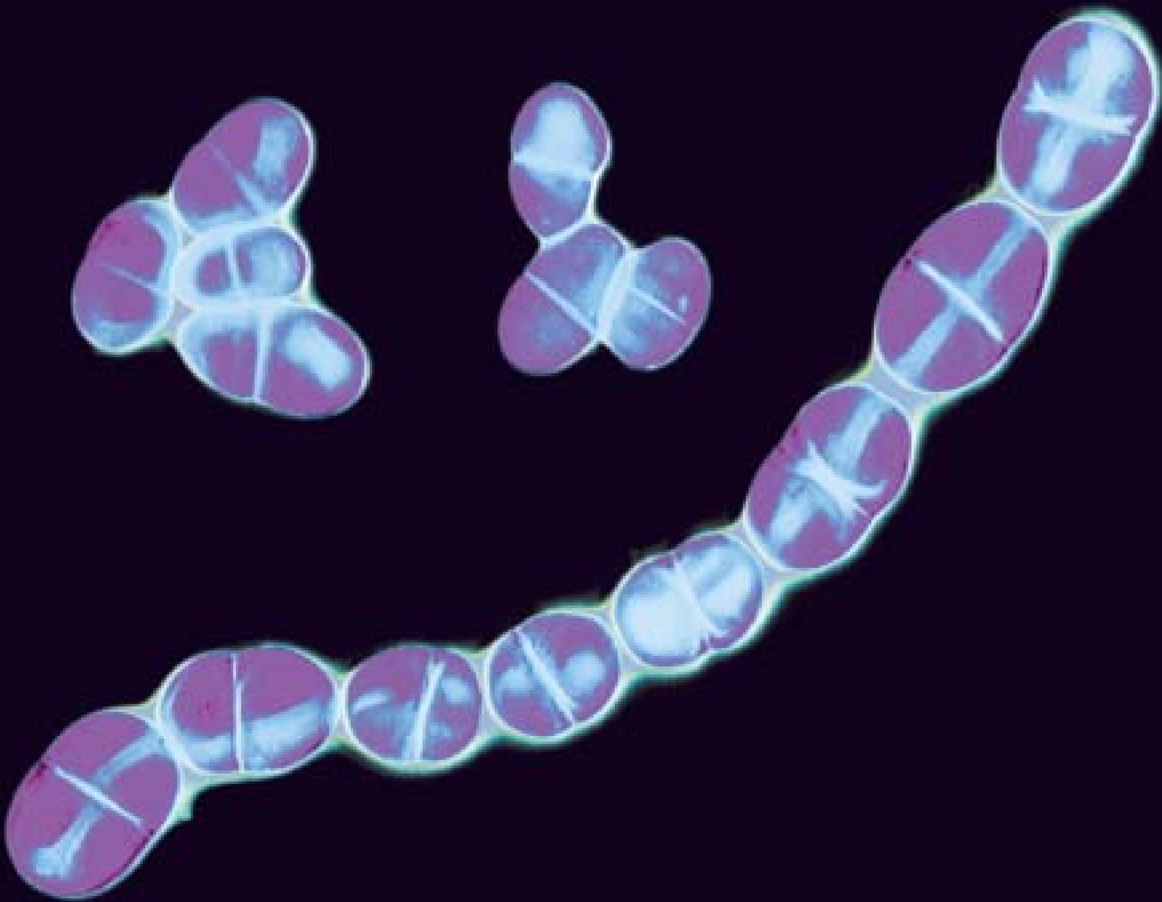
In particular, there is a need to identify social, cultural and governmental questions that should be explored further if the user challenges are to make a sustainable contribution to human, animal and plant health in Africa – apart from the obvious factors such as cost, infrastructure for storage, distribution and data management. As an example, the following are some of key questions for user challenge 3 that revolve around community engagement and equity:

