10

Conclusion

Trachoma testing and diagnosis in Tanzania
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We have used the Millennium Development Goals (MDGs) to frame our exploration of science and innovation for development. The MDGs stand out as the most comprehensive, results-focused and influential set of international development priorities so far developed. The breadth of their targets for the reduction of poverty and improvement of human welfare has allowed us to examine the contributions of science over a range of development challenges.

1. Science and innovation in the MDGs

From our consideration of MDGs relating to agriculture, health and the environment, we can draw the following general conclusions about science and innovation for development.

Firstly, *science innovation for development is not just about technological solutions.* As importantly, it is about establishing a scientific understanding of problems that will guide development policy and investment. This role for science is particularly clear with environmental challenges. Understanding ecosystem function has given us tools to value ecosystem services in development decision-making, while the growing scientific understanding of climate change has not only made this a development priority, but identified the targets around which policies and agreements for mitigation and adaptation need to be built.

Secondly, *successful science innovation for development draws on the full range of sources of science and technology*. We frequently found that conventional, intermediate and new platform technologies are all making valuable contributions to a single development challenge. For instance, we saw for malaria management the complementary development of medicines based on traditional products like artemisinin, conventional mosquito nets improved with persistent and safe pesticides, and cutting edge vaccine technology. Similarly, we saw how the conservation of natural resources for agriculture could benefit from traditional dryland water and nutrient capture methods, on the one hand, and biotechnological research to improve the efficiency of water and nutrient use by crops on the other.

This observation challenges deep-seated and extreme views. At one extreme is the naïve perception of new technologies as stand alone, “silver bullet” solutions for development problems. At the other extreme is the belief that traditional or intermediate technologies are the only legitimate, fair and appropriate technologies in a development context. A new generation of science innovators needs to replace these prejudices with the understanding that being “appropriate” is not about where innovation comes from but about how useful it is.

Finally, *there are specific needs and opportunities for **new** science innovation for development*, not simply the modification and wider application of existing, conventional technologies. New platform technologies have a key role here, and it will be particularly important that scientists in developing countries participate in the global innovation systems which exploit them.

Specific areas of new science innovation, which we have identified in our study include the use of biotechnologies for increasing agricultural productivity and sustainability through plant and animal breeding, the development of new vaccines and medicines against diseases of the poor and the synthesis of remote sensing, modelling and GIS for measuring environmental change.

Important as science innovation may be to development objectives in agriculture, health and environment, we must stress that these areas are only a fraction of those covered by the MDGs.

Specifically, we have not considered MDGs for education (MDG 2) and gender equity (MDG 3), nor have we considered development priorities identified in the Millennium Declaration but left out of the MDGs, notably peace, security, human rights and good governance. Science innovation makes a contribution towards these priorities as well, particularly in the form of advances in data gathering, communication and analysis associated with new platform ICTs.[1] Education in developing countries is already benefiting from innovation in online learning technology. Technologies, ranging from innovative mobile phone networks to satellite-based remote sensing, have considerable potential to improve monitoring, analysis and reporting of political events such as elections, as well as conflicts and wars.

2. Beyond the MDGs

The MDGs have five more years to run to their target delivery date. We will miss many targets and indicators, particularly in the poorest countries. As we approach 2015, considerable discussion has begun on whether the MDGs have proven a good model for progressing international development.[2,3] There are concerns about their conceptualization, about ownership and about the use of targets. For instance, in seeking MDG impact, efforts are frequently focused on those most easily helped, which may actually contribute to inequity. Proposals for the future range from extending the time period for the MDGs, to modifying them, to starting again from scratch.

Towards this discussion, we contribute three observations which emerge from our consideration of science and innovation for development. They relate to the linkages between MDGs, the convergence of MDG challenges and to the anticipation of shocks.

Breaking down MDG silos

As explained in Chapter 4, the MDGs were not developed from a zero base through a process of collective priority setting. Rather, they were assembled from different, independent, often long-standing sectoral initiatives, with their existing priorities and targets. This explains their patchiness in coverage between sectors, as well as within sectors such as health. Each MDG represents years of development thinking in separate sectoral silos.

This isolation of development initiatives is not unique to the MDGs. It is a phenomenon born in the disciplinary structure of university education, and realized in the specialization of governmental and inter-governmental organisations and, consequently, their development programmes. For all of the benefits which specialization brings to the rapid advancement of understanding and delivery of results, it is often ill-suited to addressing complex development challenges.

Throughout this book, the inter-connectedness of the MDGs, and the importance of these connections to their achievement, has been revealed through exploration of their underpinning scientific basis. In Chapter 9, for instance, we saw how climate change impacts on agriculture, health and other development goals. In Chapter 6 we began by highlighting nutrition, which is not an MDG target, but because a good diet is critical to the baseline of health on which the three health MDGs build – improving child health, maternal health and reducing infectious disease. The lack of integration of international development investment between agriculture, health and the environment, perpetuated in the MDG structure, needs particularly urgent attention, as illustrated in Box 10.1.

