Agricultural extension reform in Africa: Insights and lessons from livestock disease control in South-West Ethiopia

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Summary

Agricultural extension systems across Africa are under great pressure to become more efficient and effective. Whereas proposals abound as to what African governments should do in order to achieve these goals, those addressing how they might do so are rare. The literature still offers little guidance as to specific factors and processes that likely influence development and diffusion of agricultural technologies in given circumstances. This paper addresses this gap by analysing the outcome of a multi-year, farmer-centred intervention to control trypanosomosis—a devastating livestock disease transmitted by tsetse flies—carried out by the International Livestock Research Institute (ILRI) in South-West Ethiopia. While not conceived as such at the time, this intervention emerges, in retrospect, as a real-world experiment in decentralised private provision of a traditional public extension activity. The nature of the control technology and several biophysical and socio-economic characteristics of the region selected for control combined to produce a self-reinforcing process key to the success of the initiative. The intervention suggests that it is the *demand-side* of agricultural extension systems that matters the most, and that in most cases, an 'organised articulation of demand' will be required. The internal logic of that 'articulation' is the exact *reverse* of that driving privatisation and decentralisation of extension systems. That logic also differs significantly from that guiding 'demand-led, farmer-participatory' approaches to extension reform.

Keywords: Agricultural extension, policy reform, rural development.

1 Introduction

Throughout the world, public provision of key goods and services outside markets is being replaced by private delivery in increasingly liberalised markets (Florkowski et al. 1997; Ariyo and Jerome 1999; Kuczynski 1999; Nolan and Xiaoqiang 1999). This trend is particularly significant in Africa where privatisation and liberalisation often involve public withdrawal from production and delivery of agricultural extension services (FAO 1994; Umali et al. 1994; Goletti and Govindan 1995; Tambi et al. 1999).

Yet extension systems in Africa continue to flounder. And while proposals continue to emerge as to *what* African governments should do in order to improve efficiency and effectiveness (e.g. Beynon 1996; Neuchatel 1999; Rivera et al. 2000; World Bank 2000), few propositions have appeared as to *how* precisely to do so. This is not surprising, for the literature still offers little guidance as to specific factors and processes that likely influence development and diffusion of agricultural technologies in given circumstances. Especially lacking are analyses of the actual and potential roles played by, and obstacles and opportunities facing, rural traders, households, and communities—i.e. the rural 'private sector', on which so much depends, and of which so much is expected, in extension reform efforts.

This paper addresses these gaps in the literature by analysing the design, implementation, and outcome of an intervention to control trypanosomosis (a devastating livestock disease transmitted by tsetse flies) undertaken by the International Livestock Research Institute (ILRI) in South-West Ethiopia. While not conceived as such at the time, this intervention emerges, in retrospect, as a real-world experiment in decentralised private provision of a traditional public extension activity, namely delivery of animal health inputs and services. Key characteristics of the disease and its vector, of the intervention technology, of the overall intervention strategy, of the region selected for intervention, and of participating farmers suggest insights into a range of issues that arise when analysts and decision makers take fully on-board the question of *how* to reform agricultural extension services in Africa.

The next section describes the intervention. This is followed by a discussion of interactions among key regional features and household characteristics, which, in unison, implied a self-reinforcing process key to the success of the initiative. Implications for extension reform are then drawn.

2 Insecticide 'pour-ons' for tsetse control in Ghibe Valley, Ethiopia

African animal trypanosomosis is a parasitic blood disease transmitted by several species of the blood-sucking tsetse fly (*Glossina* spp.). The disease constrains livestock productivity and agricultural development across a wide swathe of Africa[1]. Fifty million cattle are found in tsetse-infested parts of the continent (Kristjanson et al. 1999). Annual losses from the disease are estimated to be at least US$ 1.6 billion (Swallow 1998) and could be as high as US$ 5 billion (Murray and Gray 1984). There are a number of ways to control the disease: tsetse flies can be suppressed using traps, targets or insecticides; preventive and curative drugs can be administered to threatened or sick animals; and breeds of livestock with genetic resistance to the disease can be selected and raised. The technical effectiveness of alternative control strategies—often involving more than one method—depends on interactions among such factors as tsetse and trypanosome species, topography, natural vegetation types, livestock breeds, livestock and human population distributions and densities, conditions in factor and product markets, and crop and livestock production systems (d'Ieteren et al. 1999).

1. The disease also has a human form and current estimates put the number of newly infected people at 300 thousand per year (Cattand 1999)

Trypanosomosis is particularly important in Ethiopia where about seven million cattle (15% of the continental total) are at risk of contracting the disease and where cattle are the main source of traction for crop cultivation. In 1991, the International Livestock Centre for Africa (ILCA) and the International Laboratories for Research on Animal Diseases (ILRAD)—-which together now comprise ILRI—-began conducting research on tsetse control in the south-western region of the country, in an area located in the upper reaches of the Ghibe Valley, 180 km south-west of the Ethiopian capital, Addis Ababa. The aim was to assess the efficacy and impacts of a then relatively novel tsetse control approach, namely applying insecticides as 'pour-ons' along the spines of cattle.[2] The trial began in January 1991 and has been very successful in reducing tsetse challenge and disease prevalence, with considerable impacts on farm productivity and farmer incomes.

2. Tsetse and other biting flies landing on animals treated with pour-on insecticides are contaminated, fly away and die. If enough animals in a tsetse-infested area are treated, and if sufficient flies make contact with those animals, the pour-on technology can be extremely effective.

Prior to the intervention, the valley was heavily infested with three species of tsetse fly, namely *Glossina morsitans submorsitans Newstead, G. pallidipes Austen,* and *G. fuscipes fuscipes* Newstead. Following control, the apparent density of tsetse and biting flies in the region fell by 95%. This reduction in tsetse challenge led to a decrease in trypanosome prevalence in cattle of over 61%, despite a high level of resistance to all available trypanocidal drugs. The number of curative trypanocidal drug treatments per animal fell by 50%. Calf growth rate increased by 20% on average; calf mortality and abortion decreased by 57%. Average cow body weight was boosted by 4%, the cow:calf ratio by 49%, and adult male body weight by 8%. Between 1995 and 1997, expenditures on trypanocidal drugs fell by US$ 39 thousand, which more than offset the US$ 16 thousand cost of the pour-on. The additional benefits of increased output of meat (40%) and milk (30%) equalled US$ 146 thousand. This implied a benefit/cost ratio of 11.6 over two years and 9.3 projected over 10 years, and increases in annual household income of between 10 and 34% (Leak et al. 1995; Swallow et al. 1995; Woudyalew et al.

1999; Rowlands et al. (forthcoming)).

Most households in the area practice integrated crop–livestock farming, with animal draft power being the central integrating factor. The total number of cattle in the control area rose from 500 in 1991 to at least 6500 in 1997, contributing significantly to agricultural productivity via availability of draft animals (Woudyalew et al. 1999). Larger livestock holdings have implied more draft animals on average. This has resulted in significant increases in cropped areas, with each additional ox owned translating into between 0.6 and 0.9 ha more of cultivated land (Swallow et al. 1998).

Not only did ILRI scientists design the trial, ILRI undertook to procure pour-ons on the international market, store them, transport them to the nine supply points ('crushes'), and apply treatments to animals presented by farmers. ILRI team members periodically engaged local cattle owners in formal and informal discussions about the effectiveness of the pour-ons and the need for a minimum level of pour-on application to maintain low levels of tsetse density and trypanosomosis prevalence in the region. Local community organisations and participating cattle owners were responsible for building and maintaining the treatment centres in their localities. In the context of the current analysis, the most crucial aspect of the trial was that, while ILRI initially provided pour-on treatments to farmers free of charge, full cost-recovery was implemented after two years (Swallow et al. 1995). Since 1992, therefore, farmers have been deciding on pour-on use-rates and intensities for themselves.

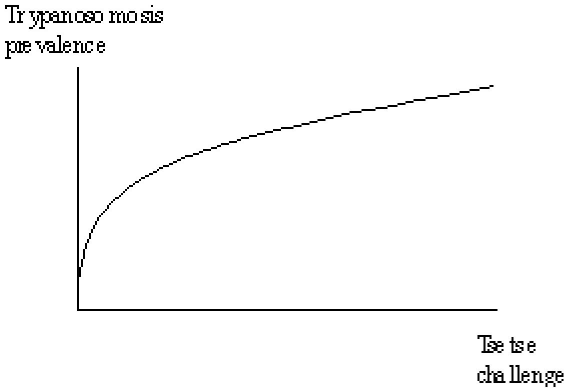
3 Indivisibilities, externalities, and the geography of farmer income and input use

A key recognition is that some of the benefits of tsetse control in Ghibe accrued to anyone who kept livestock in the control area, whether their animals were treated with pour-ons or not. Other benefits were captured primarily by owners of treated animals— for instance, those arising from control of ticks and other biting flies. Characterising pour-ons as mixed private–public goods, and using data from a 1992 survey of 166 farmers in the control area, Swallow et al. (1995) found that the probability of pour-on adoption was indeed linked to both private and collective factors. Specifically, adoption was positively associated with proportions of cows and oxen in farmers' herds, negatively with distance farmers traversed to reach crushes, and positively with tsetse challenge in the area, which varied seasonally according to the level of rainfall and temperature extant in that part of the country.

The mixed private–public nature of the pour-on technology and the factors that influence its adoption are particularly significant in light of the finding by Leak et al. (1990) of a highly non-linear relationship between tsetse challenge and trypanosomosis prevalence in cattle (Figure 1). Large decreases in disease prevalence can be achieved only with near eradication of tsetse populations. Vector challenge has to fall considerably before prevalence changes much. But then, below a certain level of challenge, the drop in prevalence is precipitous. Given reductions in vector challenge result in greater than proportionate declines in disease prevalence.[3] This implies a lumpiness to control efforts that is very much in the nature of a *fixed cost* or *indivisibility*. Relatively large-scale, widely dispersed, intense efforts are required; small-scale, spatially confined, incrementally increasing measures likely will not work.[4]

3. Note that a similar logic applies to changes in the other direction—i.e. given increases in challenge result in greater than proportionate jumps in prevalence.

4. The appropriate basis for comparing alternative technologies thus is also on a large-scale—i.e. thousands of traps and targets vs. tens of thousands of pour-on applications vs. tens of thousands of trypanocidal drug treatments.



Source: Adapted from Leak et al. (1990).
Figure 1. *The relationship between tsetse challenge and trypanosome prevalence.*

A 1998 survey in Ghibe suggests that the burden for the near eradication and sustained suppression of tsetse populations in the region has not been shared equally among households (unpublished survey data). Among 126 randomly selected households, only 77 (about 60%) applied pour-ons. And among users, there were significant differences in pour-on use-intensity, measured as the proportion of treated animals in farmers' herds.[5] In addition, a strong positive relationship between farmer income and intensity of pour-on use was discerned.[6] Most significantly, the data also exposed a very uneven spatial distribution of use-intensity across income groups (Figure 2).[7] Not only do high-income farmers exhibit higher use-intensities of pour-ons, they also tend to reside in close proximity to one another. So, too, do poorer households with low use-intensities.

5. The maximum use-intensity was 100 % of the herd, the minimum was 9%, and the mean was 38%. (unpublished survey data).

6. Off-farm income sources are relatively few in the region and only income from agricultural sources was measured. Two-stage least squares regression analysis revealed that in addition to income, the number of oxen as a share of herd size, and the number of men as a share of family size had significant positive effects on use-intensity (unpublished data).

7. Median incomes and use-intensities were used to classify farmers into four groups covering high and low income and use-intensity.

These findings confirm those of Swallow et al. (1995) that externalities (or spillover effects) have been crucial to the outcome of the Ghibe trial. Spillovers arise because cattle owned by several households living in close proximity to one another are brought into collective herds numbering between 30 and 80 and tended by one of the herd owners (Swallow et al. 1995). While there is little overlap in grazing areas used by different herds, these areas adjoin one another. Region-wide reductions in disease prevalence—covering all grazing areas and homesteads—point to efficient and equity-enhancing vector control: the richest households have contributed the most to control, which has been equally consumed by poorer households.

Physical features of the region and associated changes in land use have also contributed to the positive outcome. The control area is located in a relatively gently sloping part of the valley. On one side, it is bordered by a mountain range that reaches an altitude unsuitable for tsetse flies, and on the other by a highland area of intensive cultivation that is also a poor habitat for flies. As a result, once initial suppression of tsetse flies was achieved, the risk of reinvasion was minimal. In addition, the clear economic gains from control induced sustained in-migration from other parts of Ethiopia, major expansions in livestock and human populations, and thus steady removal of tsetse habitats (Swallow et al. 1998b).

The importance of these interacting and mutually reinforcing processes emerges upon consideration of why a similar control initiative has been less successful in another part in the valley (ILRI 1998). This second area is located in a more rugged and lower elevation part of the valley. Animals graze in a few herds, which are spread unevenly across the valley. This leaves large areas of tsetse habitat with inadequate cattle-to-fly contact, most notably the dense thickets along the Ghibe River itself and a number of its tributaries, all of which represent reinvasion fronts. Human and cattle populations within the control area remain small, sparse, and, most critically, with little pressure or incentive to expand. Thus despite regular treatment of cattle with pour-ons, vector challenge and disease prevalence remain high.

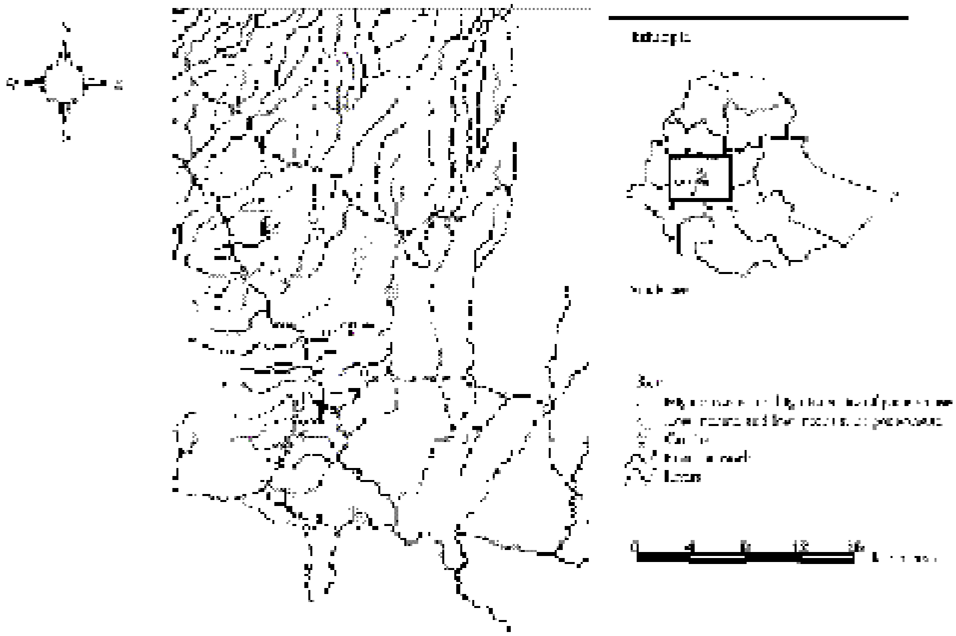


Figure 2. *Farm income and insecticide pour-on use-intensity in Ghibe Valley, Ethiopia.*

4 Implications for extension reform

Those aspects of tsetse and trypanosome biology and ecology that militate against sustained suppression of the vector and disease are quite well-understood (e.g. Leak 1999); enduring difficulties in sustaining control initiatives are largely institutional (Swallow and Woudyalew 1994; Barrett and Okali 1999; Bauer and Snow 1999; Politzar et al. 1999). Figure 1 reveals that these institutional constraints derive in the first instance from the technological difficulties raised by the non-linear relationship between tsetse challenge and trypanosomosis prevalence. All difficulties faced in collective community-based tsetse control (Swallow and Woudyalew 1994; Barrett and Okali 1999), and more generally in integrated vector and disease control (Tamboura et al. 1988; d'Ieteren et al. 1999) derive from this relationship.

But non-linear relationships such as that depicted in Figure 1 also imply major economic opportunities. For the resulting indivisibilities not only erect barriers to entry, production and trade, they also entail increasing returns to scale, favouring expanded economic activity. The greater is an organisation's ability to override the technological indivisibilities linked to an activity, the higher should be its capacity to enter into that activity, and thus the brighter its prospects for capturing associated scale economies, and vice versa. However, as illustrated by the Ghibe example, some of these economies may accrue to others as externalities, dampening private incentives to produce them.

While the lumpiness and indivisibility of public goods—such as tsetse control in Ghibe—may be long-recognised (e.g. Ellickson 1973), less well-appreciated is that, at the level of an economic system (i.e. spanning production, exchange and consumption), most *private goods* also exhibit important indivisibilities that may militate against efficient purely private production and delivery.

Consider inorganic fertiliser, an archetypical private good. Significant indivisibilities and scale economies arise from lumpy, spatially-dispersed, and seasonally-explicit demand for the input, alongside high domestic transportation costs, and intense financing and knowledge requirements in international trade. Together, these factors produce sizeable start-up costs for trade in fertiliser, rendering domestic markets imperfectly competitive at various levels and thus, by definition, constrained by the demand-side. Fertiliser traders gravitate toward locations with potentially high demand. But even there, limited quantities are brought to market at high prices. These high prices depress demand for fertiliser as producers economise on its use, many by pursuing diversified, subsistence-oriented production strategies. Returns to such practices are low. This further dampens demand for fertiliser, which lowers incentives and returns to increased procurement and distribution by traders, save for at a higher price. The result is a self-reinforcing movement toward an equilibrium featuring limited trade in high-priced fertiliser alongside a preponderance of production systems featuring limited use of the input, low productivity, and low returns. Absent an intervention that addressed one or more of the system's inherent indivisibilities, no supply-side or demand-side pressures will appear to reverse the outcome.

The significance of the Ghibe trial therefore lies in its success in overriding a set of inherently indivisible physical and institutional obstacles to growth—a set that is rife in African agriculture (IFPRI/ISNAR 1991).

Which matters more between physical and institutional impediments to growth is an empirical issue that depends on specific circumstances (Demsetz 2000). Indeed, they are likely jointly determined (Gotsch 1972). ILRI's most important interventions focused on the institutional constraints. Specifically, its efforts to raise awareness among farmers, help set up treatment centres, and organise treatment of sick animals produced a crucial combination of effects: *learning effects* (which acted to lower the uncertainty surrounding pour-ons as their pervasiveness increased), *co-ordination effects* (which conferred advantages to 'going along' with other villagers taking similar action), and *adaptive expectations* (where increased prevalence of pour-on use in the region enhanced beliefs of further prevalence). These effects led to insecticide adoption rates and use-intensities sufficient to overcome the inherent lumpiness of tsetse control (captured in Figure 1) and catalyse the self-reinforcing process described earlier. Absent this role—which sprung from a concern for the kinds of collective, regional effects that typically motivate public bodies but with which few private operators would have been concerned—the intervention would almost certainly have failed.

A defining characteristic of agricultural activity is that it is dispersed widely over space. By implication, so, too, are agricultural incomes. That spatial distribution of income appears to have been fundamental to the success of the Ghibe initiative. It mattered because pour-ons produced their collective effect in the 'wake' of their privately consumable effects. This suggests that not only must the precise nature of extension services affected by reform be ascertained—pure public versus mixed private–public versus pure private (e.g. Umali et al. 1994)—so, too, should be the extant distribution of rural income. For few 'public' goods are purely public; collective effects are typically accompanied by private gains and losses (Bergstrom and Goodman 1973; Ellickson 1973). Incomes of consumers and users will matter. And for rural goods and services consumed widely over space, the distribution of those incomes over the landscape will be crucial.

Another key aspect of ILRI's role in the Ghibe experiment thus was that it led to an 'organised articulation of demand' that resolved co-ordination problems typically involved in 'market creation' (Edquist et al. 2000). In so doing, it quite quickly formed a 'core' of innovative users sufficiently large, and sufficiently widely dispersed over space, to dissolve the 'trap' (of high vector challenge and high disease prevalence, and thus low human and livestock population, and thus high vector challenge and high disease prevalence, and so on) in which most tsetse-infested regions find themselves. In a very real sense, the strategy employed (and the process that emerged as a consequence) was the exact *reverse* of those in privatisation and decentralisation programmes currently dominating extension reform in Africa, which implicitly assume that the principal constraints on improved agricultural technology development and diffusion are on the supply-side (e.g. Rivera et al. 2000; World Bank 2000). The internal logic of the Ghibe trial was also fundamentally different from that driving the 'demand-led farmer-participatory' approach to extension reform, which assumes away the question of how a well-articulated demand for improved technologies and new information appears to begin with.

The primary lesson for extension reformers emerging from the Ghibe example thus is that it is the *demand-side* of an agricultural extension system that matters the most–i.e. the demand for new information, which itself derives from demands for such goods and services as improved inputs and credit. In effect, the question of how to 'get extension right' reduces to how to spur *sustained* and *concentrated* demand for new agricultural knowledge and information–i.e. demand for information about new cultural practices, new inputs, new crops and pests, new traders, new lenders and conditions in newly relevant distant markets.

This suggests both bad news and good news for efforts to reform agricultural extension in Africa. The bad news is that appearance of these various demands is far from automatic. Where, as in much of rural Africa, infrastructure is poorly developed and production environments are risky, natural forces will likely continue to define economic outcomes, muting demand for productivity-enhancing innovations, and translating into limited and costly supply. The good news is that if the jointly determined physical and institutional indivisibilities that these natural forces produce are properly identified and addressed, non-linear jumps in demand for innovations can occur, leading to rapid and sustained increases in productivity growth and welfare. The paradox facing agricultural extension reform in Africa thus is that its problems and solutions rest on isomorphic processes. This paradox drives to the core of the challenge for extension reform in Africa.

Most public agricultural extension systems in Africa are virtually declining. Increasingly more is being made of production and delivery of agricultural knowledge and information through private, market-based channels, on one hand (e.g. Rivera et al. 2000; World Bank 2000), and through local, collective, community-based channels, on the other (e.g. Farrington 1998). But the current analysis points to poor prospects for both strategies viewed, as they often are, in isolation. For in the Ghibe trial, ILRI—through its interest in the efficacy, impacts, and sustainability of the pour-on technology—devised an institutional solution to a deep biophysical nonlinearity and in so doing catalysed a multi-faceted and self-affirming movement toward low vector challenge and disease prevalence. Market-led and community-based extension reforms will succeed only if they contain similar solutions to inherently lumpy problems of rural development on which public sectors have stumbled. There is nothing spontaneous about such solutions. They must be carefully designed and implemented. More strongly, the Ghibe example indicates that the question of how to reform agricultural extension in Africa should not be framed as a mutually exclusive choice among markets, local community-based collective action, and public sector investments. Rather, the challenge lies in how to appropriately *interface* these three options in technology development and diffusion. The example illustrates, first, that the central ingredient in that interface is *concentrated demand* for new knowledge and inputs, and, second, that the physical and institutional factors that impede 'natural' appearance of that demand are also those that will unleash it.

References

Ariyo A. and Jerome A. 1999. Privatization in Africa: An appraisal. *World Development* 27:201–213.

Barrett K. and Okali C. 1999. *Partnerships for tsetse control—Community participation and other options. Proceedings of the International Scientific Council for Trypanosomiasis Research and Control, held in Maputo, Mozambique, 29 September–4 October 1997.* OAU/ISCTRC (Organization of African Unity/International Scientific Council for Trypanosomiasis Research and Control), Nairobi, Kenya.

Bauer B. and Snow W. 1998. *Sustainable integrated disease management (IDM) for the control of African animal trypanosomosis: Experiences in West Africa.* PAAT Position Paper 5. FAO (Food and Agriculture Organization of the United Nations), Rome, Italy.

Bergstrom T. and Goodman R. 1973. Private demands for public goods. *American Economic Review* 63:280–296.

Beynon J. 1996. Financing of agricultural research and extension for smallholder farmers in sub-Saharan Africa. *Natural Resource Perspectives* 15. Overseas Development Institute, London, UK.

Cattand P. 1999. Improved strategies for sustainable trypanosomosis management within the context of primary human health care. Paper presented at the 25th ISCTRC conference, held from 27 September–2 October 1999. OAU/ISCTRC (Organization of African Unity/ International Scientific Council for Trypanosomiasis Research and Control), Nairobi, Kenya.

Demsetz H. 2000. Dogs and tails in the economic development story. In: Menard C. (ed), *Institutions, contracts, and organizations; perspectives from new institutional economics.* Edward Elgar, Northampton, Massachusetts, USA. pp. 69–87.

Edquist C., Hommen L. and Tsipouri L. 2000. *Public technology procurement and innovation*. Kluwer Academic Publishers, Dordrecht, The Netherlands.

Ellickson B. 1973. A generalization of the pure theory of public goods. *American Economic Review* LXIII:417–432.

FAO (Food and Agriculture Organization of the United Nations). 1994. *Structural adjustment and the provision of agricultural services in sub-Saharan Africa.* FAO, Rome, Italy.

Farrington J. 1998. Organisation roles in farmer participatory research and extension: Lessons from the last decade. *Natural Resource Perspectives* 27. Overseas Development Institute, London, UK.

Florkowski W., Szulze H. and Elnagheeb A. 1997. Privatizing agricultural services in a transition economy. *Review of Agricultural Economics* 19:45–57.

Goletti F. and Govindan K. 1995. *Methods for agricultural input market reform research: A tool kit of techniques*. MSSD Discussion Paper 6. IFPRI (International Food Policy Research Institute), Washington, DC, USA.

Gotsch C. 1972. Technical change and distribution of income in rural areas. *American Journal* *of Agricultural Economics* 54:326–341.

d'Ieteren G.D.M., Authie E., Wissocq N. and Murray M. 1999. Trypanotolerance: An option for sustainable livestock production in areas at risk from trypanosomosis. *Revue Scientifique et Technique Office International des Épizooties* 17:1–32.

IFPRI/ISNAR (International Food Policy Research Institute/International Service for National Agricultural Research). 1991. *Towards a new agricultural revolution: Research, technology transfer, and application for food security in sub-Saharan Africa.* ISNAR, The Hague, The Netherlands.

ILRI (International Livestock Research Institute). 1998. Situation report of the livestock production under disease risk project. ILRI, Nairobi, Kenya.

Kristjanson P.M., Swallow B.M., Rowlands G.J., Kruska R.L. and de Leeuw P.N. 1999. Measuring the costs of African animal trypanosomosis, the potential benefits of control and returns to research. *Agricultural Systems* 59:79–98.

Kuczynski P-P. 1999. Privatization and the private sector. *World Development* 27:215–224.

Leak S. 1999. *Tsetse biology and ecology*. CABI (Commonwealth Agricultural Bureau International), Wallingford, UK.

Leak S.G.A., Collardelle C., Coulibaly L., Dumont P., Feron A., Hecker P., d'Ieteren G.D.M., Jeannin P., Minengu M., Minja S., Woudyalew Mulatu, Nankodaba G., Ordner G., Rowlands G.J., Sauveroche B., Tikubet G. and Trail J.C.M. 1990. Relationships between tsetse challenge and trypanosome prevalence in trypanotolerant and susceptible cattle. *Insect Science and its Application* 11(3):293–299.

Leak S.G.A., Woudyalew Mulatu, Rowlands G.J. and d'Ieteren G. 1995. A trial of a Cypermethrin 'pour-on' insecticide to control *Glossina pallidipes, G. fuscipes* and G. morsitans submorsitans (*Diptera: Glossinidae*) in southwest Ethiopia. *Bulletin of Entomological Research* 85:241–251.

Murray M. and Gray A.R. 1984. The current situation on animal trypanosomosis in Africa. *Preventive Veterinary Medicine* 2:23–30.

Mwanaumo A. 1999. Agricultural marketing policy reforms in Zambia. Paper presented at the Egerton University/Michigan State University/East and Central Africa programme for agricultural policy analysis workshop on agricultural transformation in Africa, 27–30 June 1999, Nairobi, Kenya.

Neuchatel. 1999. Common framework on agricultural extension. Neuchatel Group, Ministere des Affaires etrangeres, Paris, France. http://www.odi.org.uk/rpeg/Ni_index.html

Nolan P. and Xiaoqiang W. 1999. Beyond privatization: Institutional innovation and growth in China's large state-owned enterprises. *World Development* 27:169–200.

Politzar H., Omamo S.W. and d'Ieteren G. 1999. Issues related to sustainable tsetse and trypanosomosis management strategies and rural development. Paper presented at the 25th ISCTRC conference, 27 September–2 October 1999. OAU/ISCTRC (Organization of African Unity/International Scientific Council for Trypanosomiasis Research and Control), Nairobi, Kenya.

Rivera W., Zijp W. and Alex G. 2000. *Contracting for extension: Review of emerging practices*. AKIS Good Practice Note. World Bank, Washington, DC, USA.

Rowlands G.J., Woudyalew Mulatu, Leak S., Nagda S. and d'Ieteren G. (forthcoming). Estimating the effects of tsetse control in livestock productivity—A case study in southwest Ethiopia. *Tropical Animal Health and Production.*

Swallow B. 1998. Impacts of trypanosomosis on African agriculture. Position Paper of the Programme Against African Trypanosomosis (PAAT). FAO (Food and Agriculture Organization of the United Nations), Rome, Italy.

Swallow B.M. and Woudyalew Mulatu. 1994. Evaluating willingness to contribute to a local public good: Application of contingent calculation to tsetse control in Ethiopia. *Ecological Economics* 11:153–161.

Swallow B., Woudyalew Mulatu and Leak S. 1995. Potential demand for a mixed public–private good: Evaluation of a pour-on insecticide controlling tsetse-transmitted trypanosomosis in Ethiopia. *Preventive Veterinary Medicine* 24:265–275.

Swallow B., Wangila J. and Okello O. 1998. Tsetse control and animal traction cultivation in Ghibe, south-western Ethiopia. Unpublished manuscript. ILRI (International Livestock Research Institute), Nairobi, Kenya.

Tambi E., Mukhebi A.W., Maina O.W. and Solomon Haile-Mariam. 1999. Probit analysis of livestock producers' demand for private veterinary services in the high potential agricultural areas of Kenya. *Agricultural Systems* 59:163–176.

Tamboura I., Merot P., Cuisance D., Politzar H., Kourouma B., Gidel R., Bauer G., Kabore I., Some J., Traore A.N. and Paulin C. 1988. An integrated campaign against three tsetse species in the pastoral zone of Sideradougou, Burkina Faso. Paper presented at the 19th ISCTRC conference held at Lome, Togo, April 1987. OAU/ISCTRC (Organization of African Unity/International Scientific Council for Trypanosomiasis Research and Control), Nairobi, Kenya. 555 pp.

Umali D.L., Feder G. and de Haan C. 1994. Animal health services: Finding the balance between public and private delivery. *World Bank Research Observer* 9:71–96.

World Bank. 2000. Uganda National Agricultural Advisory Services Program. Project description. World Bank, Washington, DC, USA. www.worldbank.org/pics/pid/ug44695.txt

Woudyalew Mulatu, Swallow B., Rowlands G.J., Leak S., d'Ieteren G. and Nagda S. 1999. *Economic benefits of an insecticidal 'pour-on' to control tsetse in Ghibe, south-west Ethiopia. Proceedings of the 24th meeting of the ISCTRC held in Maputo, Mozambique, 29 September–4 October 1997*. OAU/ISCTRC Publication 119. OAU/ISCTRC (Organization of African Unity/International Scientific Council for Trypanosomiasis Research and Control), Nairobi, Kenya.