- How do local perceptions of the state and of transnational agencies influence their potential assessment of risk and of externally introduced risk control?
- Who promotes and distributes the devices, and what are people's previous experiences and current attitudes to this agent, e.g. the government or an overseas aid agency?
- What are the likely consequences of diagnosis? Can a positive case find treatment? Are there control measures by government institutions that make diagnosis and reporting worthwhile?
- What are local understandings of the common good, to which disease DIM could contribute?
- What is the risk that society will perceive ulterior motives by governments or specialists?
- Are African laboratories sufficiently resourced in human and financial capacity and laboratory facilities (construction and equipment) to readily assimilate the new DIM technologies?
- What is the risk that African scientists will turn out to be predominantly 'diagnostic kit technicians' (kit-users) rather than evolving into world-class infectious disease specialists?
- Could technology inventions or modifications that are made in Africa to suit African diseases or socio-economic conditions be excluded from integration into new diagnostic technologies by restrictive patent rights and overprotected intellectual property rights?
- Could industry leaders and international development agencies be persuaded to promote an 'open source' approach to diagnostic technologies so as to encourage African scientists' and institutional participation?
- How can Africa, which has the highest burden of infectious diseases, avoid being left in the slow lane?

The above and other considerations have three particular implications:

- They make it imperative that novel mechanisms are developed to communicate the benefits of the new technologies to African policy makers and to society at large.
- They argue for an 'open source' approach to infectious disease diagnostic technology development. This could accelerate the uptake of the new technologies in the countries of need, i.e. Africa, and the active participation of African scientists in the technology revolution for the DIM of infectious diseases.
- They underline the need for African institutions and African scientists to be partners in the global alliance for developing new approaches to the DIM of infectious diseases. Africa has the highest burden of infectious diseases, and it is therefore particularly important to make full use of African understanding and knowledge of the diseases and their management. The smart partnerships proposed in Chapter 8 could play a substantial role in meeting this objective.

8 A pan-African Vision and Strategy for the management of infectious diseases



8 A pan-African Vision and Strategy for the management of infectious diseases

The project held a pan-African workshop of leading experts in Entebbe in August 2005. At this event, the authors challenged the attendees to take a strategic look at the future of infectious diseases in Africa, and to advise what was needed to meet that challenge.

The experts argued strongly for Africa to take the lead in developing a pan-African Vision and Strategy for the management of infectious diseases, covering plants, animals and humans. This chapter outlines the possible nature of this vision and strategy, as envisaged by the attendees.

A single workshop cannot, of course, solve all of the problems of infectious diseases in Africa. However, the views detailed in this chapter are intended to stimulate further debate and consideration by African policy makers.

8 A pan-African Vision and Strategy for the management of infectious diseases

Infectious disease is now widely regarded as the major constraint to agricultural and animal development and to human health and well-being in sub-Saharan Africa. In spite of notable successes in controlling pandemics of infectious diseases, such as polio in humans, rinderpest in cattle, and CMD in the Great Lakes region, the continent still has life-threatening epidemics of infectious diseases that presently cripple plant and livestock production and threaten the very survival of many human communities across the continent.

At the global level, it is acknowledged that Africa has the heaviest burden of infectious diseases, whether of humans, animals or plants. However, the infectious disease burden is likely to get worse with increasing urbanisation, intensification of agriculture (including animal agriculture and aquaculture), increased mobility and movement of people, animals and agricultural commodities, increasing wildlife–livestock–human contact and the impact of climate change on disease vectors. As the world becomes more and more concerned about the spread of infectious diseases, there is a serious risk of Africa becoming even more marginalised in the future than it is at present. It is difficult to foresee a successful and global future for sub-Saharan Africa without addressing the challenge that the infectious disease burden poses. As the nature of some of these diseases has proven intractable to easy identification and present-day control tools/methods, there is an urgent need for both vision and commitment to provide the strategy for the future.

The project mounted a major workshop in Entebbe, Uganda, in August 2005, where the participants were challenged to explore options for such a vision and strategy for managing infectious diseases in Africa. This chapter sets out their advice (report A4 provides a full report of that workshop, and A5 provides a version in French).

