Agro-ecosystems, 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

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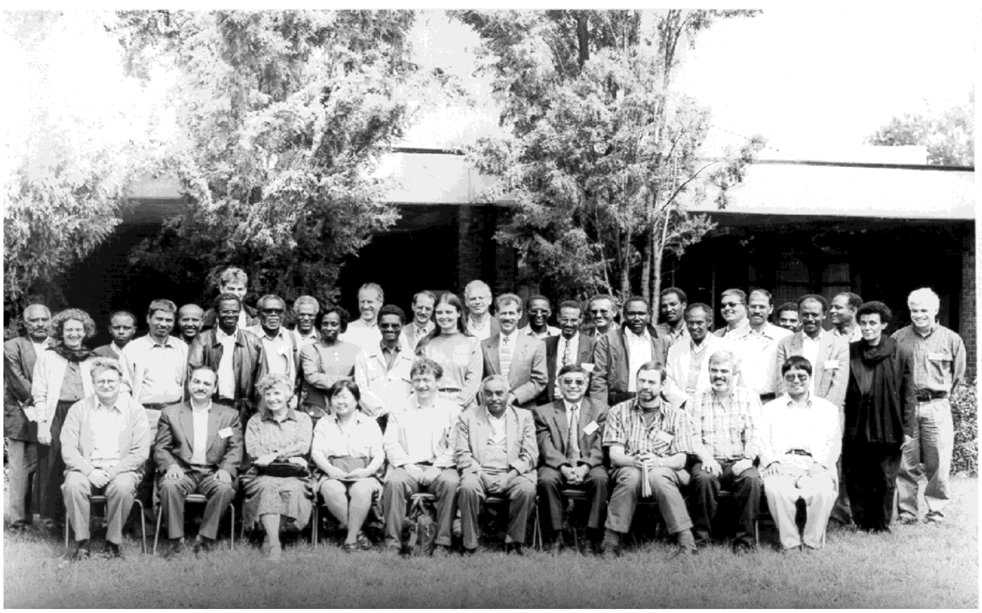
ISBN 92–9146–068–0

Correct citation: Jabbar M.A., Peden D.G., Mohamed Saleem M.A. and Li Pun H. (eds). 2000. *Agro-ecosystems, 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.* ILRI (International Livestock Research Institute), Nairobi, Kenya. 254 pp.



ILRI–IDRC planning workshop on agro-ecosystem health 11–15 May 1998

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Foreword

Within the ecosystems of the East African highlands, people face multiple challenges as they attempt to improve their livelihoods and well-being. Poverty, low agricultural productivity, and resource degradation are widespread. The human population and malnutrition continue to increase. Lack of access to cash and labour is widespread. Farmers lack access to grazing lands. Attempts to address one problem often exacerbate attempts to solve others. The situation is more dramatic in the Ethiopian highlands. Researchers and development workers increasingly recognise that people are part of complex systems called 'ecosystems.' Different categories of people (men and women, old and young, rich and poor etc) occupy different niches or life spaces. They derive different standards of living and affect other ecosystem components including other people in many ways. Independent sectoral approaches to solving the myriad of problems in complex ecosystems do not work. Researchers need a new innovative and integrative or trans-disciplinary paradigm. It must enable researchers from a variety of disciplines to redefine development and environmental degradation in a systems context. It must provide a conceptual framework for identification, testing and adoption of multiple and simultaneous interventions.

Ecosystem approaches and ecosystem health are new ideas that are transforming the traditional sectoral and disciplinary approach to agriculture, land management and human development. A consortium involving the several Ethiopian institutions, international research institutions, and non-governmental organisations facilitated by the International Livestock Research Institute (ILRI) recognised the need for more holistic trans-disciplinary approaches to tackling these complex problems. They posed two basic ideas. One was to test the suitability of the ecosystem health approach to attaining sustainable natural resources management. The second was to test the hypothesis that agro-ecosystems management could provide a complementary approach to delivering improved human health. Through ILRI, they prepared and submitted a proposal, 'Enhanced human well-being through improved livestock and natural resources management' to the International Development Research Centre (IDRC) in Canada. In consultation with ILRI, IDRC recognised the need for a new process for project development to enable the definition and pursuit of trans-disciplinary objectives. In brief, trans-disciplinarity requires full participation of all stakeholders. IDRC and ILRI decided that initial funding for the project must enable effective consultation among stakeholders to define and refine the trans-disciplinary objectives. Subsequently, ILRI organised an international workshop *(Agro-ecosystems, Natural Resources Management and Human Health Related Research in East Africa)* in Addis Ababa, Ethiopia from 11 to 15 May 1998. This proceedings documents the consultation.

Hank Fitzhugh
Director General, ILRI

Welcoming address

Ladies and gentlemen, and distinguished guests and colleagues, you are all welcome to ILRI and to this workshop.

The world is facing significant challenges as a result of population growth, coping with the increasing demands for foods, the need to improve the quality of life, the promotion of equity, and the protection of the environment.

The challenges are greater in developing countries, due to the added constraint of resources. Agriculture constitutes the main activity in terms of use of natural resources, and generation of employment in developing countries. It contributes significantly to the livelihood of the poorest sectors of society. It allows the production of food that if accessible and available in adequate quantity and quality could contribute to the overall health and nutrition of the human population.

The Consultative Group on International Agricultural Research (CGIAR), a consortium of governments from developed and developing countries, and international agencies recognises the role agricultural research plays in the development of sustainable livelihoods of the poor in developing countries. It supports 16 international agricultural research centres distributed around the world to carry out its mission. Its goals are achieving food security, poverty eradication, and environmental protection.

Within the CGIAR, the International Livestock Research Institute (ILRI) is the only institute that promotes and conducts livestock research with a global mandate. ILRI's mission is to enhance the well-being of present and future generations in developing countries through research that improves livestock production. Enhancement of the well-being of the population implies increased incomes, better health and education, an equitable society, proper leisure and a clean environment, among others. In addressing its mission and the higher goals of the CGIAR, ILRI is particularly concerned about enhancement of the positive role of livestock in achieving improved human welfare.

The simultaneous search for those goals is a complex process. Thus holistic, participatory and multi-disciplinary approaches are required. The agro-ecosystem health approach has been suggested as a paradigm to provide the conceptual framework to tackle the complex problems of improving human health and nutrition, through increases in crop–livestock productivity while managing natural resources in a sustainable manner.

On the basis of common interests to further develop and refine this concept, ILRI approached the International Development Research Centre (IDRC) of Canada to fund a small project, to which they responded positively and generously. As a test site, it was agreed that it would be put into practice under the most challenging conditions of the Ethiopian highlands, for their combination of population pressure and needs, importance of livestock for the livelihood of people, and the environmental fragility. The assumption is to prove a feasible approach and develop methodologies that could be used in other highland ecosystems, as well as in other ecoregions.

Given the complexity of the problems and needed solutions, no single institution could address them alone. It requires the participation of the communities themselves, as well as an assortment of institutions and disciplines addressing the biological and social sciences. So it was agreed that the concept being new, ILRI and IDRC would jointly organise a workshop to bring together experts in the field and potential partners and other users of the concept in the East Africa region to exchange ideas and experiences before launching the project.

ILRI is quite pleased to host the workshop and will be looking forward to the implementation of the recommendations coming from the meeting, as it constitutes a milestone in the advancement of concepts and methods on the agro-ecosystems health paradigm.

ILRI is especially grateful to the IDRC for the technical and financial support that made this initiative possible. Once more IDRC is showing its commitment to research and development for the improvement of the livelihoods of the poor in developing countries.

I wish you an enjoyable stay at ILRI.

Hugo Li Pun
Director, Sustainable Production Systems Programme
ILRI, Addis Ababa, Ethiopia

Executive summary

The proceedings contains four main sections. The first considers the theory and concepts underlying the ecosystem health paradigm and how this knowledge can lead to improved human health. Waltner-Toews et al introduces the paradigm of 'agro-ecosystem health'. Citing concepts and drawing on experience from health sciences, these authors explain how similar principles may apply to the study and care of agro-ecological systems. They emphasise that people, often with differing perspectives and demands, are part of the bigger ecosystems. The practice of promoting ecosystem health has the 'value-laden' purpose of helping them better manage the ecosystems. Often different stakeholders have different perspectives, put different pressure on the ecosystems, and have different levels of influence in decision-making. In such cases, marginalised groups may not realise sustainable development when the more powerful ones manage their ecosystems in order to achieve their own specific goals.

Two papers by Pastore and Giampietro and by Pankhurst consider in greater depth the issue of different perspectives and decision-making by marginalised groups. The former notes that when one group achieves gains, others stand to lose in the competition associated with improving livelihood from a finite level of ecosystem resources. In this paper, the authors present an innovative and trans-disciplinary approach using 'amoeba multi-dimensional' analyses to comparing and integrating multiple perspectives into one framework. Pankhurst's paper notes the importance of indigenous associations or community-based organisations (CBOs) in managing ecosystems. He describes the characteristics, weaknesses and strengths of CBOs, and some roles that they can play in ecosystem management and human development.

Although they can manage ecosystems for many purposes such as food production, Peden's paper suggests that agro-ecosystems can also be explicitly and effectively managed to improve human health. Managing for human health is a different concept from ecosystem health, with the former dependent on the latter for long-term success. Achieving this requires participation by all stakeholders, trans-disciplinarity, legitimacy, gender analysis, and a new model of project management. This paper describes several different ways of how agro-ecosystem management can affect human health. It notes that poor human health can interfere with people's capacity to manage agro-ecosystems. The paper concludes that the principles of integrated pest management apply to humans as well as to crops and livestock. It recommends greater integration of social, human health and agricultural sciences.

The second section of the proceedings describes nine case studies drawn from experiences in East Africa. Gitau et al describes the characterisation of an agro-ecosystem in Kiambu District, Kenya. They emphasise that all stakeholders must participate in the definition of the ecosystem, in problem identification and analysis, in planning and conducting research. The researchers encountered two constraints to applying the ecosystem health approach. These were the difficulties in bridging the interdisciplinary gap and the challenge posed by the potential disruption to established power structures within the community.

Several papers describe ongoing research activities within key research institutions in the East African highlands. Alemu G/Wold et al describes the Ethiopian Agricultural Research Organization's (EARO) research activities and achievements in natural resources and livestock management. Although coming from a traditional disciplinary-based agricultural research institute, EARO now places priority on the need to attain food self-sufficiency, poverty alleviation, and environmental protection. To attain this, EARO emphasises the study of integrated livestock production systems. Waithaka's paper notes that like EARO, the Kenya

Agricultural Research Institute (KARI) also had a disciplinary past. It focused on agricultural production rather than on the more holistic objectives of ecosystem and human health. Now, KARI gives greater importance to limited aspects of human nutrition. Kamau describes past activities of Kenya Ministry of Agriculture. In spite of some increases in production, the traditional disciplinary approach encouraged promotion of agricultural practices that generated numerous environmental and health problems. He stresses the need for more holistic and interdisciplinary approaches in the design of new agro-ecosystem research. These authors recognise the benefits of taking a more holistic ecosystem approach, but they remain cognisant of the institutional challenges posed by this paradigm.

Workneh Ayalew's paper describes the experience of FARM–Africa (Food and Agricultural Research Management–Africa) in Ethiopia of involving Ethiopian farmers in participatory, gender sensitive research, and participatory generation and adoption of agricultural technologies. Using dairy goat development, community forestry, wildlife and pasture management and capacity development as entry points, FARM–Africa focusses on the most disadvantaged people including women within communities.

Representing the African Medical Research Foundation (AMREF), Biteyi describes human health conditions in Africa. Priority issues include malaria, HIV, women's reproductive health, child health, and malnutrition. She emphasises the importance of community involvement in health care. Neumann's paper describes wide spread micronutrient deficiencies in East African children and the consequent impairment of their physical and cognitive development. Using examples, she outlines the potential role for small ruminant in alleviating nutritional deficiencies in Ethiopia and Kenya. Jemal Haider et al cautions that increasing supply of milk through market-oriented dairy production does not automatically lead to improved health. Sometimes, people may substitute cow's milk for mother's milk and if they sell milk in the market, improved nutrition also depends on farmers using generated cash to purchase alternative high quality food products. Thus, these authors point out the need for nutrition education for those who adopt dairy production technologies. However, in a related study in the same community, Shapiro et al found that increased dairy production led to increased milk production and reduced stunting in children. Women maintained control over much of the increased cash flow. This enabled them to purchase food. Even men increased their expenditure on food.

Researchers and development workers increasingly recognise that reducing poverty and degradation of agricultural production systems requires a more holistic integrated ecosystem approach. Addressing the multiplicity of important issues in complex systems demand's interdisciplinarity, the participation of all stakeholders including local people, and innovative institutional arrangements.

The third section of this proceedings summarises experiences gleaned from integrated eco-regional research in Ethiopia, the highlands of East Africa, and the Himalayas.

The fourth section forms the heart and purpose of the workshop. It includes the draft proposal '*Enhanced human well-being through improved livestock and natural resources management in the East African highlands.*' It calls for the development of integrated policy and technical interventions to improve natural resources management and human health, nutrition and well-being using an 'ecosystem health' framework. Smit briefly but critically analyses the proposal. It emphasises the need for greater rigour and thought in the selection and use of appropriate indicators of agricultural sustainability, human well-being and environmental quality. Mo also stresses the importance of incorporating gender and social analyses into ecosystem management research as people lead different lives. Thus, they differently share in the benefit stream and in the burden of costs associated with tradeoffs arising from management decisions.

The proceedings concludes with recommendations about the research proposal arising from six working groups. They affirmed that primary purpose of the research would be to improve human health through better natural resources management. They confirmed the need for a community-centred, participatory agro-ecosystem health approach to integrate health, agricultural and environmental issues. They elaborated detailed objectives and some priority hypotheses. One group concluded that the six essential steps to conduct the research are:

1. formation of the research team
2. diagnosis and understanding
3. design of interventions
4. testing of interventions
5. monitoring and evaluation, and
6. extrapolation and scaling up to new areas.

The working groups highlighted some specific knowledge and methodological gaps. These include community decision-making processes, representativeness of research sites, extrapolation domains, cross-site comparisons, integration of information, ethical issues, data collection fatigue, relation between policy, institutions, and technologies, and grassroots indicators. The groups conducted in-depth discussion of the need for appropriate indicators for assessing sustainable development and improving human well-being. Individual groups also considered appropriate units of analysis, definitions of households, and certain ethical issues related to researchers' interaction with communities, partnerships and future funding.

The workshop set the stage for a subsequent collaborative and consultative process by which the partners will revise the research proposal and develop a specific plan to carry out the research work.

Section one

Agro-ecosystem health analysis: Theory and concepts

One assumption, two observations and some guiding questions for the practice of agro-ecosystem health

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Abstract

The paper describes the features of agro-ecosystem health as a paradigm or framework to study and develop sustainable agricultural systems. It is posited that agro-ecosystem health research is undertaken in order to help people make better decisions with regard to managing the ecosystems in which they live and grow food. Agro-ecosystems can be viewed and interpreted from a variety of non-equivalent perspectives, and within each perspective, agro-ecosystems can be viewed and understood at different spatial and temporal scales. Therefore, whose perspective is taken into account in identification of constraints and priorities, and designing solutions will determine whether research and development efforts will lead to sustainable agricultural systems.

Introduction

Agricultural activities take place within a complex mess of multi-scalar, multi-dimensional interactions. Researchers using conventional methods have been able to describe and occasionally understand small sub-systems of this larger complexity—human health and disease, nutrient cycling, pasture degradation, livestock production genetics, agricultural economics, and so on—which have enabled farmers in many parts of the world to increase productivity and improve their lives and the lives of urban consumers who depend on them.

More recently, unexpected feedback loops across space and time, and across conventional boundaries of inquiry—urban/rural, economics/ecology, culture/ epidemiology—have enhanced some negative outcomes, such as environmental degradation and economic disparity, and undermined some desirable outcomes, such as improved human nutrition. These feedbacks have raised serious doubts about the socio-ecological sustainability of entire agricultural communities. Indeed, the fact that these issues are arising at the very time when agriculture is being rapidly drawn into a process of globalisation raises doubts about the global sustainability of current agricultural practices and the human communities who depend on them.

The urgent and multi-dimensional questions we are now asking about agriculture, human well-being and the environment, furthermore, are calling into question the normal way in which we have conducted scholarly research. If we wish to describe what is going on in any way that is even remotely realistic, then we shall have to transcend our disciplinary bases of scholarship. If we wish not merely to describe, but to promote sustainable and convivial human communities on this planet, then those people who will make the key decisions and carry them out must somehow be incorporated more fully into the research process itself.

Agro-ecosystem health is an approach to this complexity which draws on the experience and concepts developed by health practitioners and scholars over many centuries and applies them to the investigation and care of socio-ecological systems (Nielsen 1994; Waltner-Toews 1996). This would seem, at first, to be a logical and relatively straightforward step. The scholarship on which health practices are based draws on a wide variety of disciplines and transcends them in an integrative fashion. The practice of health, which has already been applied to individuals, groups and communities of plant and animal species, combines scientific knowledge, cultural values, and practical experience to make and monitor decisions in a context of uncertainty.

Recently, the practice of agro-ecosystem health has been described as occurring in five, not necessarily linear, steps, analogous to the practice of herd health management in livestock. The first two steps, which usually occur simultaneously, are: 1) describe the system of interest; and 2) identify the owners. These are followed by 3) set goals, objectives and indicators; 4) implement feasible and desirable changes; and 5) monitor appropriate indicators and reassess the situation (Waltner-Toews and Nielsen 1997). Such a process might be undertaken by an interdisciplinary team of professionals, with a few principal investigators taking the lead in integration.

Despite the seductiveness of the apparent simplicity of the agro-ecosystem health approach suggested above, initial attempts to apply it have uncovered some serious challenges which must be faced if further progress is to be made along these lines of inquiry (Gitau et al 1997; Rowley et al 1997; Smit et al 1998). These challenges may be summarised in the form of one assumption, two observations, and several questions.

The assumption is this: agro-ecosystem health research is undertaken in order to help people make better decisions with regard to managing the ecosystems in which they live and grow food. It is thus inherently a value-laden and applied activity. This assumption, which is part of the baggage that comes along with using health approaches, has implications for every step of the research process. As an assumption, this is not open to proof or disproof. If this assumption is not made, then health may well not be the appropriate frame of reference in which to do the research.

What are the implications of phrasing the issues in terms of health? In the first place, one way to clarify this is to distinguish between health and medicine.

Medicine requires its practitioners to analyse a problem, make a diagnosis, and intervene based on the best professional knowledge and practice, as defined by a professional organisation. The general approach is thus analytical, implementation depends on compliance with professional authority in a conventional hierarchy, and success, at an individual level, is measured in terms of the cure of specific diseases, and at a population and community level, in terms of prevention or eradication of specific diseases. In medicine, the experts make the decisions, the patients suffer the consequences, and the experts learn from those consequences. Many will recognise this as being the traditional approach used in applied research of all sorts. In systems terms, we might say that the purpose of medicine is to keep the system from falling apart. For narrowly defined issues (preventing or treating specific diseases), and in emergency situations—famines, acute massive erosion, car accidents—medical approaches are not only necessary but desirable. When the patient is bleeding to death, it is no time to negotiate.

Health is generally defined in terms of current overall functioning and the capability to deal with future stresses (Waltner-Toews and Wall 1997). The goal of health is flourishing, that is, the creative expression of a group or individual's genetic and social potential (Haworth et al 1998). Those who wish to have health need to be able to synthesise information from a variety of sources to respond to a changing environment. The general approach to promote health involves recognition of mutual interdependence, negotiation, and resolution of conflicting or competing goals within an overall holarchic structure (see observation 2 below for an explanation of this term). In health, decisions are made by stakeholders collectively, in consultation with experts, and stakeholders learn from their own mistakes. In research terms, this requires that participation by stakeholders is required in both the definition of the problems and the selection of solutions. In systems terms the purpose of health practice is to foster self-organisation. Health promotion, then, is best suited to dealing with questions of long term, complex sustainability.

The two general observations are with regard to the nature of the reality to which we are proposing to apply this health approach:

1. **Agro-ecosystems, like all complex realities, can be viewed and interpreted from a variety of non-equivalent perspectives** (cf Funtowicz and Ravetz 1994). For instance, a systemic description of agro-ecosystems from an economic perspective might look quite different than that reflecting an ecological perspective. Even within a broad economic perspective, women, children, men and government institutions are likely to identify different elements of importance and draw different systemic diagrams. Furthermore, although they are linked in various important ways, there is no obvious equivalence between these systemic descriptions. This means that different health indicators are likely to be used, and different conclusions drawn, by different researchers and stakeholders. That is the third axis of the so-called AESH cube (see Smit et al 1998, p. 20), and will vary with different interest groups and hence raise conflicts.
2. **Within each perspective, agro-ecosystems can be viewed and understood at a range of spatial and temporal scales** (Allen and Hoekstra 1992). Even if we take the smallest coherently managed unit to be the farm, we can see that farms occur within rural communities and watersheds, which are part of larger ecological and socio-political regions, and so on. Socially, culturally and ecologically, this multi-scalar reality is often best understood in the form of a nested hierarchy—what has been referred to in the systems literature as a holarchy. A holarchy is a nested hierarchy, a structure in which whole individuals, each with their own unique characteristics and needs, are parts of greater wholes (families, neighbourhoods, communities), which also have unique characteristics and needs which are greater than, or at least different from, the sum of the members' needs and characteristics. Each level is a holon, that is, it is simultaneously a whole with its own emergent properties, comprised of smaller wholes, while itself being part of something greater. Politically, the way we govern this multi-scalar world is most often in the form of a more conventional hierarchy. While the distinction is less clear at the global level of the United Nations or World Trade Organization, within countries, local levels of government most often take their orders

from higher levels of government without having any organic stake in those higher levels. National governments, for instance, are not usually comprised of state or provincial government leaders, which are not comprised of local leaders.

Each of these two observations generate questions which must be answered as we develop and implement agro-ecosystem health projects.

Whose perspectives are reflected in the research process? What are the implications of this for the results? How do multiple perspectives be incorporated into the research process?

Conventional research assumes that outside experts can fully describe a system, diagnose its ills, and prescribe solutions. This is simply false, even at a given scale. A woman's economic view of a farm agro-ecosystem may be quite different from a man's economic view, and both are likely to create different conceptual models of the system from what a child, an ecologist or a public health epidemiologist would create. One person's problem may well be another's solution. A shift from small mixed farms, for instance, to larger industrial farms, may improve nutrition, while at the same time representing a shift in power and income from women to men, and from the local economy to the regional economy. There is no obvious 'right or wrong' from a research point of view. Each model is correct and each is insufficient to describe the system. Furthermore, any decision about what constitutes a desirable or healthy agro-ecosystem must, by definition, be negotiated, not prescribed, since empowerment is a key component of health. Some indicators of health, especially those related to effectiveness (does the local system produce what the larger systems wants/needs), can be suggested at the research design stage. One may even—through economic incentives, political coercion and/or technological intervention—prod farmers and local communities to move toward these goals. However, unless we know for sure that they reflect the goals of the internal stakeholders, they will give no indication of sustainability or health. Therefore indicators cannot be fully defined or prioritised *a priori.*

What this means for the research is that the process must incorporate a strong element of stakeholder analysis: Who has power? Who is making the real decisions? Who is marginalised? It also means involving those stakeholders in the process of defining issues, constraints, options and opportunities for action, and indicators of success. The selection of indicators will reflect the different perspectives incorporated into the work. Indicators of agro-ecosystem health which reflect the interests and perspectives of one group may in fact dis-empower other groups. For instance, it is possible to select indicators in such a way that livestock appear to be villainous, or to be heroic. Researchers may choose indicators which are precise and quantifiable, but which require sophisticated laboratory equipment to measure and can only be interpreted by professional experts. This may actually reduce agro-ecosystem health, since farmers will either become more dependent on outside professional elites, or will ignore the professionals and act on the basis of personally selected but perhaps unverified and unreliable indicators. This is further complicated when we move across scales.

At which scale should work on agro-ecosystem health be focussed? Is there an appropriate scale to study agro-ecosystem health? What are the implications of focussing at any particular scale?

If we look across all scales, we may note that there are tensions or even outright conflicts. Slash and burn agriculture requires destruction of particular localities within a larger context. It is sustainable if that larger context remains intact so that the local settings can be rejuvenated with seeds, fertiliser, money, social support and the like. Globally, a multinational company might sustain itself through 'using up' local communities and then moving on to new communities. A herd of animals can only remain healthy if some of its members die (naturally, or through deliberate culling or slaughter) and are replaced by newborns or outsiders, who bring in new genetic information. Thus, what is good for the herd is not necessarily good for the individual. Similarly, a local farmer may want to keep all her profits at the household level, in which case the neighbourhood, community and nation cannot survive. A national government may want to take all the farmers' profits to maintain national infrastructures, pay off foreign debts, and so on, but in this case the farmers will not survive. In looking at these examples, it seems clear that, while it is important to have some death and replacement, and to have some profit removed from the farm into community infrastructure, it is in everyone's best interest to ensure that the system is locally sustainable. If all the farmers go bankrupt, the whole system may collapse. It is for this reason that local participatory research is so important.

Indicators of agro-ecosystem health which reflect the economic interests of the national government (that is, one perspective at one scale) may actually be used to promote unsustainable, poor agro-ecosystem health at local scales. Similarly, indicators which are only local may lead to social fragmentation and national disintegration.

There are nevertheless good practical reasons for focusing research into agro-ecosystem health at the farm and local community or watershed level. This is the most 'human' end of the scale, where the immediate impacts of decisions and actions are felt, and where there may be the greatest opportunity for progress in the near future. There are also important reasons for taking into account the larger context within which farms and geographically-based communities exist; at the very least, to help identify the routes of information flow and feedback across levels, both formally and through informal communities of interest. Thus studies focused at various scales should be structured in such a way that they complement each other and the participants learn from each other.

What might a research process look like which incorporates these considerations?

Checkland and Scholes (1990) have proposed a general sequence of activities for studying human activity systems in the context of organisational management. This has recently been extended to research in multi-stakeholder communities (Rowley et al 1997). Variations of this process are currently being applied in agro-ecosystem projects in Kenya, Honduras and Peru. The process builds on a rich historical exposition of the site being studied, and a socio-cultural study/stakeholder analysis. These are necessary to identify a set of perspectives which are likely to capture the main issues of interest in defining system sustainability and health.

An initial synthesis of these perspectives may give a general picture of the overall system (Figure 1). This then leads to systems analysis, to identify causal relationships and feedback loops within subsystems (water, nutrients, disease patterns, labour use), and systems synthesis, to identify linkages within a particular perspective (nutrient and water interactions; labour and economic interactions). Once researchers are reasonably comfortable with their systems descriptions, they can move to synthesis across perspectives, in order to identify options and trade-offs across the full range from male and female, economic, crop and livestock, to social and environmental systems views. Both analysis and synthesis are likely to involve a plurality of research tools. Those currently being explored include signed digraphs, qualitative loop analysis, complex systems models such as catastrophe folds, chaotic attractors and the like, and various forms of Geographic Information Systems (Flood and Carson 1993; Kay and Schneider 1994; Rapport et al 1998).

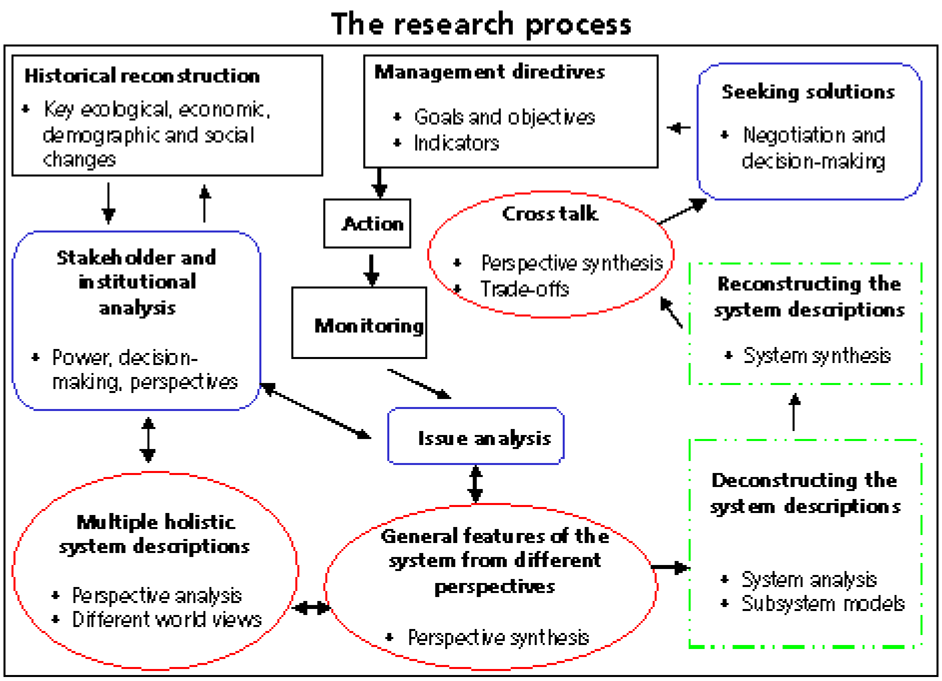

Fig 1. *A possible structure of the research process in agro-ecosystem health.*

While researchers may identify trade-offs, however, conflicts and resolutions which lead to management choices, if they are to be effective and sustainable, must be done by the stakeholders who identified the issues in the first place. Therefore, if given a choice between an esoteric analytic method and one that is more transparent to lay people, one should always choose the latter. We have found, for instance, that influence diagrams are useful for both scholarly researchers and local participants. The process and the research methodologies used are likely to be subject to debate and experimentation for many years to come. The process has already been modified several times since this work was first undertaken. It will no doubt continue to be modified as the research progresses; nevertheless, we would recommend it as a good starting place for anyone wishing to pursue agro-ecosystem health research.

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Ecological approach to agricultural production and ecosystem theory: The amoeba approach

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Abstract

The paper argues that agriculture operates on the interface of two complex, hierarchically organised systems: the socio-economic system and the ecosystem. So in any defined farming system one will always find legitimate and contrasting perspectives with regard to the effects of changes in the system, and the effects are not likely to result in absolute improvement for all stakeholders. A methodological tool, the amoeba multi-dimensional reading, is described to characterise farming system performance in an integrated way taking at various scales according to different perspectives.

Introduction

Agriculture operates on the interface of two complex, hierarchically organised systems: the socio-economic system and the ecosystem (Hart 1984; Lowrance et al 1986; Conway 1987; Ikerd 1993; Giampietro 1994a; Giampietro 1994b; Wolf and Allen 1995; Giampietro 1997a). This implies that in any analysis of a defined farming system one will always find legitimate and contrasting perspectives with regard to the effects of changes in the system. For example, increasing return for farmers (e.g. intensification of crop production) is coupled to more stress on ecological systems (e.g. loss of biodiversity and soil erosion). Similarly, improvements for certain social groups (e.g. lower retail price of food for consumers) tend to represent a set-back for others (e.g. lower revenues for farmers).

Thus, changes in agriculture, induced either by new policies or by technical innovations, are unlikely to result in absolute improvements for all stakeholders and social actors involved, nor in absolute improvements on all the scales (soil, farm fields, watershed, regional, global) on which the (side-)effects of agricultural production can be described. Hence, a 'correct' assessment of agricultural performance should best be based on an analysis of trade-offs that reflect the various perspectives, both positive and negative, with regard to the effects that a proposed technological or policy change will induce on the various scales and actors involved.

In this paper we present a methodological tool, the amoeba multi-dimensional reading, that can be used to characterise farming system performance in an integrated way on various scales and according to various perspectives.

Theoretical basis of integrated assessments based on a multi-dimensional description

Some basic concepts

Agricultural systems are complex systems made of many different components which operate in parallel on different space-time scales. Examples of such components are soil micro-organisms, populations of selected plant species in crop fields, individual farmers, farmer households, rural communities, local economies, local agro-ecosystems, watersheds, regional economies, biosphere processes stabilising bio-geo-chemical cycles of water and nutrients, and socio-economic processes stabilising the boundary conditions of farming activities. In addition to being hierarchically organised on several scales, ecological and human systems are made up of 'holons' (term introduced by Koestler 1969), that are a whole made of smaller parts (e.g. a human being is made of organs, tissues, cells, molecules etc) and at the same time they form a part of some greater whole (an individual human being is part of a household, a community, a country, the global economy).

Understanding the holarchic structure of agricultural systems is a fundamental prerequisite for a sound analysis of their performance. Agricultural research tends to be plagued by systematic errors in the choice of the hierarchical level of analysis and investigation. In fact, analyses performed at a certain level (e.g. compatibility of crop production techniques with soil health) not necessarily provide sound information on what goes on at other levels (e.g. compatibility of the production technique with expected farmer income in a defined rural community).

The amoeba reading

The basic idea of the amoeba reading is to provide a graphic representation of system performance as assessed over a certain number of aspects/qualities that cannot be expressed as a function of the others. In this way, it is possible to have an overall assessment by a visual recognition of the existing difference between the profile of expected (or acceptable) values and the profile of actual values over families of indicators of performance referring to non-comparable qualities. This method is used, for example, in marketing to obtain an overall assessment of consumer satisfaction with regard to different aspects of a product (e.g. for a car: price, driving characteristics, design, gasoline consumption, assistance and services, reliability, choice of colours). Wide differences between expected and actual values indicate lack of consumer satisfaction. Areas of the graph in which the gap between expectation and actual performance is particularly wide indicate priorities in terms of intervention. Such a reading is illustrated in Figure 1 and represents a metaphor of the need of multiple reading for sustainability. The particular product considered will not be 'sustainable' in the market place if it completely fails on one or more of the qualities affecting consumer choice.

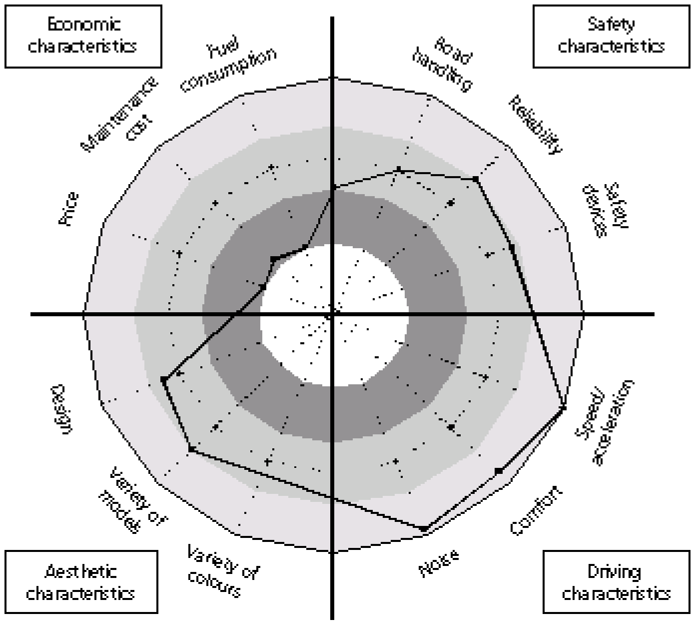

Figure 1. *Example of amoeba reading: performance of a car.*

In the field of natural resources management, the amoeba approach has been proposed by Brink et al (1991) as a tool for dealing with the multi-dimensionality of environmental stress assessment by using different indicators of ecological stress referring to events occurring on different space-time scales. In our model, the graphic representation of the system is simply based on a division of the plane of a 'radar diagram' into four quadrants, each describing a distinct view on the system (Figure 2). Within each quadrant, a number of axes referring to different indicators of performance are then drawn. The choice of both quadrant and axis is arbitrary and is made according to the system's characteristics which are considered relevant for the analysis. With regard to agricultural sustainability, aspects to be considered are generally related to the existing relation of farming to its socio-economic context, such as economic development and openness of the food system, and to its ecological context, such as type of ecosystem and demographic pressure.

In the example provided in Figure 2, the agricultural system is described by quadrants that refer to the following four aspects of performance: the farmers' view (upper left quadrant), the national (or regional) economy (lower left quadrant), extent of environmental loading (upper right quadrant), and the ecological footprint of the food production system (lower right quadrant). The latter is a measure of the extent to which a steady-state description of the agricultural system misses relevant information and hence this quadrant somehow accounts for the fact that today almost no agricultural system is in reality in steady-state (inputs and outputs are increasingly based on stock depletion and filling of sinks).

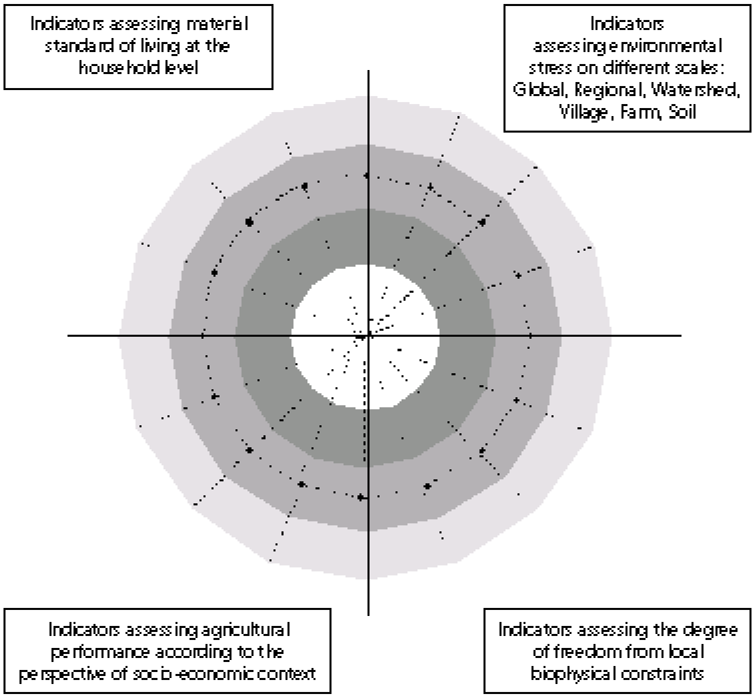

Figure 2. *Amoeba reading applied to sustainable agriculture.*

At this point we have a tool that describes the effect of changes in the system in parallel on different hierarchical levels (space-time scales) and according to a given selection of perspectives (those forming the basis for the selection of indicators in the four quadrants). However, in order to move from this multi-dimensional representation to a discussion of trade-offs in decision making in agriculture (e.g. to evaluate possible scenarios and/or use multicriteria methods of evaluation) three additional steps are needed.

1. The selection of indicators to describe the effects of a particular change (the states of the system) on different levels and according to different perspectives must be validated by involving social groups and agents whose views are considered in the analysis (who decides what is the best selection of indicators of performance?).
2. The various 'readings' of the states of the system on different scales are to be bridged by a model of analysis that links events at one level (described on a certain space-time scale) to events occurring at other levels (described on different space-time scales).
3. Models used to link changes on one level to changes on other levels must be critically appraised by the different stakeholders that are supposed to use them in the discussion of scenarios with the help of scientists from various different scientific backgrounds (who decides how good are the proposed models?).

Clearly, the success of such an integrated assessment completely relies on the 'political will' to involve straight from the outset as many stakeholders as possible in the process of decision-making using participatory techniques, and on the 'political integrity' to respect the indications obtained by such an integrated assessment.

Establishing bridges among levels

The graphic representation in Figure 2 provides a parallel description of states of the system as 'seen' and 'recorded' at different scales on different hierarchical levels. It should be noted, however, that the values of the variables used as indicators of performance are not independent of each other both within and across quadrants. Many of these variables can be linked through equations of congruence across levels referring to biophysical throughputs of agriculture (Giampietro 1997a; Pastore et al 1998; Giampietro and Pastore 1999). For example, technical coefficients (throughputs per hectare of land and per hour of labour and output/input ratios) and market variables (sale prices, structure of costs, and taxes and subsidies) define a direct link among many of the variables considered in the amoeba reading.

Passage from individuals to types to cross levels

Some aspects of the amoeba reading deserve particular attention. When the system is read at the household level, the quadrants describing the effects of farmer's choice on the environment (e.g. environmental loading) and on the socio-economic context (e.g. food surplus produced and its related cost) refer exclusively to the specific and limited space-time scale at which the individual farm household is defined and described (e.g. a 200 ha farm in the USA over a period of 1 year). To assess the effect of farmers' choices on a larger scale (e.g. regional or national), one needs to aggregate the effects induced by all the individual farm households operating in the area (region/country). Given that the effects of individual farm households are not necessarily uniform, one must first define the various 'farm types' that can be distinguished and then, using curves of distribution, obtain an aggregated effect over the given set of farm types.

To obtain a set of characteristics that can be used to define a farm type, start by analysing the constraints affecting farmers' options, as determined by internal links among the variables on the amoeba (for more details see Pastore et al 1998). Our steps in this process are as follows:

- choice of the set of indicators of performance to be used which determine the skeleton of indicators for the amoeba
- definition of a viability domain for each indicator (range of values within which the farm is supposed to operate)
- definition of the preferences of farmers in relation to different indicators, that is, establishing a preference relation among the different areas within the viability domain
- characterisation of the farm type in terms of selected combinations of farming techniques that tend to saturate to the maximum extent the existing resources (land, labour time and financial capital) available to the farm household considered given a set of objectives defined in step 3.

Different strategies adopted by farmers (e.g. maximisation of economic return or minimisation of risk) can be studied as movements of the system in different areas of the amoeba. The existence of 'internal constraints' (e.g. a farm household can not use more time, land or capital than it has available) implies that, given technical coefficients and structure of prices, costs and taxes, the possible choices for the farm household are limited. Studies of the nature of this limitation specifically address the peculiarity of research at farm level as compared to research at the plot level (see Pastore et al 1998 and Giampietro and Pastore 1999).

Each combination of techniques that satisfies the above-mentioned conditions of (1) saturating the existing budgets of land, labour time and capital, and (2) operating within the feasibility domain of the selected set of indicators of performance, represents a viable technical option for farmers. That is, such a combination is one possible state (a type) for the farm. Each farm-type defined in this way implies a certain combination of trade-offs (a defined profile of values on the amoeba) for the environment and the national economy.

An application of the multi-dimensional amoeba approach

First step: Selection of indicators of performance on different scales and related to different perspectives

A list of indicators of agricultural performance (and the range of their values) that can be used to reflect the various perspectives generated at the household level is shown in Table 1. Assessments of the performance of a farming system at this level can consider various objectives, such as minimisation of risk (e.g. safety from climatic, market and political disturbances), food security, maximisation of income and net disposable cash, and maximisation of the potentiality of the members of the farm household (e.g. better education, better communication and information processing, intensification of social and cultural events).

Several indicators assessing agricultural performance at the level of the national (or regional) economy are listed in Table 2. At this level, several goals should be considered, such as self-sufficiency in food production, minimisation of indirect costs of the food system, minimisation of the direct economic cost of food supply, and minimisation of gradients in economic development between rural and urban areas.

Indicators to monitor ecological impacts are presented in Table 3. The set of indicators should cover various distinct scales (e.g. global level, region, watershed, village, farm, field, and soil level). They might refer to (i) direct measurements of environmental loading (e.g. fertiliser and pesticides applied per hectare per year and per unit of crop output, pollutants discharged into the environment), (ii) alterations of natural configurations of matter and energy flows (e.g. thermodynamic indices of ecosystem), (iii) use of bio-indicators (e.g. key species providing information on the health of the natural system within which they operate; they can be vegetal associations, biodiversity of different taxa related to different scales such as protozoa and earthworms for the soil, arthropods for cropped areas, and birds and mammals for larger areas), and/or (iv) evaluation of landscape patterns (e.g. fractal dimension of agricultural landscape). Again an appropriate combination of these indicators depends on the scale and the type of information needed in the process of decision making.

Table 1. *Indicators that can be used to assess material standard of living at household level.*

Indicator	Range of possible value
Average body mass	34–60 kg
THT[1]/C[2]	10–45
Dependency on market for food security	0–100%
Endosomatic metabolic flow	6.5–9.5 Mj/cap per day
Exosomatic metabolic flow	35–900 Mj/cap per day
Net disposable cash	50–50,000 US$/cap per year
Average return of labour	0.10–45 US$/hour

Expenditure for food	5–75% of NDC[3]
Total food energy supply	1500–4000 kcal/cap per day
Total protein supply	30–130 g/cap per day
Animal/total protein ratio	15–70%

1. THT (Total Human Time) = Total number of individual × 8760 (hours in one year).

2. C = Total time (hours per year) allocated by the whole society to labour in primary sectors of economy.

3. Net disposable cash.

Finally, indicators can be used to describe the 'degree of freedom' of the considered agricultural system from local biophysical constraints (a measure of how misleading the description is of the system in steady-state). Some of these indicators are listed in Table 4 (e.g. dependence of agricultural output on stock depletion, filling of sinks and related accumulation of pollutants, and imports from distant ecosystems). Basically this assessment compares the ecological footprint (the demand for natural capital on which the present agricultural system performance is based) with the amount of natural capital available in the agro-ecosystem for a sustainable agriculture (without generating irreversible deterioration in ecological systems). Indicators in this quadrant often represent the extent of 'openness' or linearisation of matter and energy flows in the agro-ecosystem: The higher is the speed of throughputs on the farm, the higher is the linearisation of matter and energy flows in the agro-ecosystem, the more human choices are 'free' from local natural constraints (technological inputs short-cut the ecological system of feedback controls), and the more human activity is at risk of generating negative consequences for the ecosystem (Giampietro 1997b).

Table 2. *Indicators that can be used to assess the performance of agricultural systems according to socio-economic context.*

Indicator	Range of possible value
Average body mass	34–60 kg
THT[1]/C[2]	10–45
Dependency on importation for food security	0–50%
Exo/endosomatic energy ratio	5–90
Bio-economic pressure	15–1600 Mj/hour
Exosomatic metabolic flow	35–900 Mj/cap per day
Cereal surplus per hectare	–3000+4000 kg/ha arable land
Cereal surplus per hour	–1+85 kg/hr agric. labour
Cost of agricultural surplus	–13 +37 US$/hour labour
GNP/capita	90–36,000 US$/cap per year
Average return of labour	0.10–45 US$/hour
Expenditure for food	6–60 % of GDP
Total food energy supply	1500–4000 kcal/cap per day

Total protein supply	30–130 g/cap per day
Animal/total protein ratio	15–70%
% Labour force in agriculture	4–70%
Farmer income vs national income average	0.6–1.0
GDP in agric. vs labour force in agric.	0.10–1.5
Taxes from agriculture/subsidies to agriculture	–
Prevalence of children malnutrition	0.5–60%
Infant mortality	4–170/10^{-3}
Children mortality	6–320/10^{-3}
Maternal mortality	2–100/10^{-3}
Low birth weight	4–40%
Life expectancy	39–79 years
Population/Physician ratio	210–73,000
Population/hospital bed ratio	65–65,000
Pupil/teacher ratio	6–90
Illiteracy ratio	0.5–90%
Radio ownership	25–2100/10^{-3}
Television ownership	1–820/10^{-3}
Car ownership	0.5–570/10^{-3}

1. (Total Human Time) = Total number of individual × 8760 (hours in one year).

2. C = Total time (hours per year) allocated by the whole society to labour in primary sectors of economy.

Second step: Defining feasibility domains for selected indicators

Having chosen the variables on different axes (distributed over different quadrants), one must define a range of 'feasible' values for each indicator (the gray area on each axis indicated in Figure 2 within which light gray means 'good', dark gray means 'bad'). Within the 'feasibility domain' 'target values' may be added to the graph (the dots in Figure 2) that reflect the goals expressed by the representatives of different perspectives.

Table 3. *Indicators that can be used to assess ecological impact of agriculture.*

Indicators of stress must cover different scales		
Global level	Regional level	Watershed level
Village level	Farm level	Field level
Soil level		
They can refer to		
Direct measurements of environmental loading	Kg of pesticides applied per hectare per year	
	Kg of fertilisers applied per hectare per year	

	Pollutants discharged into the environment
Assessment of alteration of matter and/or energy flows	W/kg
	W/square meters
	Other thermodynamic indicators
	Densities of nutrient flows
Bio-indicators	Key species giving information on the health of the natural system within which they operate
	Vegetal associations
	Biodiversity assessment
Landscape pattern	Fractal dimension of agricultural landscape, hierarchical organisation in space and time of matter and energy flows

Regarding the hierarchical levels distinguished on the socio-economic side (e.g. household, region, and country), the selection of both indicators and their feasibility domain is difficult because according to the specific situations considered many different social groups (e.g. ethnic minorities, future generations) could be included into the assessment inducing conflicting definitions of what is acceptable. The existing link across levels implies that the socio-economic context within which the farming system operates is affecting ranges of acceptable values on lower levels. For example, a return of one dollar per hour of farm labour would be a remarkable achievement for a Chinese farmer (operating in a country with a low average return of labour per hour), whereas such a return would render farming in the European Union not viable.

Third step: Assessing current situation on a multi-dimensional state space

In this step, the actual value of each indicator of performance in each of the four quadrants is recorded on the graph. This makes it possible to visualise the position of the actual values, e.g. are they inside or outside their feasibility domain, what is the distance from the edge of their domain, and what is the distance from their target? The multi-dimensional state space obtained at this point makes it possible to compare the current position of the system against the 'states' defined as target for policy implementation by stakeholders and against the 'feasibility domain' based on the underlying biophysical links across hierarchical levels. Wide differences between actual values and expected values (either target values or values which would be required by congruence of matter and energy flows across levels) can be assumed to indicate stress in both natural and socio-economic sub-systems and hence indicate need for intervention.

Table 4. *Indicators that can be used to assess the degree of freedom of agricultural production from local biophysical constraints.*

Indicator	Range of possible values
Output/input energy ratio	+ ∞–0.1
Indicators based on ecological footprint (natural capital demand/natural capital available)	
Nutrients flows boosting ratio	1–50
(Embodied land + actual land)/Actual land (ha-year	Depends on calculations

equivalent/ha-year of cropped land)	

Two examples of a multi-dimensional reading are provided in Figures 3 and 4 that refer to farming systems in developing and developed countries, respectively.

The amoeba reading shown in Figure 3 characterises the situation of a subsistence farming system operating without external inputs. When population pressure is moderate, ecological indicators of stress are within the acceptable range. Note, however, that the values of the set of indicators characterising material standard of living would be unacceptable according to Western standards. The net disposable cash generated per hour of labour time, average body mass, and other social indicators of development are far away from the viability domain at which rural households operate in developed countries.

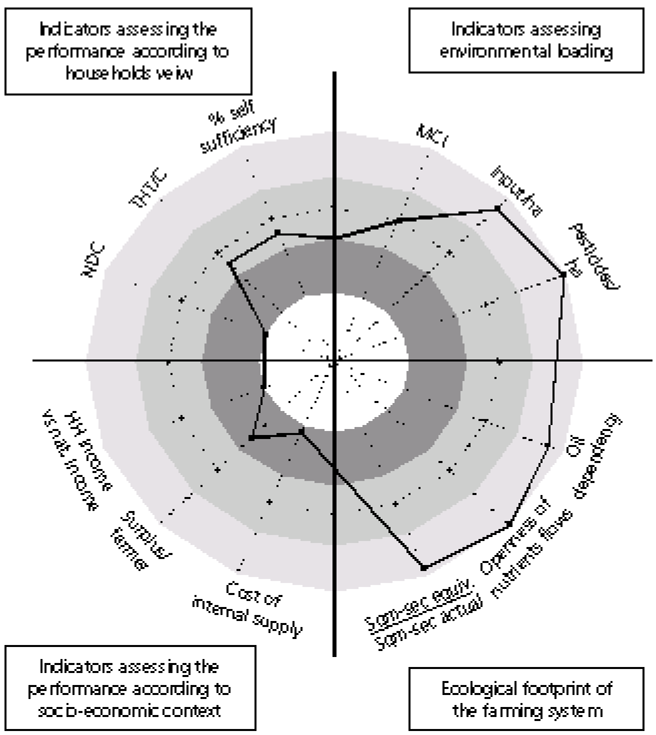

Figure 3. *Amoeba reading applied to a subsistence farming household.*

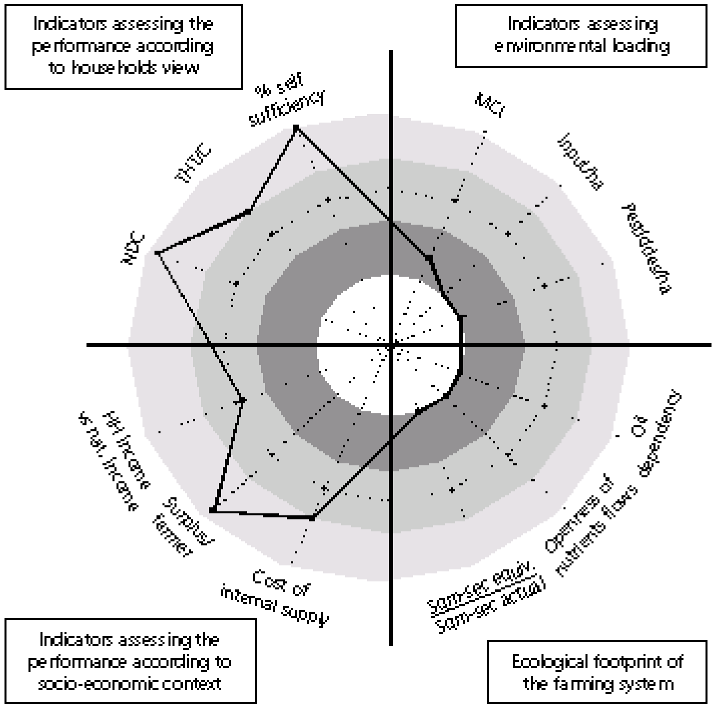

Figure 4. *Amoeba reading applied to a farming household in a developed country.*

The reading shown in Figure 4 characterises the situation of farmers operating in developed countries. The values of indicators of development at the farm household level are worse than the corresponding national averages (rural communities are poorer than urban communities), although the gap is kept fairly narrow through national policies supporting the rural population. In absolute terms, the situation of farmers in developed countries is much better than that recorded for subsistence farming in Figure 3. However, the multi-dimensional analysis reveals the trade-offs implied by this positive achievement on the socio-economic side. Higher returns for humans in developed countries are paid for by a larger environmental impact of agriculture, and by a heavy dependence on stock depletion (e.g. fossil energy), and often by import of ecological activity from distant ecosystems (e.g. imported animal feed and other agricultural commodities in Europe).

A comparison of the two profiles in Figures 3 and 4 (the distribution of actual results over the feasibility domains, i.e. the gray areas) shows the unbalanced negotiation of contrasting goals (perspectives) referring to distinct levels when the farming system is operating under a different combination of socio-economic and ecological contexts. The ecological perspective tends to be the looser in intensive agriculture as soon as the demographic and socio-economic pressure rise (see Giampietro 1997a; Giampietro 1997b). This explains why traditional farmers undergo heavy stress when fast development of their socio-economic context makes their traditional techniques no longer viable.

Discussion on scenarios in terms of effects of changes across levels using a case study in China

In a four-year project studying agricultural intensification in a rural area of Hubei Province, PR China the following three main farm types could be distinguished.

- Farm type 1: Farmers that maximise the net disposable cash (NDC) through cultivation of cash crops and off-farm labour, even though this means taking risks and a heavy work load.
- Farm type 2: Farmers that minimise their risk by growing mainly subsistence crops and that maximise their leisure time (max THT/C) by avoiding off-farm jobs, even if this implies remaining behind in the fast process of modernisation of China (low NDC);
- Farm type 3: Farmers that operate minimising risk (relying on subsistence crop), but aiming at the same time for a high net disposable cash (off-farm jobs and cultivating whenever possible also cash crops). This choice is paid for by heavy work loads (low THT/C).

These three solutions to saturate the land, time and capital resources available represent farm types that can be considered 'attractors' in the area studied given the existing socio-economic and ecological context and cultural identity of farmers. These three farm types imply different trade-offs in terms of performance of indicators reflecting other perspectives, or in other words, these three farm types have different shapes when described with the amoeba reading.

Farm type 1 implies higher income for farmers but at the same time a larger environmental load and total absence of rice surplus to feed the urban population of China (these farmers are net consumers of rice). This is evident when comparing the amoeba reading of farm type 1 (Figure 5b) with that of farm type 2 (Figure 5a). This implies that if farm type 1 would be the only one practised in entire rural China, the country would no longer be able to feed its urban (and rural) population without heavy reliance on import.

Similar multi-dimensional amoeba readings for farm types 2 and 3 are graphically illustrated and discussed in Pastore et al (1998) and Giampietro and Pastore (1999). This is to emphasise that each of these farming types defined at the household level can be linked to a certain pattern of landscape use (defined on the space scale of the farm) and to certain effects (when aggregated on a large scale) on the national economy. Latter effects are obtained by considering the distribution of the population of farm households over the possible set of farming types. Given a spatial distribution of rural villages in a determined area and assuming several different distributions of the population of rural households over the set of possible farming types simulate changes in landscape use and effects on the national economy can actually be generated by the (simulated) changes in the area. In this way, the effect of government policies or technological changes can be studied by simulating the effect that they will have on the distribution of households over possible farm types. Clearly, dramatic changes both in technology, farmers feelings, environmental settings, and governmental policies can scramble the existing picture by introducing new possible farm types, making existing ones obsolete, generating dramatic changes in the distribution of individual households over the accessible farm types.

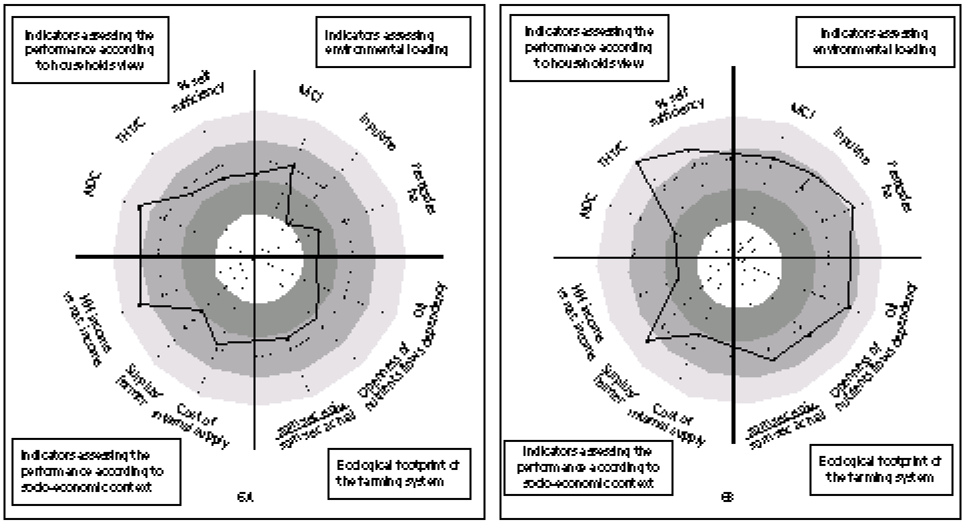

Figure 5. *Example of amoeba reading of two Chinese farming-types: Household optimising THT/C(5A) and household optimising NDC (5B).*

To illustrate our approach to crossing scales, we refer to the amoeba readings presented in Figures 6a and 6b that describe two 'virtual villages' simulated on the basis of the information obtained from the amoeba reading of the farm types in rural China.

We assumed that the village described in Figure 6a is characterised by a majority of farmers that optimise the net disposable cash (this simulation is based on a distribution of 80% of farmers belonging to farm type 1; 10% to farm type 2; and 10% to farm type 3). The village described in Figure 6b is characterised by a majority of farm households practicing traditional agriculture, hence minimising risks and time allocated to work (simulation is based on a distribution of 80% of farm households belonging to farm type 2; 10% to farm type 1, and 10% to farm type 3).

Thus, the graphs in Figures 5a and b represent the household level and are based on real data, while those in Figures 6a and b represent the village level and are simulated. Note, the different space time scale of the amoeba readings: the scale of the village (Figures 6a and b) is larger, that is, it covers a larger area and is slower in reacting to changes. At both household and village levels, it is possible to obtain the amoeba reading either by simulation (defining distribution curves of lower-level elements over types) or by gathering real data. Doing both data collection and simulation at either one level is useful to validate the assumptions adopted in the simulation. For example, in our study in China we found that the geographic location of villages (access to market and off-farm jobs opportunity) was a significant factor affecting the distribution of farmers over the possible farm types. Similar hypotheses can be tested when considering population characteristics (age and sex structure, ethnic origin, level of education) as possible factors affecting the distribution of farmer households over the existing set of farm types.

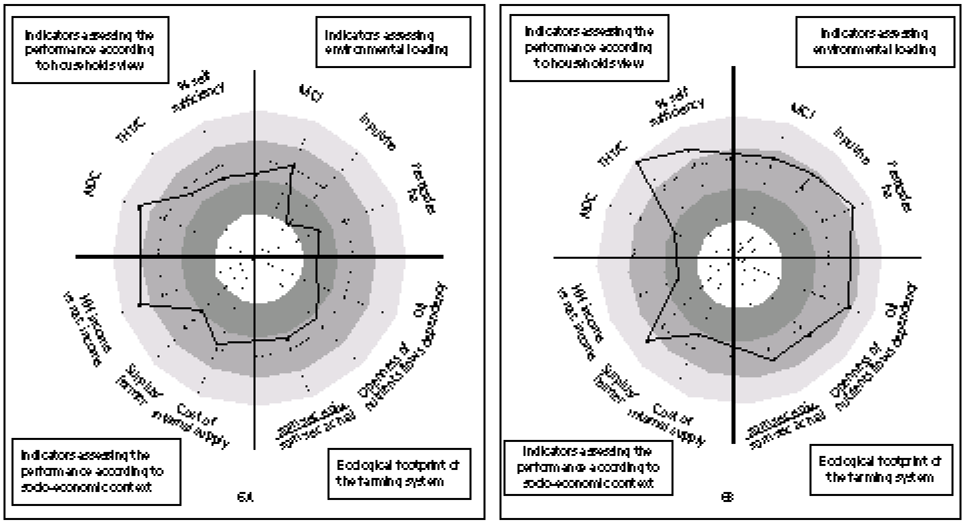

Figure 6. *Example of amoeba reading of two simulated Chinese villages: Virtual village A generated by a given curve of distribution of farming types (6A) and virtual village B generated by a different curve of distribution of farming types (6B).*

Considering the amoeba readings in Figure 6, we see that the first virtual village (market-driven choice based on off-farm work and intensive production of cash crops) is the one that generates by far the highest environmental loading and is to the larger extent dependent on coal and oil for food production. From the national perspective, this village does not produce any surplus of rice, on the contrary, it erodes the rice surplus produced by near-by villages. As expected, however, what is detrimental to the environment and the food self-sufficiency of the country also has its positive side: a high net disposable cash for farmers. The productive pattern adopted by village 1 is therefore benign to the villagers and to the people of the close-by town that have access to cheap supply of fresh vegetables and other food. On the contrary, the second virtual village (Figure 6b) with the highest surplus of rice (good for self-sufficiency of China) generates a moderate environmental impact (good for the environment). This environmental benign solution is paid for in terms of low net disposable cash from agriculture. People living in village 2 are at risk of loosing contact with the dramatic socio-economic transformation which is taking place in China. A general amplification of village 2 type will imply locking a large part of the Chinese rural population into a situation of poverty and lack of modernisation.

Conclusions

The existence of different dimensions for the concept of performance of agricultural systems and the existence of different space-time scales at which agricultural processes can be described make it impossible to determine 'optimal' solutions (optimal for how long? and optimal for whom?). When dealing with sustainable development the relations of preference and indifference are not enough, because when an action is better than another one for some criteria, it is usually worse for others, so that many pairs of action remain incompatible with respect to a dominant relation. Moreover it is impossible to assess with a single type of description/analysis the effect of a particular combination of techniques of farming on all the chosen dimensions. By acknowledging the existing problems, we propose a model of analysis that:

1. does not claim to provide 'the correct' analysis of the system. It simply generates several sets of 'view dependent' representations of the reality. The peculiarity is that we acknowledge such a dependency from the beginning.
2. can be enriched by including new alternative sets of view-dependent representations and can be used as a tool for enhancing negotiation among groups with different views and interests about the performance of food systems.
3. it acknowledges that the goals related to the concept of sustainable development can not all be achieved at the same time, just by adopting a single 'silver bullet' technical solution. Decision-making implies finding compromise solutions among legitimate but contrasting views.
4. it enables to use information generated in different scientific fields (economics, sociology, agronomy, applied and theoretical ecology etc) and referring to descriptions of the system obtained on different space-time scales.
5. makes easier the discussion of possible scenarios by either fixing the values of variables describing the performance of agriculture on the socio-economic and ecological level and then check the values of technical coefficients and/or market variables that would be required to guarantee such a performance, or by estimating future technical coefficients and then calculate the possible consequences in terms of performance of agriculture in ecological and socio-economic terms. Studying possible effects that policies formulated at the country and regional level can have on the options available to farmers and on farmers' choice over available farm types.
6. this multi-dimensional approach forces to evaluate perspectives of levels (and/or social groups) that normally are not included in the 'traditional' analysis. In fact the environment (= future generations) has been until now the big looser in negotiations among contrasting views belonging to different levels. That is, including the perspective of the environment (= considering and assessing environmental costs at several space-time scales-soil, field, farms, watershed, regional) should become a mandatory step when formulating policies affecting the sustainable use of natural resources.

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NRM and human health: Applying principles of integrated pest management to people

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Abstract

During the past century, both the agricultural and health sciences have become compartmentalised making great technical advances in relatively specialised technologies that generated significant increases in food production and reductions in human diseases. Although the primary purpose of agriculture is to maintain human health and human health depends upon agriculture, there have been few efforts to integrate the two. At a time when both realms of study are questioning the sustainability of their respective achievements, the concept is emerging that effective agro-ecosystem management may provide a cost-effective approach to improving human health. This hypothesis builds on an enhanced understanding of how the state and condition of agro-ecosystems links to human health. Experience gained by the International Development Research Centre (IDRC) reveals a number of essential methodological elements required to support research intended to test this hypothesis. It suggests that the principles of integrated pest management that have been successfully developed and applied in agriculture may be applicable to improving human health in the context of agro-ecosystems. Greater collaboration between the natural resources management and health sciences is recommended.

Introduction

WHO (World Health Organization 1976) adopted a broad view defining human health as 'a state of complete physical, mental and social well-being, and not merely the absence of disease or infirmity.' Without food, good health is not possible. Although traditionally emphasising the production and distribution of food, the ultimate overall goal of agriculture must be the maintenance of human health and well-being. Surprisingly, there is little evidence that most agricultural and health researchers and practitioners consciously accept this view. In spite of hundreds of thousands of research papers available in both fields of study, a search for recent research literature conducted by the International Development Research Centre (IDRC) resulted in only six 'hits' identifying papers that contained both 'agro-ecosystems' and 'human health' as key words. Although fine tuning using additional and related key words revealed other relevant publications, the gap in our knowledge of the links between human health and agriculture systems is evident. Closing this gap requires stakeholders to recognise that agriculture is in fact agro-ecosystem management (Nielsen 1998). By design, people are an integral component of all agro-ecosystems. It follows that both the condition and management of agro-ecosystems have a direct influence on the health of people. The purpose of this paper is to outline some of the fundamental concepts essential to using agro-ecosystem management as a tool for improving human health and to suggest some essential elements for future research and development.

Agro-ecosystems

'An agro-ecosystem is a conceptual construct used to describe a geographically and functionally coherent domain of agricultural activity. It includes all living and non-living components and the interactions among them' (Agro-ecosystem Health Project 1996). Researchers often consider the farm as the basic unit of an agro-ecosystem, but this concept may not be relevant in extensive grazing systems. The precise geographic scale can vary from a system involving a single farm to communities and watersheds composed of many farms and even beyond that to large eco-regions. The definition is context-specific, and in each case it is somewhat arbitrary. Regardless of the scale, agro-ecosystems are not closed systems. It is normal that agro-ecosystems are characterised by driving variables or inputs that include immigration and inflows of capital, information, energy, fertilisers, chemicals, and human infrastructure and knowledge. Natural driving variables or inputs include solar radiation, rain, wind and water. Most agro-ecosystems also experience losses or outflows from the system such as water, and emigration. Nutrient losses caused by leaching and the export of crops and livestock are common.

Agro-ecosystems cover 30% of the world's land area (Elliot and Cole 1989). Farmers manage more land area than any other group of people. During the last 50 years, scientific progress (the green revolution) in plant and animal breeding, irrigation, pest and disease control, labour-saving technologies, and food processing enabled food production to keep pace with the demands of a growing human population. Without these technological breakthroughs and compared to 1961, three times more land in China and the United States and two times more in India would have to be under cultivation in order to achieve the food production levels obtained in 1995 (Borlaug 1995). To meet the demand caused by the continuing increase in population and the increasing demand for animal products in the developing countries, food production must double over the next 30 years.

During the past century, agricultural sciences became compartmentalised or divided into many specialties that enabled the green revolution to happen. The apparent success of production agriculture depended on the exploitation of the world's capital held in the form of soil organic matter and nutrients. One unintended outcome of production oriented agriculture is recent global degradation of soil and water resources and the consequent loss of biodiversity (Srivastava et al 1996). High yielding production systems accelerated the 'mining' of soil capital (Sanchez et al 1997). Replenishment of soil nutrients by dependence on chemical fertilisers failed to maintain the structure and biological diversity essential for long term production. Expansion of agriculture into forests and the conversion of range lands into croplands aggravated this deteriorating situation. Under nutrient and water-stressed intensive agricultural production systems, farmers increasingly rely on the use of herbicides, pesticides and pharmaceutical drugs to control a wide range of diseases and parasites that threaten their crops and livestock.

Agriculture now faces the tasks of further enhancing food production while simultaneously reversing soil degradation (Borlaug 1995), replenishing soil capital (Sanchez et al 1997), and overcoming the harmful effects of agricultural chemicals (van Veen et al 1996). Degraded agro-ecosystems are less resilient to stresses caused by global variation and climatic changes. They are sites where there is growing concern about the projected increase in risks to human health (Lederberg 1995). Recognising this, the international community responded, particularly since the United Nations Conference on Environment and Development in 1992, by establishing numerous agreements, international conventions, and research and development programmes that endeavour to transform exploitive agricultural activity into sustainable development (e.g. World Bank 1995). One consequence has been the rise of a more holistic agro-ecosystem view of agriculture as the paradigm for understanding sustainable production.

Human health

In a pattern similar to the evolution of agriculture during the past century, human health research and practice underwent significant progress (Lederberg 1995; World Bank 1995). For example, great strides in sanitation, health education, nutrition, immunisation and antibiotics all contributed to the reduction of infectious diseases, the leading cause of mortality in the United States in 1900 accounting for at least 37% of deaths, to 2.8% in 1989. The number of children that die before the age of five in developing countries has been cut by half since 1960 (World Bank 1993). Much of this progress depended on advances in specialised aspects of medical sciences that often focused on diagnosis, prognosis and prescription in a clinical setting that separated human health from the environmental context in which people live (Ewert and Kessler 1996). Health care and delivery were built around single specialist disciplines or on a relatively restricted set of them. In spite of the progress in developed countries, the benefits of improved health care have not been shared equally among the peoples of the world. Infectious and communicable diseases remain the most common cause of global mortality (Wilson 1995). In sub-Saharan Africa they still account for 70% of the burden of ill health. There is also growing concern that many of the advances in global health now risk being offset by many factors including climate change, new and re-emergent diseases, under-nutrition, malnutrition, respiratory illness, increasing rates of cancer, and toxic chemicals (World Bank 1993; Lederberg 1995; Epstein 1997). As with attempts to control agricultural pests and disease by using excessive and inappropriate use of chemicals, health professionals are now challenged by increasing resistance of pathogenic organisms and disease vectors to pharmaceuticals and pesticides (Wilson 1995).

During the past two decades, some segments of the health care community have placed greater emphasis on a more holistic understanding of human health in the context of the environment. For example, the World Health Organization of the United Nations (WHO) and other bodies now place greater emphasis on understanding the links between human health and a range of pollutants in air, water, soil and food (Corvalan and Kjellstrom 1996). Looking beyond the notion of simply linking environmental components directly to human health issues, there is the growing recognition that these linkages operate within the complex structure and functioning of the ecosystems in which people live (Forget 1997). There is increasing cognisance of the need for students of human health to take a systems approach to understand their subject in the context of the health and resilience of the ecosystems in which people live and to view human life as part of a constantly evolving biosphere (Wilson 1995). Holistic consideration of health also recognises that the concept of health varies among cultures (e.g. Galvin 1992; Adelson 1998) while within them, there are variations in health priorities among people are common (e.g. Just and Murray 1996) and that these must be recognised (Forget 1992). In spite of the scientific advances, the levels of health care provision taken for granted in industrialised nations are not accessible to many people because of the lack of health clinics and the high costs for treatment. Consequently, many local people in developing countries are looking for cost-effective alternatives to solving a wide range of health issues (Forget 1992).

Links between agro-ecosystems and human health

Human health is directly linked to and dependent on the state of health of the ecosystems that support them (Ewert and Kessler 1996). Because people are an integral component of agro-ecosystems, a range of socio-economic and biophysical factors affect their health. A few examples illustrate this point. Particularly in subsistence agricultural systems, nutrition is a primary factor. Without food security, human health inevitably suffers.

Although, increased food production in terms of quantity has largely kept pace with the demands of a growing population, the quality of food available may be declining (Howard 1956) and maintaining the high rate of production may be difficult (Borlaug 1995). Food shortages affect about 800 million people, but more than two billion people suffer from malnutrition (IFPRI 1996). Although in some cases, nutrient deficiencies are simply characteristic of otherwise stable agro-ecosystems, land degradation aggravates the harmful effects that some factors in agro-ecosystems have on human nutrition. For example, iron deficiency alone affects 40 to 50% of women worldwide (IFPRI 1996). Two hundred and fifty million children suffer from severe or moderate Vitamin A deficiency with up to 500 thousand pre-schoolers becoming blind annually (IFPRI 1996). Other widespread deficiencies include zinc and iodine. There is growing evidence that even in developed countries, deficiencies in fibre, folic acid etc threaten human health.

Apart from nutrition, naturally occurring heavy metals, vector-borne and non vector-borne diseases, naturally occurring toxins, agricultural chemicals, and imports and exports associated with a cash economy contribute to the health risks faced by people within the context of their agro-ecosystem.

In recent years, mercury contamination of fish in the Amazon basin and the consequent rise in symptoms of toxicity in people who depend on fish has focused attention on the perceived negative impact of gold mining. However, new evidence (Lebel et al 1997) suggests that gold mining is not the only source of this heavy metal. Rather, forest clearance followed by cultivation resulted in the leaching of mercury from exposed soil into adjacent aquatic ecosystems where it entered the food chain. The introduction of agriculture initiated a process of soil degradation that directly threatened human health. With this knowledge, local people are in a position to modify their diets by shifting from the consumption of carnivorous to herbivorous fish, to establish vegetative buffer zones between the exposed soils and the rivers, and to consider other community efforts to better manage vegetative cover of their croplands. In short, the solution to this health problem lies in better management of the aquatic and terrestrial agro-ecosystems. Participation of local people is essential.

Adoption of new or innovative agricultural technologies and policies often leads to unexpected or counter intuitive impacts. Understanding and responding to these often requires an agro-ecosystems perspective. For example, the introduction of irrigated rice production into the savannah-humid forest transition zone of West Africa raised the prospect of increased malaria (Teuscher 1998). Although people living near irrigated fields had greater malaria risk in the dry season than those in non-irrigated areas, it was lower in the rainy season. Averaged over a yearly basis, irrigation had little impact on malaria risk. Apparently, 'lower anopheline densities' in non-irrigated areas were offset by higher survival and increased probability of transmitting the disease from infected to uninfected persons. However, not all irrigated agro-ecosystems escape from increased vector-borne diseases. In addition to malaria, irrigation affects health risks associated with other diseases such as Japanese encephalitis and schistosomiasis (Service 1998).

Migration and travel caused by the introduction of new technologies, migrant labour, the movement of people between densely populated urban centres and agricultural lands, and changing settlement patterns can enhance the likelihood of carrying new diseases into agro-ecosystems (Wilson 1995).

Transformation from a subsistence to a cash economy can generate a number of health consequences. Having cash enables people to purchase higher quality food, education, and health care if they are available. However cash generation does not automatically result in improved human health if the funds are used to satisfy competing demands. For example, in one isolated case in Uganda (Heifer International, personal communication), highland farmers used milk from their local cows to enhance the nutritional standard of their family's diet. After receiving improved hybrid cows, milk production jumped from about 4 to 16 litres per day. This larger amount encouraged farmers to sell the milk rather than consume it. The cash generated was used to purchase maize meal, beer and other goods that did not contribute directly to an improved nutritional regime. The effect of cash generation on human health may depend on who in the household decides how it will be spent.

The move to cash economies can result in externalised health risks. For example, chemical fertilisers, pesticides, herbicides, and fungicides applied to food crops can be leached into the ground water supplies contaminating downstream and underground water. Apart from government regulation and enforcement, there is little incentive for farmers to actively concern themselves about health impact resulting from the use of such chemicals. Even if concerned, they are more likely than not to be ignorant of the problem. Having sold their harvest, many cash croppers in turn use the proceeds from the sale of their crops to purchase food for their families. Unknowingly, they are in danger of purchasing contaminated food. In Africa, the high incidence of aflatoxin contamination of grain and ground nuts is in part a consequence of the cost and inability of farmers to pay the cost of properly drying them. They see little point in spending money to dry grain only to have it weigh less thereby reducing the cash they receive from the sale of it.

Land degradation can adversely affect human health by changing the ecology of pathogenic and harmful organisms. One consequence of soil degradation is reduced water holding capacity and greater likelihood of drought stressed crops. Peanuts subjected to drought develop high concentrations of pre-harvest aflatoxin (Sanders et al 1993). Aflatoxin is believed by many to cause acute liver damage and cancer (Adams 1996). Although this connection has not been conclusively demonstrated in humans (Park 1993), the fear of its carcinogenic effect motivates a number of governments to regulate trade in potentially contaminated food crops.

Not only do the condition and management of agro-ecosystems affect the health of people that depend on it for sustenance, human health also directly influences the ability of people to manage the system itself. For example, Acquired Immunodeficiency Syndrome (AIDS) caused by the Human Immunodeficiency Virus (HIV) causes major labour shortages and the diversion of family income to cover increased health care costs (Haslwimmer 1994). Thereby, they contribute significantly to a decline in soil fertility, an increase in agricultural pests and diseases, changes and delays in cropping practices, a decline in the variety of crops grown, and a decline in the people's access and ability to purchase external farm inputs. HIV/AIDS apparently discourages farmers from making long-term investments in soil conservation measures that do not provide immediate income and that carry a significant labour cost. For pastoralists, a reduction in herd size and a shift towards less labour demanding animals such as pigs and poultry are common. The sale of animals may be required to cover increased health care costs. HIV/AIDS also contributed to a 20% to 50% loss of working time for extension services in Uganda and a loss of agricultural skills at both professional and farm levels. Beyond HIV/AIDS, other aspects of poor health make effective management of agro-ecosystems more difficult.

Ironically, endemic health risks may limit human population densities thereby preventing human induced land degradation. For example, Nega and Gebre (date unknown) suggest that reduced malarial risk in the higher elevations of Ethiopia enabled population growth and the consequent over-cultivation, deforestation, and soil erosion.

Elements of an approach to research on improving human health through ecosystem management

The basic working hypothesis is that better management of agro-ecosystems is a cost-effective strategy for improving human health. This implies that agriculture must be viewed as ecosystem management and that the principles of natural resources management are applied to it. To test this hypothesis and to ultimately contribute to the well-being of the rural poor in developing countries, a number of issues must be considered.

Participation by all stakeholders

Local people are not mere objects of scientific study. As participants, they play research roles as both the observer and observed. In development, they become the managers and the managed. Successful ecosystems research depends on full and relevant participation by all stakeholders in the characterisation of ecosystems and prevailing health status, the setting of research priorities, the selection of potential interventions, the conduct of data collection, and the analyses and interpretation of results (Forget 1992; Forget 1997). Similarly, full participation is required in community action plans arising from the research and their implementation. Although the need for participation is often recognised by individuals having an agricultural or medical background, there is strong evidence to suggest that researchers require formal training in the methods of community involvement, participatory methods and policy development (IUCN 1997) in order to succeed in this endeavour. Although recent trends call for more bottom-up than top-down participation there is some suggestion that 'inside-out' rather than 'outside-in' participation is most important (Roe 1996).

Legitimacy

Full participation in ecosystem projects depends upon the legal, financial and political legitimacy of all stakeholders (MacKenzie 1996). Political pressure may be necessary when some key ministries or agencies are reluctant to act or when local people are not given the opportunity to effectively participate.

Empowerment through knowledge

Understanding the complexity of agro-ecosystem structure and function is knowledge intensive, but essential for all stakeholders. Involving local people in the identification of their health priorities and linking these to agricultural and other activities is essential. Achieving a holistic understanding of the varying perceptions of agro-ecosystems and health is critical in enabling the selection, testing, and evaluation of an efficient set of technical, policy and behavioural interventions that can bring about improved human health. Because each agro-ecosystem is unique, knowledge will be the key to the dissemination of an appropriate approach to its management.

Gender and equity

Including gender considerations in research protocols is not merely a question of equity but of good science. There has been much scholarly research on the differential way that the environment affects the health, social and economic lives of men and women. In brief, they simply occupy different life spaces (Kettel 1996) or niches in the agro-ecosystem so that they face different health risks and differ in their shares of the costs and benefits that arise from the agro-ecosystem and management and the introduction of new technologies and policies. The differing characteristics of women's and men's reproductive, productive and social roles may be responsible (Just and Murray 1996). For example, in much of sub-Saharan Africa, women are the primary givers of health care and at the same time are largely responsible for farming and maintaining the households. Additional demands on their time through either increased illness of themselves and family members or from additional requirements for farm labour often cannot be met. When men control the family cash, women may be denied of the opportunity to hire labour to assist them in their work. Collection and analyses of gender dis-aggregated data must be a priority if research results are to benefit the well-being of both sexes. Research must also recognise the relevance of other key categories in social structure such as age and ethnic composition.

Interdisciplinarity

The challenges posed by global environmental and demographic changes and new and reemerging diseases require research and analyses of the ecosystem as an integrated whole and not merely as a sum of the parts studied separately. In contrast to traditional efforts of drawing conclusions from simultaneous but independent component research, an ecosystems approach demands language, paradigms and models that enable researchers at the outset to understand the complex nature of systems that cannot come from separate studies of the components. Experience suggests that researchers must not underestimate the effort required to build an effective unified interdisciplinary team (MacKenzie 1996).

Because, local people's health and well-being are dependent on a myriad of processes operating on and within agro-ecosystems, they are the natural focal point for interdisciplinarity. They will likely demand that simple solutions arise from understanding complex systems (Roe 1996). Although local people are the reservoirs of much valuable local knowledge, there is no guarantee that their understanding is correct, complete or relevant. For example, education is often needed, and outside expertise is essential to assist local people to understand the intricacies of soil fertility and the ecology of agricultural pest and human disease vectors. When human populations are subject to rapid change in their ecosystems or the populations themselves move to a new environment, the knowledge that they once had may no longer be helpful in managing agricultural and health care.

Hypothesis testing and assessment

A rigorous methodology in experimental design forms the foundation of much research particularly in the specialised single discipline of agricultural and health sciences. However, each agro-ecosystem is unique in terms of its structure, function, human society, management, and its exposure to inputs and outputs. Methods for testing interdisciplinary, multi-scale, and multi-cultural hypothesis have not been formally developed. Ecosystem research directed to the understanding of the complex set of biophysical and socio-economic interactions within agro-ecosystems is expensive, and replication may be difficult. To overcome these difficulties given limited budgets, IDRC encourages two approaches. One is the integration of human health into ongoing and proposed ecosystem research. Because these large studies often lack effective participation and community-based control over development, IDRC also encourages a local assessment process that requires community participation in the research-development process to enhance the health of agro-ecosystems and the human well-being (IUCN 1997). This assessment process that allows for all stakeholders to enter into a reiterative cycle of diagnosis, action, monitoring, evaluation, and reflection brings the research process to a practical community level.

Defining and characterising agro-ecosystems and human health

Ecosystems are complex. Their boundaries and scale are arbitrary and there is no particular definition that is likely to satisfy all stakeholders (Roe 1996). They contain all the atmospheric and geological characteristic along with the living components that include microbes, flora, fauna and people. These diverse elements are linked together through a variety of biophysical and socio-economic processes. A multi-stakeholder approach requires that all participants reach a common operational definition of the ecosystem that they intend to manage. Some workers stress the need for models that capture the essential interactions among component parts of ecosystems. Commonly used approaches include simulation, decision support systems, and geographic information systems. Even if useful for some purposes, these are often computer-based technologies to which local people have no access. To overcome this, a variety of community-based assessment methods exist that enable local people to understand the holistic nature of their agro-ecosystems (e.g. IUCN 1997).

Ethical issues

The health, social and agricultural sciences separately recognise a number of ethical standards that they endeavour to follow. By integrating these disciplines each may face ethical issue not normally considered. Issues related to informed consent, compensation for losses resulting from the testing of interventions, and the ownership and sharing of data and access to them must be considered. In a multi-stakeholder environment, some parties will have conflicting codes of ethical standards while others may have none at all. In cross-cultural settings, unexpected differences in ethical standards may exist. A clear set of standards acceptable to all is needed.

Project management model

International development has been characterised by a project management model that typically starts with an expert's concept paper that results in an agreement by recipients (usually developing country governments) and donors to 'do' a project for a target population. Such 'a vertical problem-solving method ignores the developing country context ... making the intervention irrelevant to the circumstances at hand' (Forget 1992). Subsequent steps typically include the development of a 'request for proposal' (RFP), selection of an executing agency based on responses to the RFP, project inception, a project operational phase, mid-term evaluation, project completion and a final report. Funding usually covers a period not exceeding five years although follow up phases are common. With the project's objectives fixed prior to starting work, there is usually little opportunity or inclination to effectively characterise the ecosystem components and the links that connect them. The target population often has little or no role in setting project objectives, implementing the research, and evaluating the results. This project model limits the ability of stakeholders to adopt the ecosystem approach by constraining activities to the number, range and quality specified in the terms of reference, by limiting the learning opportunities for many stakeholders, by encouraging projects of limited duration, and by restricting the responsibility and role of the intended beneficiaries. To overcome these constraints, a new model for project development will be needed. It must provide for consultative process that is time consuming and often requires the expenditure of funds to bring people together to describe their agro-ecosystems and the health of the people within them and to formulate their research and development priorities. It must also recognise that these priorities are not static and will change over time. Thus, a new project model must enable the appropriation of funds before specific project objectives and deliverables have been defined and agreed upon.

Research strategy

Interdisciplinary ecosystem level research is expensive, and financial resources are scarce. A pragmatic two-pronged strategy is recommended. One encourages the inclusion of human health research in ongoing or planned ecosystem level studies. Conceptually, the addition of health research is only a small but an important step forward in achieving a more holistic view. The second approach recognises that effective local participation may be overwhelmed by large complex multi-stakeholder projects. Therefore, more modest agro-ecosystem research at the community level may be appropriate. This will lead to community based natural resources management intended to identify, understand and test interventions that can result in improved human health at a local level.

Principles of integrated pest management applied to people

Taking an ecosystem approach to the improvement of human health shares much in common with the principles of integrated pest management (IPM). It is an interdisciplinary, knowledge-intensive, community-based management approach that encourages natural maintenance of human health by anticipating illnesses and preventing them from jeopardising the well-being of the people (adapted from van Veen et al 1996). The experience gained in IPM by the agricultural community has much to offer to the health sciences. The facts that agro-ecosystems are major determinants of human health and that health sciences are needed to fulfill the ultimate goal of agriculture strengthens the case for cross-sectoral collaboration. In all countries, the needs for alternative cost-effective improvements in human health are great. Food importing communities and nations will also benefit if this research results in less contamination of imported food products.

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Towards an understanding of associative society: Characteristics, potentials, constraints[1]

1. This was originally prepared as a concept paper for the workshop on ‘The Role of Indigenous Associations in Development’ organised by the Ethiopian Society of Sociologists, Social Workers and Anthropologists, in Adddis Ababa, 25–26 June, 1998.

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Abstract

The paper emphasises the need for giving attention to indigenous community-based organisations within the framework of participatory research approaches. Then enumerates a number of strengths and weaknesses and a number of issues that need to be investigated in relation to such organisations.

Introduction

With the growing recognition that development can only succeed with participation of local communities, non-governmental organisations (NGOs) and other agencies have sought partnerships with indigenous associations, sometimes referred to as community-based organisations (CBOs). The rationale for such collaboration is based on the premise that external agents of change should work with local institutions, indigenous associations and community based organisations rather than creating new or parallel structures which depend on external inputs. It is believed that such collaboration can ensure that local needs are prioritised and the beneficiaries are involved from the onset in the planning, decision-making, implementation, and evaluation of projects. Most importantly, such collaboration is believed to enable local communities to take over projects and run them once external agencies leave thereby ensuring sustainability and long-term benefits.

However, CBO–NGO collaboration poses its own problems and success cases are rare. In some cases such organisations are said not to exist or are considered 'invisible, unable or unwilling to become partners in development.' Part of the problem may result from an inadequate understanding of the differing characteristics of various types of CBOs. There is therefore a need for a better understanding of the range of CBOs in a given locality, region and the country as a whole. This requires assessing their purpose, strengths and weaknesses, autonomy, involvement in development, and the record of CBO–NGO collaboration. This may take the form of bringing together academics, NGO practitioners, and representatives of CBOs and relevant government agencies to discuss the following four inter-related issues:

- analysing the differing profile of indigenous associations
- reviewing spontaneous attempts by associations at self-initiated development
- assessing the record of NGO–CBO collaboration
- designing strategies to promote the role of indigenous associations in development.

This concept paper seeks to provide some initial insight into key issues which such a consultation could address. The paper discusses different issues in terms of major debates as well as suggesting specific questions that could be answered. It should be stressed that these suggestions are not guidelines; they do not represent an exhaustive list of relevant topics, nor are all contributors expected to address all the points raised; they are merely meant as pointers to stimulate discussion.

Understanding indigenous associations

The term indigenous association is used in preference to CBOs or local institutions for several reasons:

- the term CBO raises the problematic question of what constitutes a community. This is situationally specific and all 'communities' are heterogeneous, comprising different interest groups, factions etc. The term organisation also seems less specific than the notion of association, which refers to people joining to promote common aims.
- the phrase local institution raises the question what is 'local'. For instance would migrant associations be excluded? Also institution is a more complex and diffuse term than association, since it comprises notions of norms, values etc, rather than primarily people getting together as a group on their own initiative for specific purposes.
- the term indigenous suggests that such associations are locally initiated groups rather than set up by external agents or authorities.

In the Ethiopian context there are a range of indigenous associations such as iddir (burial associations), iqub (credit associations), mehaber (social/religious associations), debo, wenfel etc (agricultural labour groups), migrant associations, and various resource management associations. The names may vary in different regions but many of these are present all over the country.

Strengths and weaknesses of CBOs

There is a debate about the strengths and weaknesses of CBOs. What for some and in certain situations appears as a strength may be interpreted by others or in different circumstances as a weakness. For each strength one can anticipate a weakness (see Table below). However, differences exist between indigenous organisations, and significant differences exist within the same type in different contexts.

Table 1. *Some strengths and weaknesses of community-based organisations.*

Strengths	Weaknesses
Spontaneous formation	Short-lived; liable to dissolve
Voluntary membership	Exclusive membership
Voluntary contributions	Social compulsion
Self-reliance and autonomy	Weak and isolated
Membership control	Leadership control

Mutual benefit of members	Benefits limited to group
Sharing of risks, costs benefits	Disadvantages poorest
Group cohesion	Excludes others
Trusted and respected	Limited to the group
Social security and insurance	Assistance limited
Information and flexible	Hidden and invisible
Accountable leadership	Weak control of leaders
Democratic structure	Represent hierarchies
Efficient pooling of resources	Wasteful consumption
Promote democratic behaviour	Influence and role limited
Role in resource management	Limited influence and authority
Role in resolving conflicts	Lack of enforcement mechanisms
Local counterbalance to state authority	Limited scope to act; no higher groupings
Promotes participatory development	Limited to small isolated groups
Promotes sustainability of projects	Weak ability to manage projects

Sources: Braton (1988); Blunt and Warren (1996); Uphoff (1996); Pratten (1997); SPADE (1997).

Indigenous associations vary in many ways. Understanding this organisations begins with an appreciation of their purposes and how individuals and groups use them in different contexts. The following fifteen issues deserve discussion: (1) origins and diffusion, (2) functions, roles and mandates, (3) membership and representatives, (4) leadership and decision-making, (5) management and accountability, (6) durability and sustainability, (7) capacity for self-transformation, (8) relations with the state, (9) role in building civil society, (10) role in poverty alleviation, (11) role in disaster management, (12) role in resource management, (13) role in investing capital, (14) role in pooling labour, (15) self-view and identity.

1 Origins and diffusion

There is a debate about origins of such associations, notably burial and credit associations. Some suggest that they relate to urbanisation, or monetisation of the economy (e.g. credit associations), others claim that they began during or after the Italian occupation (burial) and are linked with certain groups (e.g. the iqub with the Gurage). Some suggest that they were built on cultural needs (burial, religious associations) but became more formalised (with monetary contributions and election of officers more recently). We therefore need to ask for each of the different types of associations:

- are they a relatively recent phenomenon and if so how recent?
- when, how, where and by whom were they initiated, and how did they spread?
- what was the role of individual leaders and entrepreneurs in their formation?
- were they rural spreading to urban or vice-versa?

- when, how and to what extent did they become formalised?

2 Functions, mandates and roles

There is a debate about whether such institutions are mono-functional (e.g. that iddir are purely burial associations, iqub are merely credit associations, mehaber are religious associations) or whether they are multi-functional (including social gathering, mutual support, insurance, economic self-help etc). To understand the characteristics of indigenous associations we need to know what purposes the different associations serve, what roles they play in social and economic life and the range of their activities.

- what various purposes do different indigenous associations serve?
- what range of activities and issues are they involved in?
- what are they best at doing and in what are they unable to become involved?
- is there an overlap between different types or is their functional specialisation?
- how do they contribute to the economic and social life of the society?

3 Membership and representativeness

There is a debate about how inclusive and representative indigenous associations are, and to what extent the membership criteria are exclusive, preventing certain groups from participating. We need to know the relative size of the different types of associations within and between areas, what the composition of their membership is in terms of age, gender, wealth, education, social groupings. What are the criteria for eligibility, who is excluded and can people be expelled and if so for what reasons.

- what are the numbers and sizes of different types of associations within an area?
- what are the minimum and maximum sizes of groups?
- what are the formal and informal criteria for membership?
- what is the composition of the membership (age, gender, education, wealth etc)?
- who is excluded on what grounds and can people be expelled (if so for what reasons)?

4 Leadership and decision-making

There is a debate as to whether indigenous associations are democratic, making decisions on the basis of concensus, or are reflections of existing power structures and hierarchies, excluding certain groups (women, the young, craft minorities etc). We need to know how the leadership is formed and whom it represents, how decisions are made, by whom and how dissent or opposition is dealt with.

- what leadership positions exist, how are leaders chosen, by whom and for how long?
- what are the characteristics of the leadership and whom do they represent?
- how often does the association meet, and how are people notified?
- how are decisions made, by whom, where and how often?
- how are differing views and dissent accommodated or rejected?

5 Management and accountability

There is a debate about the extent of managerial capacity of CBOs and the extent to which they are accountable to their members. We need to know more about their management structure, capacities, experience, working procedures. It is also important to understand the different forms and mechanisms of accountability. We should know what happens in cases of problems, disagreements, disputes and abuses.

- how are property and resources managed by indigenous associations?
- what are the rules, mechanisms and procedures for managing property?
- how accountable is the leadership to the members?
- what sanctions exist against abuses, and what mechanisms for changing the leadership?
- how are funds managed and is there an accounting system?

6 Durability and sustainability

There is a debate about whether indigenous organisations are durable and stable and ongoing or whether they are temporary, unstable and liable to disintegrate. The answer depends to some extent on the kind of association. We need to know more about the time span of different associations, their capacity for renewal and continuity and the dangers of disintegration.

- how long do different types of associations last?
- to what extent is the membership stable or changing?
- what are the theoretical and practical minimum and maximum sizes?
- what are the threats to the stability and continuity of different associations?
- what conditions render different associations unsustainable?

7 Capacity for self-transformation

There is a debate as to whether indigenous associations are flexible and responsive to new needs of their members or whether they are conservative and limited to the initial purposes for which they were set up and are therefore unable to become involved in other issues. We need to know more about examples of indigenous associations that have transformed themselves to work spontaneously for development and the constraints and barriers that prevent so many others from doing so.

- what examples do we have of self-transformation of indigenous organisations?
- what factors explain these changes and how did they take place?
- what was the role of leadership, labour, capital in this transformation?
- what was the role of culture and social values in this transformation?
- what was the role of outside interventions, roads, markets etc in this change?

8 Relations with the state

There is a debate about whether indigenous associations can complement the role of the state at the micro level or are viewed as acting in contrast to or even in opposition to the state. We need to consider whether there can be a division of labour in which CBOs are allowed to work at the micro level, and if so in what areas they can or should be involved, and in which areas they are unable or should not participate.

- to what extent is the state willing to tolerate independent indigenous associations?
- what benefits and problems are there for such associations becoming legally registered?
- what are the options for such associations to obtain credit and legal protection?
- what advantages and problems are there for associations to form higher groupings?
- what structures for support exist or can be created to enhance their developmental roles?

9 Role in building civil society

There is an international debate about whether there is a role for CBOs in the building of civil society and the development of a democratic culture of governance, or whether these are areas CBOs are not interested, competent, able or willing to become involved in. In Africa generally associations have flourished and played a vital role, whereas in Ethiopia they have tended to have been mistrusted, ignored or even discouraged.

- have CBOs played a role in the making of civil society in the past?
- do CBOs have an interest and ability to become involved in civil society issues?
- is there a societal acceptance of CBOs taking more initiative on such issues?
- do CBOs have legal rights and mandates to address civil society and governance issues?
- does involvement of CBOs in such issues threaten their ability to serve their members interests?

10 Role in poverty alleviation

There is a debate as to whether indigenous associations benefit the poorest by providing a social security alternative where none exists or whether they benefit mainly the leadership and exclude the poorest, who are unable to cover the costs. External inputs may even lead to increases in membership fees, further marginalising the poorest. We need to know who is included and excluded and whether outside interventions result in positive and/or negative changes in membership and activities of the association.

- to what extent do indigenous associations provide social security to the poorest?
- do membership fees restrict membership and result in elite associations excluding the poor?
- does paying for membership jeopardise or enhance the livelihood of the poor?
- do external inputs or 'capital injection' increase membership fees and marginalise the poor?
- can indigenous institutions provide value for money in alleviating poverty?

11 Role in disaster management

There is a debate as to whether indigenous associations can be vehicles for disaster preparedness and prevention or whether this is an area that should be left to state structures. In many African countries indigenous associations play an important part in local responses to famine, epidemics, conflict etc. We need to consider whether there is a potential for associations to play a role in anticipating disasters, in preparing local communities and managing grain banks, employment generation schemes, credit schemes.

- do indigenous associations respond to disasters or do they collapse under stress?
- do local associations use indigenous knowledge in disaster management at the local level?
- can and should such a role be strengthened or established or is this best left to state structures?
- can associations manage grain banks, employment generation schemes, and credit schemes?
- is it practical to work through or strengthen the capacity of associations to manage disasters?

12 Role in resource management

There is a debate as to whether indigenous associations can play a role in management, sustainable exploitation, protection and regeneration of local resources or whether they are not capable or are not appropriate bodies to work in this area. As local associations they can represent group interests for environmental preservation, but whether they have the capacities to do so requires substantiation and an assessment of the abilities to reach concensus and enforce decisions.

- to what extent have indigenous associations played a role in environmental protection?
- what is the potential for indigenous associations to manage resource use and protection?
- do such associations have the ability to reach concensus, make decisions and enforce them?
- what are the constraints of indigenous associations managing their resources?
- can indigenous associations resist external or internal threats to local resource abuse?

13 Role in investing capital

There is a debate about whether certain indigenous associations can play a role in collecting and reinvesting capital into development initiatives. Migrant associations for instance can collect revenue to invest in roads, mills, schools, clinics etc. We need to inquire how effective indigenous associations are in generating capital for development and what the constraints and potentials for stimulating such a role are.

- how effective are indigenous associations at pooling capital for development purposes?
- what are the potentials for indigenous associations raising and managing funds?
- what are the constraints on indigenous associations raising and managing funds?
- how are contributions suggested, rated, collected, extracted from different actors?
- how are priorities for the use of funds decided, by whom and how are proposals executed?

14 Role in pooling labour

There is a debate as to whether indigenous associations can mobilise labour for developmental purposes, e.g. forestry and conservation projects, building roads, dams, clinics, schools, helping the poor to plough land etc. We need to consider whether such projects are best managed at the micro hamlet, village or catchment level or whether they should be left to larger, more inclusive state structures.

- how effective are indigenous associations in mobilising labour for developmental purposes?
- what are the constraints and limitations of associations mobilising labour for development?
- how are decisions on labour allocation reached and what is the labour pooling mechanisms?
- how is labour pooled in terms of households, gender, age and wealth?
- how is labour pooling for development accepted or resisted by group members?

15 Self-view and identity

There is a debate about how indigenous associations view themselves and their roles. We need to consider whether they see themselves as having limited and specific roles with little direct involvement in development issues or whether some view themselves as concerned partly or even primarily with developmental objectives.

- do indigenous associations view their role as limited and outside of development issues?
- what types of associations and what cases do we find becoming involved in development?
- who defines the associations objectives, purposes and missions?
- how are changes in the roles of associations explained, justified and rationalised?
- what can be learnt from self-sponsored spontaneous initiatives of involvement in development?

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Section two

Agro-ecosystems, natural resources management and human health related research in East Africa: Case studies

Agro-ecosystem health: Principles and methods used in high-potential tropical agro-ecosystem

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Abstract

The paper briefly describes the application of agro-ecosystem health framework for characterisation of an agro-ecosystem in central Kenya, and identification of the indications of its health. The lessons learnt from the application are briefly discussed.

Introduction

Given the newness of the agro-ecosystem health (AESH) field, the major accomplishments to date are conceptual and methodological. The empirical information that exists serves, for the most part, to demonstrate the applicability of the concept rather than supply a comprehensive numerical estimate of the health status (Smit et al 1998) of a given ecosystem. The University of Nairobi and the University of Guelph are carrying out a research programme (funded by International Development Research Centre, IDRC) whose objective is an integrated assessment of a tropical highland agro-ecosystem using the agro-ecosystem health framework.

This approach acknowledges that an agro-ecosystem can be defined from many different perspectives, giving rise to multiple—conflicting or complementing—descriptions of them. Considering all these perspectives is the only means to elucidating the structural-functional characteristics of the agro-ecosystem. Stakeholders must therefore be included in both the definition of the system and in its description. For the system to be sustainable, the stakeholders must be part of the search for solutions. Their involvement in problem identification, analysis, planning and implementation becomes a key component of the process. Indeed, they must own—and feel that they own—the problems, the solutions and the means of solving them.

To incorporate these concerns, this project is using participatory techniques, soft system methodologies and conventional research methods in an integrated, iterative and trans-disciplinary process that both evaluates and attempts to improve the health of agro-ecosystems.

The process involves: (1) characterisation of the agro-ecosystems, (2) development of health indicators, (3) empirical assessment of indicators (monitoring and evaluation), and (4) taking remedial action where pathologies are detected.

This paper describes the methods used in the characterisation of the agro-ecosystem and selection of indicators. The lessons learnt from the application of these techniques are briefly discussed.

Study methods

Study area

The study is being carried out in Kiambu District, Kenya. The district is divided into several hierarchical administrative zones (Figure 1). The three lowest levels of the agricultural hierarchy (the village, farm and field) are being targeted. Six villages were selected through a multi-stage but purposive sampling strategy. The key factors influencing selection of a village were preponderance of farmers and presence of other research and development agencies. Data on villages (names of villages, their boundaries, farming activities, development activities) was supplied by opinion-leaders from the locations.

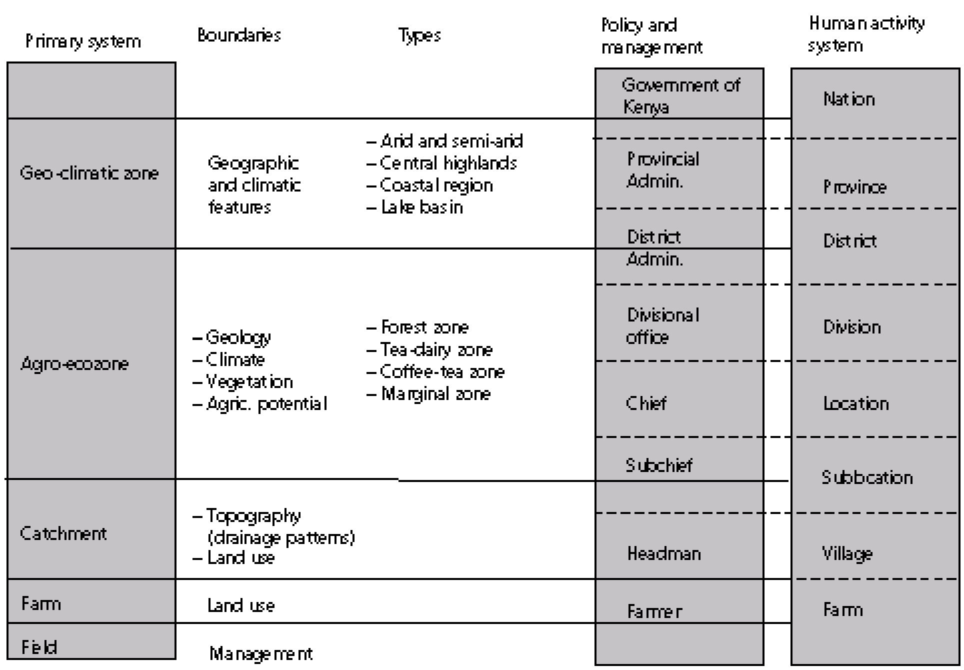

Figure 1. *Hierarchy in agro-ecosystems: The central highlands of Kenya.*

Participatory approaches

A five- to eight-day participatory action research (PAR) workshop was held in each of the six villages. Community members were informed about the workshop through opinion leaders, churches, administration officials (Chiefs and Assistant Chiefs) and posters. The workshops were held in venues within the village. Workshops commenced with an explanation of purpose and seeking community acceptance of the exercise. Communities were allowed to set their own time-schedules and to prepare budgets for refreshments, foods and other expendables required during the exercise even though the funds were provided by the AESH project. This served as a trend-setting mechanism for participation. Table 1 shows the key PAR techniques, the expected outputs and the order in which they were used.

Soft systems methodology

Soft systems methodology (SSM) is an approach to studying human activity systems developed by management specialists (Checkland and Scholes 1990). The methodology includes rich descriptions of problematic situations and the creation of various systems models, as well as an exploration of the social and cultural context for the systems being considered.

Cultural and social settings within the various human activity sub-systems in the village were studied. Relationships between various interest groups and stakeholders in the village were assessed through discussions with people involved and depicted in rich pictures. A similar approach was used to analyse the meaning ascribed to various social, cultural and economic issues in the village. Roles, norms and values ascribed to various stakeholders in the village were examined. Note was taken as to what embodies opinion leadership in the village and how leadership positions are obtained, used and protected. Root definitions, which are used in SSM to describe the actors and beneficiaries, the world-views on which their models are based, and the environmental constraints of the systems, were used to model both the primary-task and the issue based sub-systems in village agro-ecosystems.

Observational study methods

Semi-structured interviews were conducted during the transect walks of the PAR workshops. Communities were asked to stratify farms and/or households in the village based on criteria developed in a participatory manner. Households to be interviewed were selected from each stratum based on a random process but taking into consideration the availability of household members for the interview. A team of three people visited each of the selected households: a researcher, an extension agent, and one community member. The household head was requested to give a guided tour of the farm/dwelling. Farm sketches were made indicating types of enterprises and resource availability and utilisation. The interview was administered following a checklist (Table 2). Copies of farm records were made as well as a listing of time and work schedules.

Table 1. *PAR tools used in the study and the expected outputs.*

	Objectives	Tools	Expected output
1.	Introduction	Self introduction, pairing, speeches, ice-breakers	Acceptance/permission to carry out exercise
2.	Planning for the workshop	Time schedules, assigning roles and responsibilities	Workshop logistics, trend-setting for community participation
3.	Village boundaries and inventory of resources	Social map	Location of farms and households, names and sex of HH heads, boundaries

		Resource map	Inventory of resources, infrastructure, state of resources, identify problems
4.	Historical background	Historical profile	Community identity and history, past events and their impacts, coping strategies
5.	Trend-lines and time-lines	Trend charts	Lists changes, direction of change, triangulation of (4) above
6.	Seasonal trends	Seasonal calendars	Seasonal trends in climate, economic and social activities
7.	Transect walks	Route mapping	Identification of issues and problems
		Walk	Observation of type and status of resources, problem identification, triangulation
		Transect profile	Resource inventory
		Semi-structured interviews	Observation of type and status of resources, problem identification, triangulation
8.	Resource mobility	Mobility charts	Flow of goods, services and resources to and from village
9.	Identification and analysis of institutions	Venn (chapati) diagrams	Types, numbers and importance of institutions, problem identification
10.	Major gender concerns	Activity profile	Types and degree of drudgery of chores, persons responsible
		Daily calendar	Daily routines by age and gender
		Access and control matrix	Resource types, ownership, control and utilisation by age and gender
		Decision making matrix	Power and opinion leadership issues in the village and household
11.	Major health concerns	Health analysis	Types, causes and importance of major health concerns by age and gender
12.	Problem identification and analysis	Problem listing	Triangulation of needs
		Ranking (pairwise/matrix)	List of needs in order of priority
		Problem analysis	Opportunities and constraints, coping strategies, possible solutions
13.	Action planning	Community-action planning	Resources, schedules, strategies

In addition, a survey of all households in the village was conducted. The survey questionnaire was designed in the local language. Information on household structure, farm/household management, incomes, farm productivity and resource availability/ utilisation was sought. The village ecosystem committee members were trained to assist households in filling-in the forms to ensure a high response rate.

Selection of AES health indicators

Gitau (1997) provides a detailed description of biophysical, socio-cultural and economic characteristics of the Kiambu AES. From this a summary of goals, objectives, expectations, problems and issues of concern of stakeholders in the Kiambu AES was developed. Influence diagrams with linkages between various issues and problems as visualised by the communities were drawn. From these, a generalised list of attributes relating to issues, goals, objectives and expectations of the main stakeholders in the AES were derived. Variables that reflect changes in these attributes over the short- (fast changing = current to one year), medium- (between one and three years) and long-term (more than three years) were listed. Indicators were selected from these variables based on their validity, feasibility and who the operator and/or end-user would be. Variables selected as indicators were those having a high feasibility (practicality of measurement, cost/time effectiveness) and validity (how well it measures the attribute of concern). Some attributes are of interest to a variety of groups (researchers, farmers, community in general, policy makers etc). Indicators for these attributes were selected based on the ease of measurement and interpretation by the users.

Complex systems modeling

Methods of analysis and synthesis for data generated by AESH research are still being explored. Several complex-systems approaches—ranging from influence diagrams and loop models to various forms of catastrophe and chaos theory—seem to be promising. The loop models seem to be the most transparent in terms of understanding internal system dynamics. Figure 2 shows an interim conceptual model of the AES. Outputs are divided into amenities, by-products and value products. The external environment and the human activity system influence the type, quality and quantity of output through subsidy to the system (Izac and Swift 1994). The external environment and the human activity system influence the type, quality and quantity of output through subsidy to the system. With time, more detailed models will be used to study system behaviour in terms of various ecosystem health attributes (and hence indicators). System characteristics such as integrity, adaptability, efficiency, effectiveness, resilience, productivity, stability and equity will be varied in order to predict system behaviour under various conditions. Values taken by attributes under these conditions will be taken as reflecting system thresholds, targets and ranges.

Table 2. *Checklist for the semi-structured interview.*

1.	Introduction Introduction Personal Data Name of household head HH size Occupation	8.	Access and control Ownership of resources Decision making Utilisation of proceeds Activity profile
2.	Land use Settlement history Acreage Ownership/Tenure Access to control of land	9.	Water Sources Uses

	Apportionment of land		
3.	Crop production Types of crops Cropping seasons Crop rotation Soil conservation measures	10.	Institutions Types of institutions Relative importance Membership Activities and responsibilities Benefits derived Family ties, friends, neighbours
4.	Agroforestry Types of trees and their uses Trends in vegetation cover	11.	Human health Common diseases Health of the household members Trends in disease occurrence
5.	Livestock production Species of livestock and breeds Relative importance Pests and diseases of livestock	12.	Off-farm income generating activities Types Relative importance Schedule of activities
6.	Yields and outputs Types of farm produce Marketing of produce Trend and seasonality of prices	13.	Problems and coping strategies Soil fertility Pests and crop diseases Livestock diseases Markets and prices Costs and availability of inputs Water quality and availability Usefulness or lack of institutions

7.	Farm inputs Fertiliser Concentrates and supplements Fodder Seeds Labour Vet. services Availability of credit	

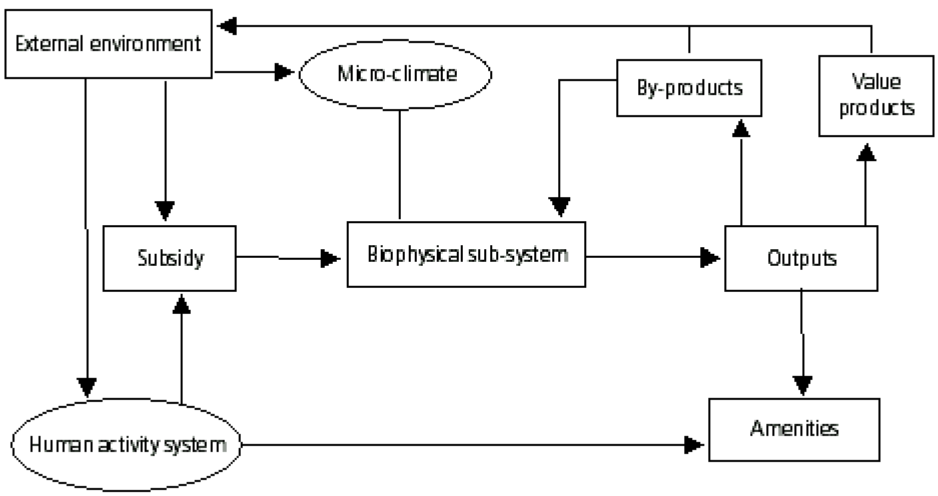

Figure 2. *A simplified conceptual model of the agro-ecosystem.*

Discussion

Agro-ecosystem health studies are currently underway in several other countries as well as Kenya. These have demonstrated that holistic approaches—such as agro-ecosystem health—are feasible even under difficult field conditions.

In some ways the current study is a revisiting of older notions of integrated community development, but with more explicit consideration of both systems theories and the socio-economic, political and ecological dimensions which are the determinants of agro-ecosystem health. It takes cognisance of the multiplicity of perspectives and interests. The SSM approach facilitates an understanding of conflicts, opinion leadership and the power structure within the human activity sub-systems. This provides a more structured system for dealing with equity and development issues than standard community development approaches.

The combination of participatory work and systems theories grounds the work both theoretically and practically, providing a framework through which health and sustainability can be promoted. It circumvents the basic problem with standard research and development programmes: the inability to arouse popular participation (Holdcroft 1984) while providing a means—to communities, researchers and policy makers—for monitoring and evaluating both the human activity and the underlying biophysical sub-systems.

The key constraints within the agro-ecosystem health approach are the difficulty in bridging the interdisciplinary gap and the potential resistance to the empowerment of disadvantaged (but not always the minority) groups within the multiplicity of stakeholders in the system. The approach is potentially disruptive to existing power-structures because of its all-inclusive, empowering-through-information approach. Moreover, methods for a more holistic interpretation of empirical data (both qualitative and quantitative) are yet to be developed. However, the incorporation of a plurality of approaches and ideas ensures that the learning cycle remains open.

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R&D experiences of IAR in NRM and crop–livestock interactions in the highlands of Ethiopia

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Abstract

The paper describes the research activities and achievements of the Ethiopian Institute of Agricultural Research in the areas of natural resources management, livestock feed improvement and cattle production improvement, for the highland farming systems.

Introduction

Agriculture is the dominant economic sector in the country, accounting for about 45% of the GDP and 85% of export earnings. The highlands of Ethiopia comprise 45% of the country, include 95% of the cropped area and two-thirds of the livestock. Approximately 88% of the population live in the area, at an average density of 64 persons per km^2 (CSO 1988). The highlands reach up to 4620 m asl in altitude which provides a wide range of environments suitable for the growth of tropical, sub-tropical and temperate crops. A wide range of farming and land use systems has thus developed over several millennia in response to this diversity.

The major environmental and developmental issues which are of concern to Ethiopia include drought, poverty and food insecurity, soil erosion, land degradation, deforestation and over-grazing.

Annual soil loss in Ethiopia is estimated at between 1.5 and 3 billion tonnes. Of this, 50% occurs in croplands where soil loss may be as high as 296 tonnes/ha per year on a steep slope (SCRP 1987). Because the Ethiopian highlands support a large livestock population, the area experiences severe deficit of animal feed. One estimate (Hurni 1988) forecasts that all pasture land will be fully utilised by 2005. The demands for crop and for grazing land are increasingly in competition.

Ethiopia has diversified topographic and climatic conditions. The human population are mainly concentrated in the highland and semi-arid zones (46% and 42%) while the cattle population distribution varies among the different agro-ecological zones. Livestock are an important component in the highland mixed farming systems. