

Livestock R&D in East and Southern Africa: An innovation systems perspective with special reference to the International Livestock Research Institute

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Abstract

The concept of 'innovation system' is used increasingly in current science policy discourse as a metaphor to indicate the need for a much wider perspective on relevant decision-making procedures than has been the case in the past. This paper explores its use from the standpoint of the behaviour of an international agricultural research institute located in Africa and focused on two vector-borne livestock diseases, trypanosomiasis and theileriosis, which form case studies for this paper. The paper argues that adopting an innovation systems perspective could open up new possibilities for research institutes of this type with impacts on both socio-economic development and scientific quality that are likely to be positive.

Keywords

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agriculture
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Introduction

The concept of 'innovation system' is used increasingly in current science policy discourse as a kind of metaphor to indicate the need for a much wider perspective on relevant decision-making procedures than has been the case in the past.¹ Its particular use in agricultural research policy discussion is even more recent. For example, it is difficult to regard publicly funded agricultural science as the only source of crop yield improvements, and thus, of international food security and social wellbeing. Instead, the research agenda has expanded to include issues of continued (and worsening) poverty, environmental sustainability, private sector activity, the complementary roles of non-governmental organisations (NGOs) and community-based organisations (CBOs), the importance of farmer knowledge, the growth of relevant agribusiness and changing

1 See for example Biggs, S.D. (1990), Hall et al. (2000, 2001, 2003, 2004), Clark et al. (2003), Juma C. and Lee Yee-Cheong (2005).

(national and global) macroeconomic conditions. In short, the agenda for agricultural science has arguably become much more complex and multi-dimensional. In particular, it is about building up knowledge on how to integrate agricultural science better with client need and complementary capabilities, especially ensuring relevance to poor rural communities.

In short, modern literature shows that the agenda for agricultural research has changed dramatically from the days of the Green Revolution, and with it also the demands on relevant organisations. It is this new complex agenda that has created the need for a fresh look at science policy analysis for agriculture. Arguably, agricultural R&D can no longer be left on its own to meet the new demands of the 21st century using the old institutional methodologies. This means new types of relationship with other stakeholders and new types of capacity on the part of scientific institutions and organisations. This does not mean any reduction in the quality of the science. Rather the reverse is the case, as a UK Parliamentary Select Committee has pointed out in a recent report.² It implies that scientists and the organisations, in which they work, need to improve their capacities to undertake quality science. But to do this, they also must become more aware of the wider context of their research and how this can inform the nature and purpose of what they are trying to do.

At the same time, there is no clear understanding of the interdisciplinary issues involved, mainly because most stakeholder groups and individuals have been trained in ways that give emphasis to a narrow disciplinary focus and a reductionist approach to the conduct of research programmes. They are aware of the complexity, of course, but often have difficulty translating this in their minds and actions to appropriate change. Hence at one level, many scientists, for example, appear to accept that an 'innovation systems' approach may be a useful way forward in agricultural research planning. But at another level, they are at the same time not quite sure how to implement this as a set of practical projects. And the prevailing fear is that scientific quality may thereby be compromised. This paper should be seen as a contribution in this respect. It argues that far from compromising scientific research, the adoption of an innovation systems approach could actually add value to such research in both a cognitive and an applications sense. And in so doing, the role and purpose of international bodies like the International Livestock Research Institute (ILRI) can be enhanced and expanded.

Section II explores two cases of particular relevance to livelihoods in East Africa, and of particular relevance to the evolution of ILRI. One of these deals with the issue of theileriosis [East coast fever (ECF)], and the other with trypanosomiasis in cattle. In the former case there have been two basic prophylactic approaches. One is the so-called infection and treatment method (ITM) of preventing the disease while the other is the attempt to develop a molecular vaccine that would have similar results. ILRI scientists have been intimately involved in the development of both approaches, although in the case of ITM, ILRAD (one of the progenitor

institutions of ILRI) relied heavily on the original discovery and development work done at the East Africa Veterinary Research Organisation (EAVRO) in its laboratory at Muguga in the late 1960s. To date, the ITM method has proved expensive and difficult to manage (although versions have been adapted and applied extensively in Tanzania and Zambia), while the new vaccine is still very much under development. Thus, there has been limited impact on rural livelihoods and poverty reduction so far. To date, prevention is still primarily carried out by dipping cattle in a bath of acaracides designed to kill off the vector (the tick) that transmits the pathogen. In the case of trypanosomiasis, the original aim of developing a vaccine has now been put aside (because of the complexity of the science), and resources are now concentrated on diagnosis, molecular characterisation and factors that determine *trypanotolerance* in cattle. The cases raise some interesting questions about how taking an innovation systems approach might have improved (and could still improve) the focus and effectiveness of research.

Section III expands the discussion to what all this might mean for the organisation more widely. It suggests that ILRI might usefully engage more directly with a wider variety of stakeholder groups who have relevance to the associated 'supply chain'. In particular, it suggests that this engagement should take place at all stages from the original research strategy and design of proposals, the conduct of the research, testing of candidate protocols, formulation of medicines right through to final production, marketing and follow-up. It also reflects briefly on what this might mean for capacity building both within the organisation and in related bodies.

Section IV summarises the paper and presents concluding remarks. To some extent, the conclusions drawn are speculative and should be subject to discussion and debate. But enough will be said to indicate that a general move in an innovation systems direction could pay rich dividends to research bodies such as ILRI³ and perhaps to agricultural science in the service of development more generally.

Case studies

In 1973, a memorandum of agreement was signed between the Government of Kenya and the Rockefeller Foundation (acting on behalf of the Consultative Group for International Agricultural Research [CGIAR]) for the establishment of one of the forerunners of ILRI,⁴ ILRAD, as an international and autonomous, non-profit organisation. According to this agreement:

(t)he purpose of the Laboratory will be to serve as a world centre for research on ways and means of conquering, as quickly as possible, major animal diseases which seriously limit livestock industries in Africa and in many other parts of the world. The Laboratory will concentrate initially on intensive research concerning the immunological and related aspects of controlling trypanosomiasis and theileriosis (mainly East coast fever). It may, however, eventually extend its research to other serious animal disease problems for

- 3 In fact it has to be said that ILRI under its new Director General has already taken steps in precisely this direction through the creation of a specially designated innovation systems team.
- 4 The other is the International Livestock Centre for Africa (ILCA). The two bodies were merged in 1994.

5 It should also be noted that the overall goal of the CGIAR at the time was to focus first world science and capacity on third world problems that were unique and important but would not attract attention of first world research or industry.

which its facilities and expertise are appropriate . . . In carrying forward its program, the Laboratory will develop close linkages with governmental and regional organisations undertaking research on the same or related disease problems (ILRAD 1973: 2).

ILRAD was, therefore, set up as a laboratory-based scientific research institute with a global mandate to develop immunological solutions (mainly vaccines) to theileriosis and trypanosomiasis. In practice, as a result of the distribution and effects of the diseases, ILRAD would focus on Africa.⁵

Trypanosomiasis research and development

Trypanosomiasis is caused by unicellular protozoan parasites, termed *trypanosomes*, which propagate in the blood and tissue fluids of their hosts. Pathogenic species of *Trypanosoma* occur in Africa, Asia, Latin America and the Middle East, and infect among others humans, cattle, sheep, goats and water buffalo. Some species of *trypanosomes* also cause sleeping sickness in humans. The susceptibility of host species differs – the disease can be either acute or chronic. Trypanosomiasis is frequently fatal in highly susceptible animals (such as *Bos indicus* Zebu cattle and some exotic breeds), while in more resistant ones (including N'Dama cattle, a west African *Bos taurus* breed), the disease results in decreased productivity. Symptoms of trypanosomiasis include sporadic periods of fever, wasting, enlargement of lymph nodes, anaemia, infertility and immune dysfunction. The major *trypanosome* species that infect animals in Africa are *Trypanosoma congolense* and *Trypanosoma vivax*. These are mainly transmitted by tsetse flies although non-tsetse transmitted forms of trypanosomiasis also occur in Africa and South America.

Trypanosomes assume different morphologies during their lifecycles in hosts and vectors (tsetse flies). They expose a variable surface glycoprotein coat on their outer layer when in the bloodstream of the host. This coat is lost once the parasite is ingested by a tsetse fly. The *trypanosomes* migrate to the salivary glands of the flies, where a new coat begins to develop. They now take on a non-dividing, coated metacyclic form. Upon feeding on another animal, the tsetse fly transmits these metacyclic forms into its skin. The *trypanosome* begins to acquire characteristics of a bloodstream form, and eventually enters the bloodstream. Thus, variable surface glycoproteins are present in both the bloodstream and metacyclic forms of *trypanosomes*.

Once in the bloodstream, the *trypanosomes* begin to divide, and trigger an immune response from the host – antibodies are produced against the surface glycoprotein coats (essentially, 'the antigen face') of the parasites. The *trypanosomes* have developed a survival strategy to avoid destruction by the host immune system. *Trypanosome* infection occurs as successive waves of parasites (known as parasitaemic waves) appearing in the blood and tissue spaces of the host. The host mounts an immune response to the repertoire of antigens (variable surface glycoprotein coats) present in each

wave. By the time this immune response has occurred, some *trypanosomes* have altered their ‘antigenic faces’ – these will initiate the next wave of *trypanosome* infection, for which the host immune system is not prepared. This *trypanosome* survival technique is referred to as antigenic variation. It is a pre-programmed defence mechanism, which occurs in the absence of an antibody challenge, and is therefore not triggered by host immune pressure.

For decades, trypanosomiasis control has been attempted mainly through two routes – vector (tsetse fly) control and trypanocide drugs. The former has involved a range of approaches, from tsetse habitat clearings and the use of impregnated traps, to the widespread application of insecticides and the use of the sterile male technique. Indeed in the early to mid-1980s, according to one authoritative source, ‘the days of tsetse seemed numbered’ (Torr et al. 2005:1). Large scale spraying at ground and aerial levels had all but eliminated tsetse from large areas of east, west and southern parts of Africa that had previously been infested. This had given enormous benefit to livestock owners, many of whom were poor farmers. In addition, a range of newer technologies such as odour-baited targets and pyrethroid-treated cattle seemed to indicate that the problem was showing every sign of getting under permanent control.⁶ According to Torr et al. (2005:1), however, what seemed a promising research trajectory began to fall apart because of changing donor priorities and research policy positions. This combined with general economic decline in these countries meant that considerable ground was lost. It was in this context that ILRAD embarked on a biological solution to the trypanosomiasis problem in the early 1980s, namely the discovery of a vaccine. But as outlined above, the development of such a vaccine was hampered because of antigenic variation; and vaccine research efforts effectively ended at ILRI in 2000. The focus of trypanosomiasis research at ILRI subsequently shifted to the genetic characterisation of trypanotolerant cattle.⁷

ECF vaccine development

Theileriosis refers to a complex of diseases caused by protozoan parasites from the genus *Theileria*. These parasites invade and propagate in the cells of the immune and haematopoietic (blood cell producing) systems of their hosts, mainly cattle. As in the case of trypanosomiasis, susceptibility to the disease differs among breeds – in highly susceptible, imported and more productive breeds, the disease is acute and frequently fatal (within 3–4 weeks of infection). Even in more resistant breeds, lower productivity follows recovery from an infection. Symptoms include fever, lethargy, enlargement of the lymph nodes, difficulty in breathing and wasting. In Eastern and Central Africa, the most important species is *Theileria parva*, which is transmitted by the brown ear tick, which causes ECF in cattle. The parasite is closely related to the causative agent of malaria in humans.

Similar to *trypanosomes*, the *T. parva* parasite exists in different morphological states during the course of infection. The parasite is transmitted

- 6 Torr et al. (2005) argue that cheap mechanisms for tsetse control have now been refined to a stage that were they carefully applied, trypanosomiasis could well be effectively if not completely eliminated.
- 7 Sources: ILRAD Annual Scientific Reports 1989–1994; ILRAD Annual Reports 1980–1993; ILRAD Strategic Plan 1994–2003; ILRI Annual Reports 1995–2003; Discussions with Dr. Duncan Mwangi.

from a tick to a host in the sporozoite form, which directly infects the host's white blood cells. The parasite develops into a schizont form, which transforms the white blood cells, causing them to continuously divide. The schizont essentially integrates itself into the cell division cycle of the host, and the effect is comparable to leukaemia. The maturation of the schizont into the merozoite stage causes cell rupture. These parasite forms infect red blood cells where they develop into the piroplasm stage. The piroplasm forms of the parasite are picked up by a tick when feeding on a carrier host. Once in the tick, the parasite undergoes sexual reproduction, and development into a sporozoite, which is now distinct from the parasite it acquired while feeding.

Control of ECF has relied on the application of acaracides against ticks. In high-risk areas, cattle have been sprayed with, or dipped in, acaracides on a frequent basis. However, this is expensive, and tick populations have been shown to develop resistance to available chemicals. Pasture management has also proved to be effective, but small-scale livestock keepers often lack the resources required to implement this. Chemotherapeutic drugs have also been developed (naphthoquinones), but these are expensive. Furthermore, infected animals must be treated early in order to fully recover. The most widely used approach remains the 'infection and treatment method' (ITM) of immunisation, described below.

The prospects of a vaccine against ECF were initially encouraged with the discovery that an episode of theileriosis in an animal led to immunity. Subsequently, however, distinct strains of *T. parva* were found, and it was established that broad protection could only follow exposure to a variety of strains. This obstacle was overcome when it was elucidated that exposure to a combination of three different strains appeared to provide a broad immunity, and when it became possible to harvest sporozoite forms of the parasite from ticks. This became the basis of the live vaccine used in ITM. Different strains of sporozoites extracted from infected ticks were injected into animals, and the animals were simultaneously treated with long-acting tetracycline antibiotics. While preventing full-blown clinical manifestations, the immunised animals occasionally show mild and transient symptoms of the disease. ITM, although widely implemented, has several shortcomings. It requires a cold chain facility to maintain the sporozoites alive, antibiotics, and expertise to monitor animals after treatment. These factors contribute to the high costs of ITM. Additionally, there is the risk of the live suspension being contaminated by other material from the tick. Furthermore, immunised animals become carriers of the parasite, and can potentially infect ticks and spread theileriosis. ILRAD initially, and ILRI subsequently, have been involved in the quality control aspects of ITM stocks.

However, since the early 1980s, ILRAD's and ILRI's activities in ECF have mainly been focused on the development of alternative vaccines. The targets have been envisaged as both the sporozoite and schizont forms of the parasite. ILRI is currently developing a recombinant vaccine based on the antigens exposed by these forms. An anti-sporozoite vaccine has

already been developed, based on the p67 protein (antigen) of the sporozoite to which the host immune system responds. Eight candidate schizont antigens have been identified to date, of which six are under closer focus. Ultimately, ILRI (with its extensive range of partners on this project) aims to develop a combination vaccine consisting of specific antigens of the sporozoite and schizont forms.⁸ Although it has to be said that the biology of the parasite has proved much more complex than initially assumed and it is proving harder to satisfy donor demands in this respect.

Implications for institutional policy

What then does this discussion tell us about research policy for an organisation like ILRI? We have suggested that an important analytical approach in this respect is that of the ‘innovation system’. This may be defined as the network of agents whose interactions determine the innovative impact of knowledge interventions, including those associated with scientific research. The concept is now used as a kind of shorthand for the network of inter-organisational linkages that apparently successful countries have built up as a support system for economic production across the board. In this sense, it has been explicitly recognised that economic creativity is actually about the quality of ‘technology linkages’ and ‘knowledge flows’ among and between economic agents. Where the interactions are dynamic and progressive great innovative strides are often made. Conversely, where systemic components are compartmentalised and isolated from each other, the result is often that relevant research bodies are not at all productive. In extreme cases, they have ceased to provide any innovative output at all. Put another way, the key property of a system of innovation is therefore not so much its component parts, or nodes, but rather how it performs as a dynamic whole.

But this still leaves the question how in practice does a research body like ILRI amend its institutional structure to take advantage of such an approach? Perhaps the best way of approaching this question is through looking through the lens of a ‘production’ or ‘supply’ chain since this automatically captures the totality of the system under consideration and, by extension, the relevant stakeholder groups. In general a supply chain looks something like that outlined in Figure 1.⁹ However, in reality it is immediately

- 8 Sources: ILRAD Annual Scientific Reports 1989–1994; ILRAD Annual Reports 1980–1993; ILRAD Strategic Plan 1994–2003; ILRI Annual Reports 1995–2003; Discussions with Dr. Duncan Mwangi.
- 9 Drawn from Clark et al. (2005), which deals with the introduction of the treadle pump in Bangladesh and India. [‘Mistris’ are well-diggers who played a key role in the development of this technology.]