Firstly, there was considerable support at the workshop for the view that African diseases were primarily an African responsibility, although it was recognised that they also had the potential to affect other parts of the world. The significance of this was that investigations into African problems needed to be conducted, in a major part, within Africa. Furthermore, it was a strongly held view that such research had to be generational and long-term, not merely the typical 3–5 years for research projects. There was, however, support for ‘smart partnerships’ between African and developed countries that might offer both expertise and training in relevant scientific technology. There was a consensus that addressing the infectious disease challenge in Africa demands a quantum leap in the application of detection, identification, surveillance and monitoring systems and thereby influences science-based disease control strategies. While this responsibility is primarily African, it also served the international public good and therefore justified international support. In the increasingly globalised world, it is in the interests of industrialised countries not to be indifferent to the persistence of dangerous infectious diseases in Africa.

8a Some underlying problems for the DIM of infectious diseases in Africa

The following key issues were identified:

- There is increasing reliance on syndrome-based diagnosis without recourse to specific diagnosis (i.e. detection and identification).
- There is acutely low capacity for laboratory-based diagnosis at sub-national level.
- There is low activity in general surveillance. For human and animal infectious diseases, surveillance is generally limited to activities of specific projects or targeted disease control programmes, e.g. polio or rinderpest. For plants, there is little or no regionally co-ordinated surveillance for pests and diseases and the quarantine system is poorly operated in many sub-Saharan-African countries. So the capacity for early detection, early warning and early response to changing patterns of new or old diseases in Africa is weakening and increasingly infectious disease control strategies (whether of plants, humans or animals) are becoming late reactive emergency programmes.
- There are some excellent international agricultural research centres located in Africa with an animal or plant health mandate. These are essentially centres of technology for defined research objectives and none are involved in infectious disease surveillance. However, their existence would be an excellent technological asset in any future surveillance programme for infectious diseases. There are no equivalent international centres for human diseases located in Africa.
- For animal and plant systems, there are AU and sub-regional institutions (e.g. IBAR, the AU-Inter-African Phytosanitary Council, and the SADC-Livestock Technical Committee) that can act as co-ordinating organisations for DIM. These institutions work closely with and are supported by the FAO and the OIE. However, no such African-owned regional organisations exist for human infectious diseases and therefore the inter-country co-ordination of the surveillance for human infectious diseases is provided by the WHO.
- At the national level, in many countries, there is excessive compartmentalisation of specialists either according to sector (human, plant and animal) or according to administrative boundaries (government, academic and private institutions). Accordingly, there is sub-optimal utilisation of the meagre available resource that could drive a surveillance-based programme.

8b A new paradigm for the DIM and control of infectious diseases in Africa

The Entebbe workshop concluded that in order for Africa to make the requisite quantum leap in the DIM of infectious diseases and thereby rational disease control strategies, new and innovative approaches needed to be introduced. In particular, it was felt that there was a strong need to create an articulated pan-African vision for managing infectious diseases of human, animal and plants.

However, to be effective, such a vision needed to be accorded a high priority at the national and continental levels and integrated into the national and continental development plans in addition to the current donor-supported programmes, such as those addressing AIDS/malaria/tuberculosis, polio, rinderpest, the AU-IBAR PACE programme, the CMD pandemic in the Great Lakes region, or the coffee wilt disease programme in east Africa.

The following ideas and approaches were suggested for further consideration by the experts present at the workshop:

- DIM and thereby surveillance of infectious diseases should be primarily rooted in scientifically strong national systems. These should in turn have effective sub-national or community-based foci for primary diagnosis close to the point of primary (animal, plant or human) healthcare.
- As the most serious infectious diseases of humans, plants and animals are transboundary in nature (i.e. can easily spread to other countries and reach epidemic proportions) and since many African communities reside in ecological systems that transcend national boundaries, it is important that disease surveillance systems in Africa be co-ordinated through a 'Pan-African Programme on Infectious Diseases in Africa'. Such a programme could operate on the basis of regional co-operation among countries within a common ecosystem, i.e. an epidemiological cluster.
- Within each epidemiological cluster of countries (or geopolitical sub-regional cluster, e.g. the EAC or ECOWAS), there should be at least one laboratory that is able to undertake the identification and genetic characterisation of infectious disease agents from the national surveillance programmes. These could be regarded as sub-regional centres of excellence in infectious diseases, capable of recognition by the WHO, the OIE, the FAO and the AU/ISTRC as regional reference laboratories or collaborating centres.
- Current international agricultural research centres or NEPAD centres of excellence in agriculture could act as outstanding centres of technology that could support the regional and national centres, especially on genetic identification of PCR products of infectious agents – where the mandates of these centres permit such collaboration.
- There was a strong endorsement that the new approach to the DIM of infectious diseases in Africa should strive to be cross-sectoral (i.e. integrated between plants, animals and humans) at the national and epidemiological cluster (or regional/sub-regional) level. This was considered by the workshop to be novel and would promote the optimal utilisation of resources in order to make the quantum leap that is required to address the infectious disease burden in Africa. It was also considered desirable since the new and emerging detection and identification technologies are increasingly common for the three sectors. There would therefore be benefits in technical resource development, cross-fertilisation and in maintaining a critical mass of expertise in this fast-

developing field. It would also promote the development of technology relevant to African problems and not merely as a derivative of technology from the developed countries. Furthermore, this novel approach would provide the kind of scientific challenge to the new generation of African scientists that should propel them to undertake work in Africa that will both address a central issue to African development and be conducted at the global cutting edge of science.

- The Pan-African Programme on Infectious Diseases in Africa would be co-ordinated at national, cluster, sub-regional and pan-African levels. The programme would operate through a system of partnership and networking, via virtual (rather than physical) centres in order to focus funding primarily on DIM activities and to minimise spending on constructing new infrastructures with consequential high overhead costs that might prove to be unsustainable.

A pan-African Vision and Strategy for the management of infectious diseases

A pan-African concerted effort, shared by AU member governments, reflecting the needs of the African society and supported by the international community, with the goal of a society protected from the ravages of dangerous infectious diseases that compromise human, animal and plant health, improved livelihoods, agriculture and economic development.

This vision could be implemented through the disease-surveillance-driven objectives for:

- the effective prevention of the spread of currently African endemic, introduced or exotic and emerging or evolving diseases (and pests) in Africa or parts of Africa
- enhancing African capacity and participation in scientific and technological developments for the early detection, specific diagnosis, early warning of evolving disease events and national/regional capacities for early response. The aim would be to contain unusual disease episodes so as to break the cycle of each such episode turning into a serious epidemic
- science-based and socio-economically sound strategies either for disease containment, or for the progressive control of those diseases that most threaten society – either as human disease problems or as an impediment to food security or the tradability of plant and animal commodities and products.

The following develops further the concept of the pan-African Vision and Strategy for the management of infectious disease in more detail.

8c Developing a pan-African Vision and Strategy for the management of infectious diseases

A sub-Saharan African vision for the detection, identification and management of infectious diseases would need to identify current and future disease risks that affect human health/well-being, livestock and plant production. Furthermore, in the face of such risks, it would need to assess the technologies that will be needed to detect and identify microbial pathogens in approved national and regional centres and, thereafter, apply the control measures that might be undertaken. If the future vision were to extend beyond the present time (i.e. beyond 10–15 years), then it is highly probable that newly emerging or re-emerging diseases will be present and that a sub-Saharan African capability to contain rapidly such infections will also be needed. The advantage of trans-sectoral (plants, animals and humans) integration is obvious when it is remembered that 75% of those newly emerging human infectious diseases are likely to be of animal origin i.e. zoonotic.

Also, unless checked, the current level of spread of infectious diseases in Africa will preclude African agricultural commodities from international trade. In this context, future technologies for the novel detection and identification of infectious disease will also need to be considered, since these will impact considerably on the advantage and/or restriction of international movement of livestock and plants. This is vital in order to safeguard national export and import programmes as well as to ease international human mobility.

There was a strong feeling that the present OST Foresight initiative on the DIM of infectious diseases could act as a critical ‘catalyst’ to inform and influence the G8 and Commission for Africa to support a pan-African strategy on infectious disease.

8d Ownership of the vision and strategy

The ownership and responsibility for the pan-African vision and strategy would need to be established. Because it should represent an integrated vision for how African countries will identify and combat future infectious diseases, there is a persuasive argument that the AU could usefully champion the vision and strategy now and in the future. However, to be effective, there would also be a need for national governments to ‘sign up’ to the vision and strategy, thereby strengthening the control of those epidemic diseases that do not respect national boundaries, namely transboundary diseases of animals (e.g. FMD), humans (e.g. AIDS) and plants (e.g. CMD). It would also be important that the WHO, the FAO and the OIE were associated with the pan-African Vision and Strategy for the management of infectious diseases, as these organisations have global mandates for human, plant and animal health.

