



**AgEcon** SEARCH  
RESEARCH IN AGRICULTURAL & APPLIED ECONOMICS

*The World's Largest Open Access Agricultural & Applied Economics Digital Library*

**This document is discoverable and free to researchers across the globe due to the work of AgEcon Search.**

**Help ensure our sustainability.**

Give to AgEcon Search

AgEcon Search

<http://ageconsearch.umn.edu>

[aesearch@umn.edu](mailto:aesearch@umn.edu)

*Papers downloaded from **AgEcon Search** may be used for non-commercial purposes and personal study only. No other use, including posting to another Internet site, is permitted without permission from the copyright owner (not AgEcon Search), or as allowed under the provisions of Fair Use, U.S. Copyright Act, Title 17 U.S.C.*

***Linking Natural Resources, Agriculture and Human Health:  
Case Studies from the East African Highlands***

Hugo Li-Pun, Johann Baumgaertner, Juergen Greiling, Hiremagalur Gopalan,  
Mohammad Jabbar, Victor Mares

**Shifting to holistic R&D**

Past attempts to alleviate the problems of poor farmers engaged in mixed crop-livestock production have generally focussed on the design and diffusion of new technologies targeted on specific components of the agroecosystem. Unfortunately, such piecemeal efforts, both in the East African Highlands - the focus of this paper - and elsewhere in the developing world, have had limited impact.

In the case of human health, the traditional R&D approach has tended to be narrowly sectoral. The health of people has been separated from that of crops, animals and the environment, with different disciplines and institutions concentrating on different constraints. Despite the progress reported, improvements to human health have fallen far short of expectations. A key limitation of the sectoral approach is that it does not consider interactions among priority human health conditions and their socio-economic and ecological determinants, such as the impact of poverty and malnutrition on human health. Nor does it account for the close associations between people and livestock, as in the case of human sleeping sickness and bovine trypanosomosis, both vectored by tsetse flies.

If future development efforts are to have significant, long-lasting impact on the people they are intended to help, they must be based on a firm understanding of the complex links among the environment, natural resources, agriculture, food security and human welfare. Furthermore, the ensuing interventions must not be limited to technological solutions. Rather, they must include better policy formulation, health and education, and the building of local community assets.

In recent years, participatory and multidisciplinary research methods have begun to make inroads in many parts of the world. For example, several international programmes are attempting to address agricultural productivity and resource sustainability issues through so-called ecoregional research. These efforts involve various mixes of partners: international agricultural research centres, advanced research institutions in industrialised countries, national agricultural research systems in developing countries, non-governmental organisations, and funding agencies.

Below we describe recent experiences of two research centres with a global reach: the International Livestock Research Institute (ILRI) and the International Centre of Insect Physiology and Ecology (ICIPE). Both are currently conducting research in the East African Highlands, based on holistic, participatory methods. Each centre's strategy integrates activities intended to increase food security including nutrition and health, environmental health, asset building and farm income through better natural resource management and higher crop and livestock productivity. Computer

modelling is one of the research tools used to assess the potential impact of interventions, e.g. better management of soil nutrients, grazing management strategies, improved livestock feeding, livestock health improvement, tsetse fly and other vector control, and ways to reach those goals.

## **Human health in the Highlands**

Widespread poverty, malnutrition and disease, along with low farm productivity and degraded natural resources, are major problems of the East African Highlands. For example, in Ethiopia, which makes up 60% of the 3.5 million square kilometres of highlands, per capita annual income is a little over US\$100. Some two-fifths of the rural population live in absolute poverty and one-third are malnourished. Nearly two-thirds of children suffer from protein-energy malnutrition, sometimes with irreversible damage to cognitive development. Deficiencies in micronutrients, particularly vitamin A, iron and iodine, are also commonplace. Poverty and malnutrition are aggravated by large-scale resource degradation such as soil erosion, nutrient depletion, deforestation and the decline of pastureland, all of which undermine agricultural productivity and food security. It is estimated that half of the Ethiopian Highlands' arable lands are moderately to severely eroded. If the erosion rates of the 1980s persist, over 7 million ha of cropland could be lost by 2010.

The burden of ill health in sub-Saharan Africa (SSA) is twice the global average and life expectancy lags some 25 years behind that of the wealthiest nations. In the East African Highlands, a region with a population of 150 million, women and children are especially at risk of ill health. This is due not only to malnutrition but also to the fact that these family members are more closely connected with unhealthy household environments. Indoor air pollution from burning wood and dung, for example, causes acute and chronic respiratory diseases. Women and children are also at high risk from insect-borne diseases such as sleeping sickness, malaria and dengue fever. A major reason is that the sites where they collect water and wash clothes tend to be insect-breeding areas as well.

Among the vector-borne diseases, malaria (transmitted by female anopheles mosquitoes) is the most important health risk. As for human trypanosomosis, or sleeping sickness, the epidemic levels of the 1930s have returned, with the case load now estimated at 300,000 per year. Unsafe water supplies and limited access to clinics and health posts, combined with domestic and environmental health hazards and poorly developed communications, contribute to high incidences of disease. Zoonotic infections spreading from animals to people are also of increasing concern in the region.

## **Livestock as leverage**

Mixed crop-livestock systems are common in the Highlands. While grain yields have shown modest increases in the past two decades, they are still under 2 tons per hectare. This is due to the low usage of agricultural inputs such as fertilisers, as well as to damage by pests and plant diseases. Livestock play multiple roles in these systems by providing food and income, and inputs (draught power and manure for crop production) and also manure as fuel. They are a farm family's most important and flexible marketable asset. They can be sold in times of need, particularly when crops fail.

The beneficial role of livestock in intensifying production, alleviating poverty and malnutrition, and conserving natural resources has not been adequately exploited. Livestock productivity remains well below potential due to insufficient and poor-quality feeds along with animal diseases. Available forage in SSA is currently insufficient to meet needed livestock output, with protein being in even shorter supply than total energy. The amount of available pastureland is declining, as crops encroach on traditional dry-season pastures. Mineral fertiliser is needed to boost better quality feed supply from both pastures and cropland.

Infectious diseases, particularly those transmitted by tsetse flies (*Glossinidae*) and ticks (*Ixodidae*), pose a constant threat to livestock. Cattle deaths related to trypanosomosis are estimated at 3 million head annually, mainly young animals. Up to one-quarter of pre-weaning calves succumb. Sick animals have lower milk and meat yields and fewer offspring. Crop production is indirectly affected as there is less draught power for ploughing, and less manure for fertiliser. This will result in fewer crop residues and by-products for animal feed.

The consumption of even small amounts of meat and milk products improves human nutrition and makes people, especially pregnant women and young children, less susceptible to diet-related diseases. Animal products are rich in micronutrients, such as vitamins A and B12, iron and zinc. These are essential to good child health and the development of cognitive and motor skills. What's more, agriculture and food-based approaches to combating macro- and micronutrient deficiencies may be more sustainable than chemical supplementation such as consumption of vitamin A tablets. Nutritional benefits of greater agricultural production, particularly dairy, partly depend on the mother's knowledge of nutrition. Since that knowledge is currently low among poor farmers, effective nutrition education is required. However, better education and family health in turn depend on community participation and empowerment. Stakeholder participation in the diagnosis of constraints and in the design and implementation of solutions is essential to the success and sustainability of development efforts.

## **ILRI's experience**

Over the years, ILRI's research in the Ethiopian highlands on several component technologies has shown the potential for improving human welfare through increased crop and livestock productivity, better natural resource management and related interventions. Some examples are as follows:

- Vertisols are an underutilised resource due to problems of waterlogging. A drainage equipment using animal power (called broad bed maker or **BBM**) combined with improved wheat technology (better varieties for early planting, fertiliser and agronomic practices) can increase wheat yield from less than one ton per ha to over 2 tons per ha, thus contribute to solve the country's perennial food deficit. The drainage technology also significantly reduces soil erosion compared to traditional vertisols management practices.
- Modification of the **BBM** for row planting via a seeder attachment resulted in a large saving in seeds. On-farm studies showed that it require only 90 to 110 kilograms per hectare, as compared with 150 to 250 kilograms for traditional broadcasting. Tillage and planting tests during the onset of the main rains showed that the time required to establish a crop using minimum tillage was about one-third that needed with traditional methods.

- On-farm studies have shown that improved dairy technologies (better breeds, feeds and management) can significantly increase production and income, and improve household nutrition and food security, particularly of women and children.
- Results from a study of grazing pressure suggest that a no-grazing strategy does not help conserve biodiversity or improve soil quality. Recycling nutrients through manure ensures sufficient biomass production for regulated grazing and provides soil with a protective cover. Using dung for fuel aggravates the negative nutrient balance in the soil and depresses biomass production.
- An adoption study regarding multipurpose trees showed that farmer-to-farmer diffusion through seed sharing – a good indicator of potential for further adoption – has been occurring. The species selected by farmers varied with biophysical factors such as altitude and rainfall. Most farmers were using the trees for fencing, fuel and construction.

Given the limitations of component technology and sectoral approaches to improve agricultural productivity and human welfare, and the need for more integrated participatory approaches, as discussed earlier in this paper, a three-year project has been implemented in the Ginchi community in the Awash watershed taking an “agroecosystem health” approach to assessing the sustainability of current and alternative crop-livestock production systems. The overall aim is to improve human health and nutrition through better management of livestock and natural resources. After a 1998 workshop to refine the methodology, researchers gathered detailed biophysical and socioeconomic information on the Ginchi microwatershed. They used a variety of methods, such as on-farm trials, site surveys and participatory rural appraisal. Then, together with members of the target community, they defined indicators of agroecosystem health, related to factors such as household food security, disease incidence, gender-related equity, community water supplies for both households and livestock, and their links with human health, soil erosion and biodiversity.

A bioeconomic model, based on Ginchi field data, was designed for *ex ante* assessment of the impact of improved crop and livestock technologies and natural resource management strategies on economic, ecological and food-production sustainability. It allows researchers to evaluate both short- and long-term impacts (up to 12 years) of technology and policy interventions. In a nutshell, this “dynamic” model quantifies the tradeoffs involved when farmers attempt to increase or maximise one of three factors: their income, their food self-sufficiency, or the sustainability of their farming systems (by reducing soil erosion).

The modelling reveals that there are strong tradeoffs between the attainment of food self-sufficiency, high income and reduction in soil erosion. The model shows, for example, that with the application of modest amount of fertiliser to teff and wheat in an otherwise traditional production system, farmers’ cash incomes would rise by 50% from a currently low base. However, annual soil losses would be 31 tons per hectare, which is still higher than the permissible level for the Highlands.

Under a scenario involving the introduction of a set of new technologies – such as higher-yielding crop varieties, agroforestry methods, and techniques to reduce soil waterlogging – the modelling results are quite different. It would be possible, over 12 years, to increase cash income tenfold and decrease aggregate soil erosion by 20%. However, farmers would be increasingly dependent on

livestock for manure, draught power, milk and cash flow. The use of agroforestry methods and zero grazing demands a longer planning horizon. But this is feasible only if farmers have more secure land tenure than at present. Livestock play a major role in reducing the negative effects of soil erosion, but proper pasture management, including removal of animals from certain vulnerable areas in some years, is required. Under this scenario, farm outputs would also be sufficient to provide a minimum daily intake of 2,000 calories per adult.

The results of the modelling have been shared with farmers in the watershed and district extension agencies as an aid to resource-use decision making. They will also be extrapolated to other regions.

## **ICIPE's experience**

ICIPE has been recently implementing a BioVillage Initiative, an integrated natural resource management project designed to improve human health and alleviate poverty in rural Ethiopia. It responds to a community request following a successful tsetse control operation in the southwestern part of the country. The tsetse control system, established with community participation, was based on mass trapping of flies. As in ILRI's tsetse and trypanosomiasis control work in other nearby communities, the programme resulted in a significant reduction in the incidence of farm animal disease. While farmers saw the value of the technique for improving livestock health, they also noted its limitations as a means of addressing human health problems and poverty. In fact, the farmers stressed that in order to plough fields and grow crops for human food, animal feed and income, both oxen and men need to be healthy. They also recognised that a healthy farming community can engage in other income-generating activities such as bee keeping.

Hence, it was agreed that a comprehensive programme for farm animal and human health management was needed as a way to solve the most urgent problems of rural development. The resulting management scheme is built on three elements: fly and disease control, sustainable management of natural resources, and community participation.

**Fly and disease control :** The BioVillage Initiative builds on the experience of African rural communities whose housing for people and livestock has been apparently designed to divert malaria-transmitting mosquitoes from human hosts to animal hosts. The traditional straw-thatch design is kept in the new system, but improved to reduce mosquito access to houses.

The disease control and resource management measures are also designed to minimise breeding sites for mosquitoes and filth flies, thus improving health and sanitation. In addition, the BioVillage Initiative incorporates zero grazing methods as complementary means of protecting cattle from tsetse flies.

**Natural resource management:** The programme aims to reduce the need for external inputs, particularly energy and fertiliser. Biogas digesters are used to extract energy from organic waste and manure, and the slurry is transformed into organic fertilisers through composting. The loss of nutrients such as nitrogen is minimised by separating urine from other organic waste and processing it separately. An expert from the Swiss Federal Institute of Technology provides the BioVillage Initiative with expertise in organic waste processing, including composting.

Besides providing the fertiliser needed to make cropping systems more productive, such waste management techniques also reduce the breeding sites of disease vectors. In addition, the resulting supply of biogas reduces the need to collect firewood for cooking purposes and conserves local trees which may also supply fruits and pest-control materials. The use of biogas also promotes a healthier household environment by reducing disease-causing indoor pollution caused by wood burning.

The BioVillage community also intends to make use of the biogas energy to pump water from the ground to the village. Easy access to clean drinking water is an important contribution to human health and helps free up time for income-generating activities.

**Community participation:** Local participation is essential to the project. Community members assist with the design and construction of demonstration sites for the health and natural resource management components and participate in training courses. They also transfer technologies to neighbouring villages. The farming communities interact with project management via an ICIPE staff member who serves as BioVillage manager.

### **Concluding note: The special role of women**

Livestock play a central role in environmental protection, food security, and human health and welfare in the African Highlands and, indeed, in most developing countries. They are critical for asset building, soil-nutrient cycling, and climatic risk buffering, and they constitute a sustained and irreplaceable source of macro- and micronutrients, especially for women and children. In designing interventions for mixed farming systems, researchers and their partners need to understand the complex interactions between people, livestock, crops and the environment. An ecosystem approach to human health provides a valuable perspective in this regard.

Both individually and collectively, women are key repositories of knowledge about the nutritional value of livestock products. This role should be recognised and enhanced by encouraging women to actively participate in the design, implementation, monitoring and evaluation of educational and other programmes aimed at income generation and better family nutrition and health. At the same time, sustained investments in R&D are needed. These too should take into account women's vital contribution to agricultural production, thus making the ongoing search for solutions especially relevant and widely applicable to the realities of developing countries.

**Hugo Li-Pun**, formerly ILRI's Director, Sustainable Production Systems, is now Deputy Director General, Finance and Administration, at the International Potato Center (CIP) in Lima. E-mail: h.li-pun@cgiar.org. **Johann Baumgaertner** is ICIPE's Division Head, Environmental Health, and Head, Population Ecology and Ecosystems Science Department, based in Addis Ababa. E-mail: j.baumgaertner@cgiar.org. **Juergen Greiling** is Agricultural Advisor, German Agency for Technical Cooperation (GTZ), Addis Ababa. E-mail: harmony@telecom.net.et. **Hiremagalur Gopalan** is Task Master, Division of Policy Development and Law, United Nations Environment Programme, Nairobi. E-mail: eisinfo@unep.org. **Mohammad Jabbar** is an agricultural economist with ILRI, based in Addis Ababa. E-mail: m.jabbar@cgiar.org. **Victor Mares** is a livestock consultant to ILRI, based in Panama. E-mail: v.mares@cgiar.org.

## Further reading

Jabbar, M A, D G Peden, M A Mohamed Saleem and H Li-Pun (Eds). 2000. *Agroecosystems, natural resources management and human health related research in East Africa*. Proceedings of an IDRC-ILRI international workshop held at ILRI, Addis Ababa, Ethiopia, 11-15 May 1998. International Livestock Research Institute, Nairobi, Kenya. 254pp.

Okumu, B N. 2000. *Bioeconomic modeling analysis of watershed conservation in the Ethiopian highlands*. PhD thesis, University of Manchester, UK. 259pp.

Tangka, F.K. 2001. *Crossbred cows and food security in Ethiopia*. Ph.D. dissertation, Food and Resource Economics Department. University of Florida, Gainesville, USA. 200pp.