Box 10.1 Agriculture, health and environment – inter-linked development goals?

Figure 10.1 – The livestock revolution – an agricultural, health or environmental issue?

The link between agriculture and health is surely straightforward, is it not? Agriculture produces food which is necessary for the maintenance of health. The focus of the Green Revolution on the improvement of cereal production – maize, wheat and rice – had a strong health driver. In the 1960s, when developing countries like India were facing famine, increasing the availability of calories to the poor was critical.

Subsequent yield improvements and intensification contributed to a global reduction in the cost of cereals and vegetable oils. By contrast, vegetables and fruits, sources of important micronutrients, have had comparatively little development and promotion, and access to meat and dairy products by many poorer households has remained low. The relatively low cost of commodities like cereals, combined with globalisation of food processing and distribution, and creeping urbanisation, have made a cheap, energy-dense, nutrient-poor diet available and affordable to millions of increasingly less active people.

This is fuelling a global obesity crisis.[4,5] Steady growth in the body mass index (BMI) of populations has been linked to a range of diseases: including diabetes, stroke, hypertension, osteoarthritis, cardiovascular disease and a number of cancers. Diabetes and cardiovascular disease, historically a major cause of ill health in wealthy countries, are now growing most rapidly in poor countries, even amongst the urban and rural poor.[6] At the same time, as incomes increase in some developing countries, we are seeing a rapid growth in the consumption of meat, providing important nutrients, particularly to children, but also contributing to chronic disease risk in adults through consumption of saturated fats.

The concept of malnutrition must now embrace both under- and over-nutrition, a "double burden" of food-related diseases. Thus how we invest in future research for agricultural development will affect future patterns of price, consumption, diet and therefore health. It will also affect how we address environmental challenges. Agriculture contributes substantially to anthropogenic greenhouse gas (GHG) emissions – four fifths of this contribution can be associated with animal production systems which generate GHGs from the production of crops to feed animals, from forest conversion to create pasture and through methane production by ruminants. Getting the right balance of agriculture, health and environmental investment is challenging, but it can have substantial benefits.

For instance, a recent study on how to achieve climate change targets for the agricultural sector in the UK has concluded that a 50 % reduction in GHGs from animal production by 2030 could be achieved by a combination of improvements in agricultural technology and a 30 % reduction in the overall amount of livestock produced. Were this reduction to translate directly into a proportionate reduction in consumption of saturated fats from animal sources, we could see a reduction in the total health burden from ischaemic heart disease by 15 % in disability-adjusted life-years (DALYs), by 16 % in years of life lost, and by 17 % in number of premature deaths.[7]

Another predictive exercise, the Agrimonde Project conducted by the French institutes CIRAD and INRA, has constructed two possible future scenarios for the relationship between agriculture, health and the environment: one focused on increasing food calorie production through technological innovation and increased trade, and the other on changing regional production, consumption and diet to specifically address under- and over-nutrition. The first scenario, because it focuses on agricultural intensification, has low environmental sustainability, while the second, because it shifts food consumption patterns to benefit populations, generates less environmental stress.[8]

Linking international development policy on agriculture, health and the environment is important, because of considerable interactions between these, including substantial co-benefits. As it stands, the MDG targets for hunger focus on dietary energy consumption and do not consider diet quality. Neither nutrition nor chronic disease enter into targets for health MDGs, and the MDG targets for environment do not identify agricultural, or indeed, any other specific indicators for GHG reduction. Continuing in our existing MDG silos will not address this cross-cutting issue effectively. Inter-disciplinary scientific research in these areas, which is just now beginning[†], may help to frame better future development goals and policies.

† These initiatives include the Agriculture Health Research Platform (programs.ifpri.org/ahrp/ahrp.asp) a collaboration between the CGIAR, WHO and other partners, and the new Leverhulme Centre for Integrative Research on Agriculture and Health (LCIRAH) established at the London International Development Centre (www.lidc.org.uk). Both of these focus particularly on international development dimensions of the agriculture, health and environment interaction.

Convergent future challenges

Besides revealing the inter-connectedness of development goals, scientific research reveals likely trajectories of development progress. We are now able to develop increasingly sophisticated models which predict how key development parameters like population growth, use of natural resources, and agricultural productivity change over time and interact. This in turn helps us to visualise the timetable over which progress in development goals is required. For instance, John Beddington, the UK Chief Scientist, has highlighted how scientific models predict the convergence of a number of inter-connected development demands by the year 2030. As Beddington explains, “It is predicted that by 2030 the world will need to produce 50 % more food and energy, together with 30 % more available fresh water, whilst mitigating and adapting to climate change. This threatens to create a ‘perfect storm’ of global events.”[9] Figure 10.2 illustrates the crucial connections which drive this process.