The leadership that provides the vision for future approaches to infectious diseases would need to be at the highest scientific and political level, particularly since it would cut across human, animal and plant diseases. At this level, there is opportunity to engage with governments and the relevant pan-African agencies, as well as the international development and funding bodies. Individual governments and African society would need to share the goals of such a pan-African Vision and Strategy for the management of infectious diseases.

8e Linkages with national strategies and infrastructure

The crucial issue for this pan-African vision and strategy would be the acceptance and responsibility by member nations for their own disease detection and control. Without this ‘buy-in’, there would be inequalities in trade, tourism and national productivity between neighbouring countries and possibly the failure to secure long-term funding for either regional/cluster centres of technology or international funding for partnerships between developed and developing countries. It is clear that funding agencies are not prepared to provide this continuous background support.

Therefore, it is suggested that the starting point for implementing the pan-African Vision and Strategy for the management of infectious diseases would be at the national level. Here there are financial and other resource constraints. The greatest stumbling blocks, however, may be institutional setups as there is excessive compartmentalisation of scientific expertise according to administrative and sector divisions. So one possibility could be to set up in each pilot country an inter-ministerial national institute for infectious diseases, that is, a virtual centre, not a physical one. This would function as a networking mechanism for DIM programmes that pool resources from both government and academic establishments across the three sectors (animal, human and plant). In line with the stated new paradigm, the virtual centre would seek to co-ordinate programmes within existing infrastructures, concentrating new funds on equipment, reagents and operational expenses far more than on new constructions. It is acknowledged, however, that in some cases it may be necessary to upgrade existing constructions in order to make them compatible with the safety requirements for handling infectious agents.

It would be important that the strategy is based on strong community empowerment and networking for the supply and delivery of samples for analysis and information. It is in the interest of both governments and communities that diseases are controlled and that new epidemics are detected rapidly and prevented from spreading widely. The responsibility for community networks should be at the national level – there is obviously national advantage in such effective networks. It is envisaged that the sub-national primary diagnostic centres would remain client-based and linked to the separate primary healthcare systems for humans, animals and plants.

It was considered that there is a real need for strong scientific and economic arguments to be provided to national governments to substantiate the costs and benefits for disease control across all three sectors. The continued attrition of healthcare services across all these sectors in many sub-Saharan-African countries will invalidate the delivery of many future technical advances in disease control. So the identification of the importance of community networks would be seminal to any pan-African strategy for the overall diagnosis and control of infectious disease.

8f The role of regional and cluster centres of excellence for infectious diseases

Within designated regions or clusters, the establishment of centres of technological expertise would empower their hinterlands to access, assess and modify technologies that are relevant to national needs. Moreover, the networking of such centres across the regions/clusters would provide a powerful framework for integrated monitoring and surveillance as regional or cluster reference laboratories. Such centres of excellence would need to be dedicated to the surveillance of infectious diseases (utilising the most modern technologies) and not be merely hubs of potential technologies.

Well-resourced centres would also help to promote enduring 'smart partnerships' between developed and developing countries. However, such centres would not be entirely dependent on outside funding bodies. They would be essential hubs within the overall pan-African strategic framework, providing regional outreach to all national programmes for DIM. The centres of excellence would act as regional/sub-regional reference and co-ordination centres (RRCCs). They would address aspects of epidemiology and disease surveillance, reference microbiology, and control. In line with statements made in the Commission for Africa report, it is suggested that there would be an RRCC co-ordination centre in each region/epidemiological cluster or sub-region linked to new and existing centres via a virtual network. The network would also link with national and local disease surveillance/control services.

The RRCCs would work with the national hubs (i.e. the national institutes for infectious diseases) in:

- monitoring infectious diseases of plants, animals and humans in their region, progressively creating a pan-African surveillance network
- helping countries in the region to control disease outbreaks (through advice and assistance to disease management professionals and to African governments)
- research into disease control appropriate to local conditions and local needs
- promoting the spread of relevant technology and capability for disease control in their respective regions

- scientific capacity building through training of all cadres of staff in the identification, diagnosis and control of infectious diseases.

8g Specific advantages for linking infectious disease surveillance and disease control strategies in humans, animals and plants

The pan-African Vision and Strategy for the management of infectious diseases advocated by the workshop would be unprecedented anywhere in the world – so it would not be so much a case of Africa catching up, more a case of Africa taking a ground-breaking approach in this important area.

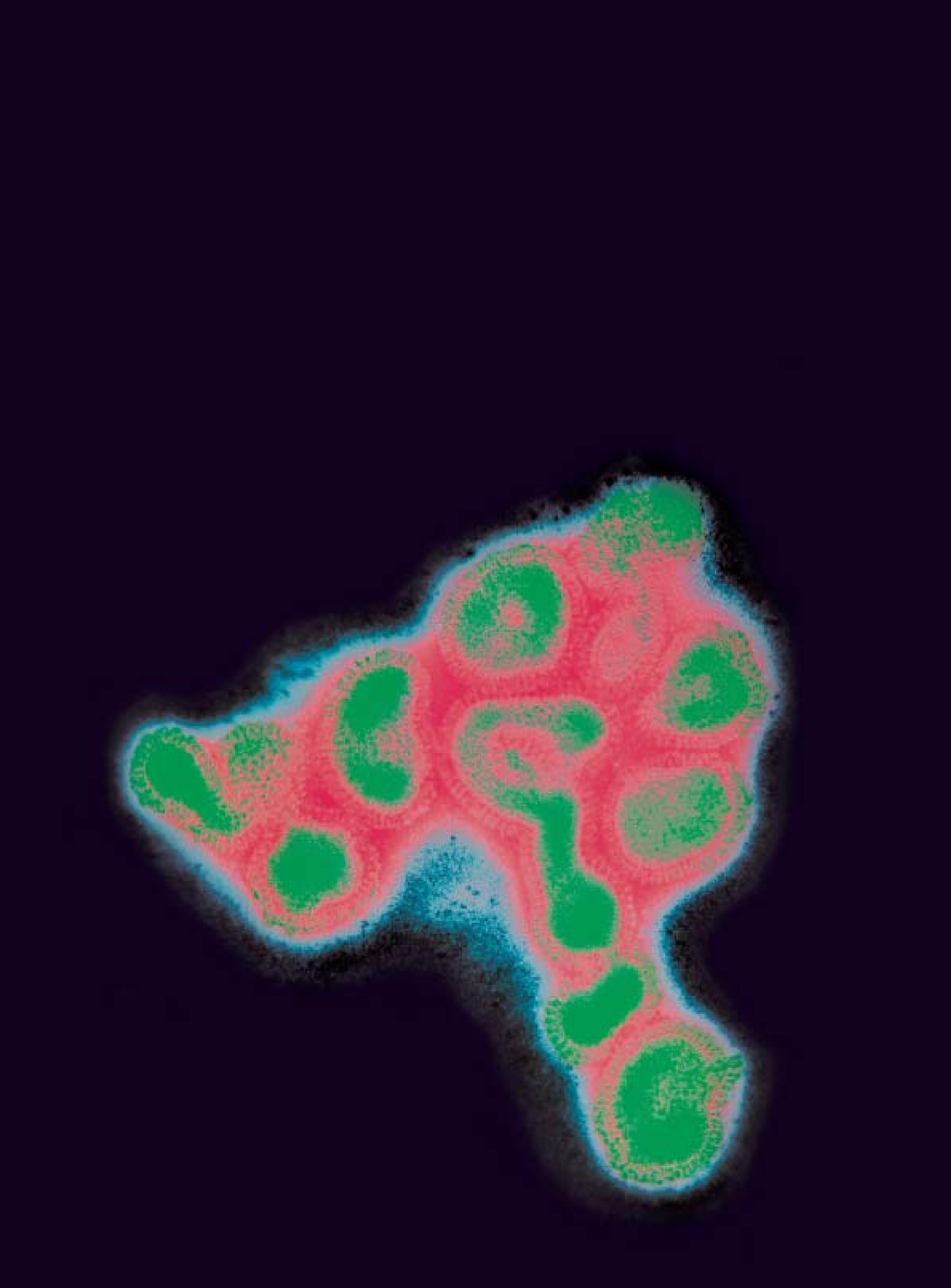
It is, above all, a vision for the optimal utilisation of human expertise and the relatively meagre resources available. This strategy has scientific merit and deserves the serious consideration of both national and international stakeholders.

The key advantages can be summarised as:

- greater ease in obtaining a critical mass in the scientists and experts involved
- promoting the most efficient use of human scientific resource: some fields such as genomics and informatics are relevant to disease control in plants, animals and humans
- better sharing of disease monitoring data – for example, between human and zoonotic diseases (around 75% of human infectious diseases originate in animals, and major pandemics such as HIV are considered to be animal in origin)
- promoting the sharing and spread of best practice in disease surveillance and control
- achieving economies from sharing scientific and support facilities
- including human, plant and animal disease control to address both economic development and human health needs, thereby linking the output of the centres to a range of policy needs
- promoting cross-fertilisation of science across the three areas.

8h Conclusion

Clearly, neither a single meeting of experts, nor a single Foresight project can hope to solve the immense challenge of infectious disease in Africa. However, the evidence in this chapter and elsewhere in the report argue the need for a step-change in approach – a quantum leap. A key output has therefore been the expression of a range of expert views on how such a quantum leap could be achieved. However, in expressing those views, the authors have not sought to tell African governments and stakeholders what must happen, but rather to inform and stimulate fresh debate and thinking in this area. It is hoped that those governments and stakeholders will themselves take these ideas forward and develop them further.



Appendix A

Areas of commonality of the proposed pan-African Vision and Strategy for the management of infectious diseases with the Report of the Commission for Africa (CfA)[8]

These include:

- **Science**
  - promoting capacity in science and technology (CfA Report Ch 4, para 26)
  - using centres of scientific excellence as springboards for developing scientific capacity (Ch 4, para 28)
  - up to 30 centres proposed in physical, medical and social sciences (Ch 4, para 30)
  - the need to combine physical centres of excellence with virtual networks of research that are internationally competitive (Ch 4, para 29).
- **Agriculture**
  - the need to link the creation of centres of excellence with the need to expand agricultural research (Ch 4, para 32)
  - the huge burden faced by farmers from pests and diseases affecting crops and livestock (Ch 7, para 83) – particularly important in view of the large dependence of some African economies on commodities (Ch 8, para 49)
  - the need for major growth in research in agriculture in Africa in the next 10 years (Ch 7, para 92).
- **Health**
  - the need for urgent investment to repair and develop health systems
  - promoting capacity building in the health worker crises (Ch 6, para 40)
  - building information and management systems for health, and using them to build capacity (Ch 6, para 41)
  - strengthening infrastructure – including access to affordable diagnostics etc. (Ch 6, para 42)
  - development of effective diagnostics (para 43)
  - adopting a regional approach to achieve critical mass between small markets and limited capacity (para 45)
  - taking the initiative forward as a partnership between the WHO and AU/NEPAD (para 49)
  - investing in training of health workers (para 50)
  - the need to integrate better the various existing initiatives that are tackling different diseases in Africa (paras 33 and 58).

[8] *Our Common Interest – Report of the Commisson for Africa.* March 2005. ISBN 0-1410-2468-2.

Appendix B

Experts who participated in the African component of the Foresight project

The authors and the UK Office of Science and Innovation would like to thank the many experts and stakeholder organisations who have contributed to the work in the project relating to Africa. These are listed below.

The authors of this report, together with other individuals who have played a particularly important role in the work are listed in bold.