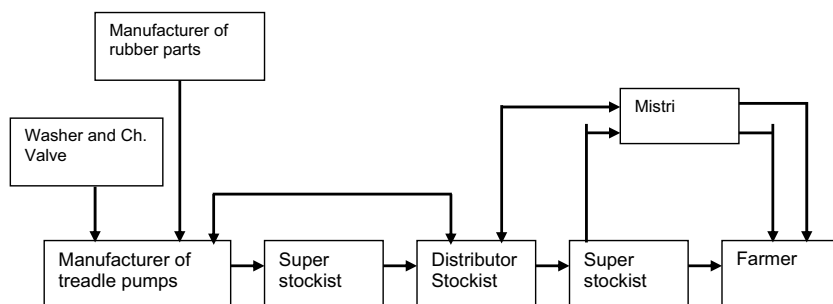


Figure 1: Treadle pump supply chain; source: Clark et al. (2006).

10 This notion of making an analogy with electro-magnetism in physics was first put forward in Clark and Juma (1992). The idea is to capture informational influences on socio-economic activity that have yet to be fully determined. See also Clark (2002).

obvious that such a chain can never be linear since to be effective it must accommodate feedback of information (and resources) and therefore provide opportunities for learning and change. In fact what is commonly called a supply chain is in reality a system of interaction among key 'nodes' and it is how collectively such nodes interact that determines the effectiveness of the system as a whole. Or in the case of a new technology how effective it is as an 'innovation system'. Clark et al. (2005) show how this worked in the case of the introduction of new transportation technology in Himachal Pradesh, India. Here, while the original supply chain (i.e. the production and sale of tomatoes) looks fairly simple, when translated into innovation terms it becomes much more complex as may be seen in Figure 2.

In the case of research interventions (e.g. for interventions that may require bench science), the chain (or system) might be more like that outlined in Figure 3. In fact, the chain really acts more as a sort of 'backbone' to a system of considerable complexity. Here, the translation of resources into products that have value is subject to the informational impact of a wide range of activities only some of which are formally 'scientific'. Government regulation, for example, sets boundaries as to what innovative interventions are permissible. NGOs of different types will usually possess tacit knowledge regarding the effectiveness and acceptability of new technologies, as often will be the case with the private sector. Public sector agencies will usually be in similar positions. In effect the simple 'supply chain' sits in the middle of an 'informational cloud' with properties analogous to those of an electro-magnetic field.¹⁰ The problem though is how to manage these potential informational flows to maximise developmental opportunity. A further complication is that many of these different agencies may have interests that conflict and may resist interventions where they feel they might lose resources or power.

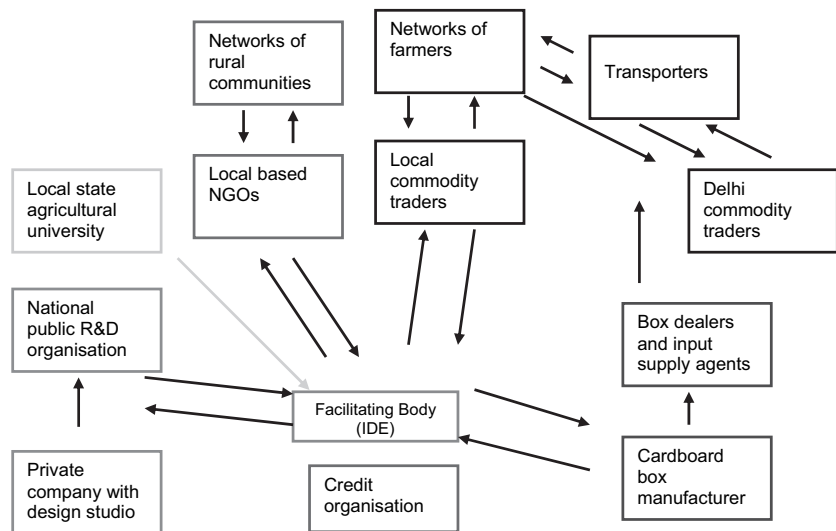


Figure 2: Innovation system for tomato boxes; source: Clark et al. (2003).

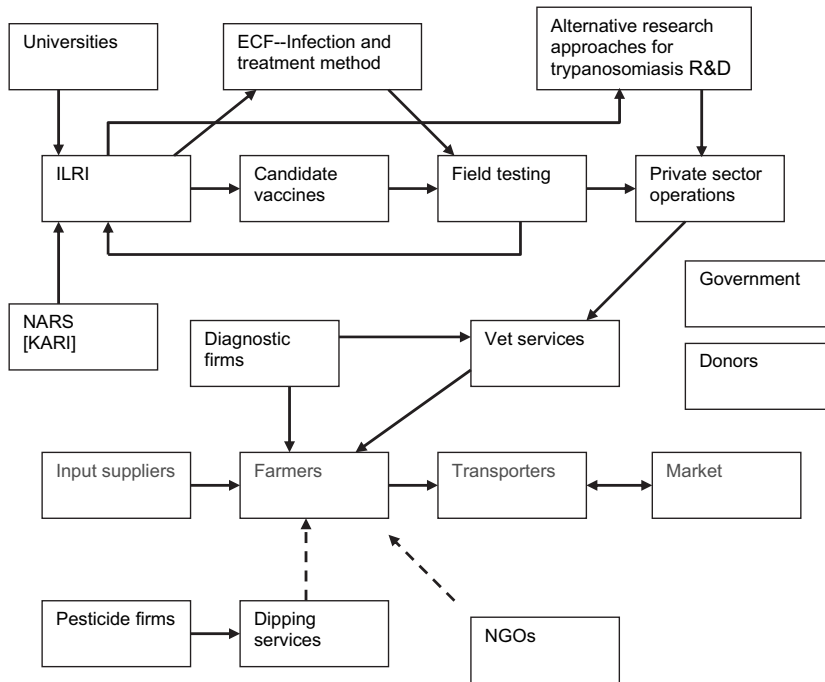


Figure 3: ECF supply chain.

What implications does this have for the management of research in particular and science policy more generally? Returning to the case study discussion of trypanosomiasis in the previous section the decision was taken in the early 1990s to abandon vaccine research because despite nearly 15 years of effort, the likelihood of getting to a viable vaccine was felt to be minimal. The tsetse fly continues to be a scourge but, as we have said, there are other methods of dealing with trypanosomiasis in cattle – for example, the use of traps and targets and bush clearing. Much of the research for this had produced good quality science throughout Africa but ILRAD did not ever really engage with it as a ‘research trajectory’.

Within ILRAD itself, science continues to play a role but in the more limited sense of diagnostic research and research into trypanotolerance in cattle. Of course, the question still remains as to why these other research trajectories were not given more emphasis in the early days despite the fact that ILRAD (the predecessor of ILRI) established itself as a centre of bovine immunology, arguably it could still have been proactive in other senses. At the same time, it must be said that the knowledge generated about antigenic variation has led to an increased understanding of their basic biology, which, although it has highlighted the complexity and difficulty of developing a conventional vaccine, has identified alternative options. Similarly, the knowledge generated in the field about alternative methods to control *trypanosomes* has led to increased emphasis on research into drug resistance and the genetic basis of trypanotolerance.

- 11 We are grateful to Dr. T. Dolan for his insights into the history and present status of ITM technology. These stem from his close association with this type of research since the mid 1970s.
- 12 However, extensive testing of ITM was conducted in Kenya by UK supported projects with Kenyan counterparts from 1978 until 2000 extending the original FAO funded work, using locally isolated stocks; ILRAD conducted trials at the Kenya coast in the early 1980s with a coastal stock, Marikebuni, that was later tested in many parts of Kenya and adopted as the national immunizing stock.
- 13 Although that centre ceased to be capable of large scale vaccine production as early as 1992 (personal interview).
- 14 At the time of setting up ILRAD, the countries of the region looked to it for the next generation of vaccines and, as molecular techniques for parasite characterisation were developed, they offered tools with which ITM strains could be better defined and compared. The cost of isolating, defining and producing national strains make it difficult for countries to adopt the control measure and most national programmes have been sustained through donor support – UK in

The case of ECF is rather more complex.¹¹ As mentioned above, the ITM method was actually ‘invented’ not by ILRAD but by an UNDP/FAO project at the East Africa Veterinary Research Association (EAVRO) in its laboratory at Muguga in the late 1960s with the aid of considerable UNDP/FAO funds. In fact, ILRAD was only established in 1974 and did not begin serious research until some years later, when as an organisation it relied on expertise and unique parasite material at EAVRO. Early testing of the EAVRO ‘Muguga cocktail’ was carried out in the field but mainly in Malawi, Uganda and Tanzania. Testing was not permitted in Kenya where it had been prohibited because of the inclusion of a parasite of Tanzanian origin that might induce carriers of the disease. Also, there was a probability that dipping frequency would be reduced requiring changes in the Cleansing Act and undermining the opportunities to monitor cattle for other diseases when gathered for dipping.¹²

The ‘cocktail’ was finally approved for limited use in Kenya in Maasai cattle in the last two years. Other countries, particularly Zambia with Belgian support, have continued to conduct live vaccine research, testing and production. In the intervening period live vaccines have been produced and used in Zambia and Zimbabwe, and a centre was established in Malawi for tick-borne vaccine research and production.¹³ In addition, there are now a range of therapeutic products on the market based on earlier research in UK, Germany and at Muguga and produced by international companies. Other reasons why vaccination was slow to be adopted in Kenya may have been the vested interests on the part of either veterinary authorities and/or acaricide manufacturers. And it has been suggested that one reason for the recent relaxation of prohibition in Kenya is the increasing problem of acaricide resistance in the tick population. Arguably this has made the need for alternative solutions much more pressing. A final argument concerns the high costs involved in production and delivery, though these seem nowadays to be smaller than they once were.

In fact, ILRAD, in its initial mandate, made the strategic decision to look for an immunological solution to the ECF problem. From that point on, the organisation saw itself as a high quality centre for research in bovine immunology with the ultimate objective of discovering vaccines for both cattle diseases through molecular research into the biology of the problem. ITM research continued but gradually gave way to the alternative approach until now it plays almost no part in ILRI activity. Hence it is apparent that there were (and still are) three prime mechanisms for dealing with the disease (ECF). In practice, ILRAD took the view that the molecular ECF vaccine should be the preferred route. This may have been due to problems associated with the complexity and the expense associated with the ITM method. At the time of the early decision in the 1980s, it seems reasonable to suggest that existing organisations would have had trouble actually testing and delivering this crude vaccine no matter how successful it had been in early trials.¹⁴ Conversely the prospects for a science-based vaccine must have seemed promising at the time.¹⁵

However, as the new millennium has arrived the issue no longer seems so clear cut. The biology of ECF is now recognised as much more complex than initially expected and donors funding this research are inevitably wondering whether the expense will ever pay off in practical terms for the poor farmer, no matter how good the research is in purely scientific terms (although there is evidence that the project is building other kinds of research and innovative capacity, cf. Smith, 2005). There is some evidence (interview data) that the fallback remedy (dipping the cattle) is becoming less effective because of growing acaricide resistance in the ticks. In addition, it may very well be that better capacity now exists for ITM delivery because of institutional learning, improved infrastructure and possible private sector investment. It is here perhaps that an innovation systems analysis can play a decision-making role, since by focusing on the wider context it allows for a more objective view of how to proceed. Thus the diagrams reveal the following generic properties:

1. Formal research institutes are only one knowledge source among many. Others will certainly have a wide range of potential knowledge although much of this may only be tacit
2. Hence all actors (stakeholders) in the system are potentially nodes of a system that interact both informationally and economically
3. Thinking in innovation systems terms enables you to map out options for creating coherence among the wider variety of actors
4. It allows for more inclusive decision-making procedures on research projects
5. It also provides guidelines for necessary institutional reform
6. It extends the notion of 'capacity building' beyond merely formal training
7. It emphasises the importance of partnerships and continuous learning

Returning to Figure 3 it is clear that ILRI research is inevitably embedded in a highly complex set of stakeholder interests. In the early days (i.e. from 1980 on), the organisation (at that time ILRAD) took the view that its major role was one of placing the bulk of its resources firmly behind the search for molecular vaccines. In a sense this became the central thrust, one that fitted well into a CG ethos that focused on the great importance of strategic science in solving the world's food problems, although why alternative scientific approaches were not given greater consideration at that time raises interesting questions of scientific management and political economy. Also, though other stakeholder interests were present these appear to have played little or no role in such a specifically defined and science-led strategy. But as outlined in Section II, time has gone on and the wider context has changed (partly, it is true, because of the merger between ILRAD and ILCA in 1995). Nowadays, it is probably no longer possible for ILRI to function in an exclusively science-led mode, which leaves it in a difficult position as a research organisation. How should it reposition itself to continue to make a contribution?

Kenya, FAO and the Netherlands in Tanzania now and Denmark in the past, and Belgium in Zambia. For a useful discussion of these issues see Musisi and Dolan (1999). See especially pp. 133–136.

- 15 Although the 3rd EPMP in 1992 recommended only a further 5 years research on ECF vaccine research.

It is our view that scientific research is clearly still of fundamental importance in dealing with a variety of livestock diseases that continue to plague the poor farmer in this part of the world. And therefore it is also clear that a research institute like ILRI should continue to play a pivotal role in technology development particularly where the necessary interventions are science-based. From an innovation systems perspective, however, the difference would lie in its need to act also as a 'knowledge facilitator' in the wider system of animal health resolution. It might for example develop a set of ITM projects that consisted of a consortium of stakeholder groups (led by ILRI) with a set of objectives that were ultimately developmental. Research needs could be anticipated to some extent but would also depend upon the evolution of the projects themselves. ILRI's capacity to play such a wider role would also have to be developed.

Concluding remarks

We began this discussion paper by suggesting that the agenda for agricultural research has changed markedly from that obtaining in the days of the Green Revolution. One upshot of this is that scientific research bodies like those of the CG system are under increasing pressure to modify their ways of working. This much is already widely recognised in relevant policy circles. Indeed, ILRI is beginning to acknowledge some of this new thinking regarding knowledge:

ILRI's strategy . . . reflect[s] a changing approach to international public good (IPG) research, particularly as it relates to poverty reduction. This approach acknowledges that a simple pipeline of technology transfer from researcher to the poor does not adequately respond to the complexities and dynamic changes faced by poor livestock keepers. These need to be addressed by an array of disciplines and expertise, through mechanisms that recognise and respond to demand and with institutional support for learning and information sharing between partners. (ILRI 2004:108)

The problem is really one of how to proceed. It is in this context that we have cited the cases of ECF and trypanosomiasis. Both have been central to ILRI historically – both illustrate the complexities of science-based technology development, and in both cases, adopting an innovation systems perspective might have modified research trajectories. Indeed, elements of the current ECF vaccine research display an innovation systems approach. However, it is not our intention to use these cases to criticise the organisation *ex post* as it were. On the contrary ILRAD (as it then was) probably behaved perfectly naturally given the culture of its time. A pessimistic view would be that the history of research into the science of this type of disease control has shown both the immense complexity of the problem and the underestimation of this complexity in early research approaches. Moreover, the great reduction of funding for this type of strategic scientific research may now mean that bodies like ILRI no longer have the rationale that was envisaged at the time of their creation.

A more optimistic view is that we now have a better idea of the role of knowledge in socio-economic development and that ILRI could benefit from this knowledge in its future research planning. While the lack of core funding may preclude the type of research that will lead to major breakthroughs, ILRI could begin to play more of a scientific brokerage role in which it acts as a sort of central scientific resource dealing with strategic scientific issues affecting animal health and livestock production in Africa. A similar function might also be adopted by other CG centres. However, as has often been pointed out, there are still tensions within relevant science communities regarding the professional status of science policy concerns. The basic issue is the familiar one of 'mode 1' versus 'mode 2'.¹⁶ Research managers worry that bench scientists will become distracted from their research, which will suffer as a consequence. Some still do not yet accept that the agenda for research has changed and wish to return to earlier Green Revolution mandates.

The policy-making community is also torn. On the one hand, it is used to treating the R&D system as a disinterested source of knowledge of relevance to sectoral ministries. On the other, it has developed a view that many publicly financed R&D projects are an expensive drain on resources and are not having the impacts expected of them. The issue here is probably one of awareness raising. Evidence from industrial sector experience indicates that a focus on 'innovation' rather than 'science' requires fundamental institutional changes that have themselves to be innovated. Such changes mean experimenting with the unknown and are bound to lead to uncertainty. Nevertheless, some movement in this direction is inevitable. It is our considered view that far from compromising science, there is every likelihood that science will re-establish itself as a central component in the achievement of the Millennium Development Goals.

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16 See Clark (2002) for an account relevant to international agricultural research. For the original source on this point see Gibbons (1994). Very crudely the distinction is as follows. 'Mode 1' approaches (the traditional view) argue for a complete organisational separation between scientific research on the one hand and its practical application for economic and social welfare on the other. Conversely 'Mode 2' approaches argue for institutional arrangements that build science policy concerns directly into the conduct of R&D.

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