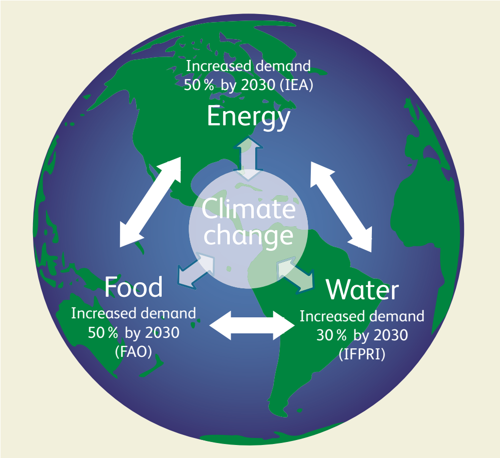

Figure 10.2 – Interacting elements of the Perfect Storm scenario[9]

Beddington's analysis is a wake-up call to those preparing timetables for future development goals. This timetable is likely to vary between regions and the convergence may come sooner in many developing countries due to more rapid population growth or more rapid environmental degradation.

Preparing for shocks

Across the range of MDG challenges which we have surveyed, we have found that scientific research points to a future pattern of agricultural, health-related and environmental shocks which may increase in intensity and frequency.

Climate change predictions suggest an increase in the frequency and severity of extreme weather events, for instance, droughts, extreme temperatures, flooding and tropical storms. Globalisation of trade and travel has contributed to the rapid movement of new pests and diseases of crops and livestock, leading to more frequent outbreaks that threaten agricultural production and trade. The same process of globalisation is increasing the risks of human infectious disease pandemics.

A recent UK Foresight study on *Infectious Diseases: Preparing for the Future* has shown how quite similar processes are operating today to increase the movement and risk of disease for humans, animals and plants, both in the developed and developing world. Changes in trade, travel, transport and tourism have increased the rate and distance of spread of human, animal and plant species, while more protected and rapid transport has increased pathogen survival over these longer distances. In addition, this movement of pathogens enables more mixing of species and strains, sometimes generating new and virulent forms.[10]

For human diseases, we have seen the emergence of new pathogens to be particularly associated with greater mixing of human and animal pathogens. Of 173 emerging or re-emerging human pathogens (pathogens that have appeared for the first time, or whose incidence has increased, over the past two decades), 130 or 73 % are zoonotic, having moved from animal to human hosts, usually from livestock or other animals used for food.[11]

How can the design of future development goals prepare for the environmental, agricultural and health-related shocks that are the inevitable consequence of globalisation and our impact on climate? In Chapter 9 we explored the concept of resilience as a development objective for climate change adaptation. This concept and its components: anticipation, prevention, tolerance and learning, apply equally well to agricultural and health shocks arising from movement and evolution of pathogens. For these problems, developing countries are not only the most vulnerable, but they are likely to be the "weakest links" in building a system of global resilience. Due to a lack of surveillance and response capacity, new disease shocks are most likely to emerge and spread undetected in these countries. Once detected, wealthy countries are likely to restrict the movement of people and goods from poorer countries, thus damaging their economies.

We suggest that future international development priorities should include strengthening national capacity for resilience to shocks. While these shocks may be varied, the processes underpinning resilience are similar. They include building a technical capacity to monitor populations and the environment so as to detect shocks, a capacity for predictive modelling and anticipation, and a range of responses that help communities and nations to prevent, tolerate and recover from disasters. Development itself, including improving food security, human health and the management of environmental resources, is the necessary foundation for building this capacity

These steps all point to a need for investment in science and technology. Before we do that, however, we might ask whether recent development investment in this area has been successful?

For instance,

- East Africa has suffered between the 1980s and the present a series of disastrous new plant pest and disease outbreaks on cassava, coffee, banana and wheat (see Box 5.14). Has East African national and regional capacity to respond to such agricultural shocks improved over this period as a result of technological development assistance directed at these outbreaks?
- In the Indian Ocean and Pacific, the terrible tsunami of 2004 led to the expansion of a network of satellite-linked sensors that monitor tsunami development across the world's oceans, the Deep-ocean Assessment and Reporting of Tsunamis (DART) system.[12] Has this improved national resilience to subsequent shocks, such as those in Indonesia and the Pacific in October 2009?
- With human infectious disease, have we seen an improvement in the speed and efficacy of response to the threat of swine flu in developing countries as a result of surveillance and diagnostic technology developed in response to SARS and avian flu outbreaks in 2003 and 2004, respectively?