Experts who were involved in the work		
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Experts who were involved in the work *(continued)*		
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Dr Jerome Kubiriba	Banana Programme	National Agricultural Research Organisation, Uganda
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Experts who were involved in the work *(continued)*		
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Samuel K Offei	Dean, Department of Crop Sciences	University of Ghana
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Experts who were involved in the work *(continued)*		
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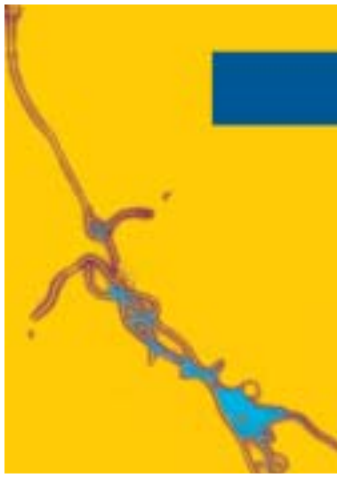
Appendix C

Structure of the project reports and supporting papers

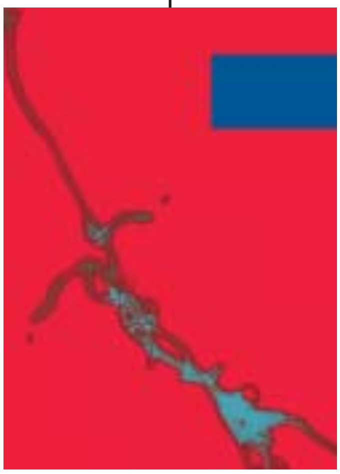


E1: Executive Summary

S1: Science Review Summaries

Detailed reviews of science:

- S3: Intelligent sensor networks
- S4: Data mining and data fusion
- S5: Non-invasive screening and scanning
- S6: Genomics and bioinformatics
- S7: Biosensors and biomarkers
- S8: Interrogation of natural signals
- S9: Predictive and real-time epidemiology
- S10: Earth observation
- S11: Host genetics and engineering
- S12: Immunological techniques



T1: Future Threats

Risk analysis:

- T2: Risk analysis
- T3: Expert survey of the UK and Africa

Disease case studies:

- T5.1: MRSA
- T5.2: HIV/AIDS
- T5.3: Influenza in humans
- T5.5: Food-borne pathogens
- T5.6: Fish diseases
- T5.7: Potato late blight
- T5.8: Malaria
- T5.9: Rinderpest
- T5.10: Plant viruses in sub-Saharan Africa (SSA)
- T5.11: Sudden oak death
- T5.12: West Nile virus

Climate change:

- T7.1: Overview
- T7.2: Plant diseases
- T7.3: Animal diseases
- T7.4: Human diseases

Modelling reviews:

- T8.1 Overview
- T8.2: Malaria in SSA
- T8.3: Bluetongue in Europe
- T8.4: TB control in SSA
- T8.5: Global traffic
- T8.6: Foot-and-mouth disease (FMD)
- T8.7: Paediatric HIV/AIDS
- T8.8: Tsetse in SSA
- T8.10: Malaria UK
- T8.11: Eco-costs of potato ring rot

NOTE: Report numbers are not sequential.
Some report numbers were originally reserved for reports which were subsequently not commissioned.

A1: Africa

D1: Vision of Future Detection, Identification and Monitoring Systems

P1: Action Plan

Further reviews and research:

- T9: Review of initiatives
- T10: Travel and migration and their impacts on diseases
- T11: Effects of diseases on ecosystems
- T12: Wildlife trade
- T13: China – human and zoonotic diseases
- T15: Plant pathogen database analysis
- T16: Human pathogen database analysis

Africa papers:

- A3.1 Paper for the Commission for Africa (CfA)
- A3.2 CfA paper appendices
- A4: Report of a pan-African workshop
- A5: Report of a pan-African workshop (French)

User Challenge work:

- D2: Introduction to the User Challenge work
- D2.1: UC1 – Data mining and data fusion
- D2.2: UC2 – Genomics and post-genomics for characterising new pathogens
- D2.3: UC3 – Hand-held diagnostic devices
- D2.4: UC4 – Fast-throughput screening devices

Future control of diseases:

- D3.1: Plant diseases
- D3.2: Animal diseases
- D3.3: Human diseases

Culture and governance:

- D4.1: Plants
- D4.2: Animals
- D4.3: Humans

- D5: Historical perspectives
- D7: Public perceptions of risk

Details of all the reports and papers produced by the Foresight project: 'Infectious Diseases: preparing for the future' can be obtained from the Foresight website (www.foresight.gov.uk). Any queries may also be directed through this website. The reports and outputs of the project should not be taken to represent the policies of any governments or organisations involved in the work.

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