Has science and technology improved the capacity of poorer countries to deal with these successive agricultural, health and environmental shocks? Evaluating examples such as these might be a first step in understanding the role of science innovation in preparing developing countries for future shocks.

3. Conclusions

In this book we have explored the potential of science innovation for international development. We have written the book particularly for those who have little experience of science in a development context. Necessarily, we have therefore focused on scientific aspects of development, and placed less emphasis on the other factors critical to successful progress, including good governance, infrastructure, economic growth and lack of conflict. Science does not provide wholesale solutions for development; it only makes contributions to those solutions. Further, we have not explored in detail the importance of linking natural and social science research in addressing development problems, a key feature of modern innovation systems.

We are very positive about the role of science in international development. Our confidence is based on its long history of success and the clear indication that problems encountered in the past when applying science to development are being addressed.

This timeliness derives from three emerging trends. First, the problems of rich and poor are increasingly shared problems. Wealthy countries no longer represent a model of successful technological achievement, towards which less wealthy countries can target their technological growth. We are all needing to change, and we are all on new trajectories for sustainable growth and stability, seeking paths towards agricultural security, control of global infectious and chronic disease threats, a low carbon economy and adaptation to climate change. While different paths will be taken by rich and poor, common problems will have elements of common solutions, particularly in science and technology.

Second, we are experiencing today in science a growth in new platforms that have the flexibility to be turned quickly and easily towards the problems of rich or poor alike. Biotechnology has given us a tool to accelerate the development of improved crops or new vaccines which, because of its reliance on fundamental genetic and molecular processes, is easily directed towards the crops and diseases of the poor. Scientific progress in these biological areas is less dependent today on marginal advances on a body of accumulated knowledge for a particular target species. Instead, we can understand and study valuable traits in new species quickly by exploiting complementarity between species in genomes and physiological processes. Similarly, new scientific platforms for nano-, energy, information and communication technologies are much more flexible than earlier engineering technologies which depended on established infrastructures and big industry.

Finally, we are experiencing a revolution in information and communication technology that increases our capacity to communicate and participate globally in science innovation, and to engage stakeholders and beneficiaries in this process, across historical boundaries of developed and developing countries.

Shared challenges, shareable technologies and improved opportunities for communication and collaboration – all very recent trends – greatly improve the prospects of effective science innovation for development. What actions will best secure these new opportunities and accelerate development? We close by suggesting five priorities for action, drawn from the experience of preparing this book, and the examples which we have gathered:

Train and empower scientists who can work internationally on science innovation for development. This involves first and foremost investment in science in developing countries. Building good science training into school systems, supporting universities to develop undergraduate and postgraduate science degree programmes, and supporting both universities and government research institutions to provide attractive career paths for bright scientists are all part of this priority. Development institutions which fund science need to shift their programmes from supporting national scientists on short term research grants to funding national research grant systems that make possible longer term research programmes driven by developing country institutions.

But empowering scientists to work internationally on science innovation for development also means raising the awareness of scientists in developed countries of developing country problems and improving their skills in being effective participants in international development research.

Strengthen science innovation systems in developing countries. National science innovation systems are needed to bring together scientists, entrepreneurs, regulators and other stakeholders who will support and deliver research and its benefits. At the same time, we need to help scientists from developing countries participate in global innovation systems through research with experts in other countries, working South-North and South-South. These research partnerships need to be more equitable and empowering for developing country scientists, supporting their careers in national institutions through opportunities for longer term research, publication and building research groups.

Ensure that new technologies are accessible to science for development. Besides engagement of scientists from developing countries in global innovation systems, we need to ensure continuous and sufficient resourcing for international public goods (IPG) research, so that the full potential of science innovation is available to address poverty reduction. This means supporting research institutions which focus on developing country problems and generate IPGs available to all. But it also means making imaginative partnerships with the private sector to make proprietary technologies available to research for development.

Design and deliver research for impact, by building results based frameworks for development research which ensures the "impact pathway" between the generation of scientific research outputs, the outcomes which they will achieve, and the *impact* which they will have on reducing poverty and improving well being. This means involving stakeholders in the framing of research questions, so that they are prepared to be involved as partners in the execution, application and scaling up of research outputs and outcomes. This will encourage development of appropriate technologies, drawing upon both international and local knowledge, and conventional and new platform science. At the same time, we must never forget the value of curiosity driven or "blue sky" research and we must ensure that some research investment is left to explore new ideas without the need to deliver specific impacts.

Raising the profile of science in governments, by helping governments and industry to understand the value of investing in science innovation systems to their poverty reduction and economic growth agendas. This includes demonstrating the societal value of support to science education and research, and to the establishment of independent scientific societies and advisory groups which can help governments make more informed policy decisions at the national and international level.

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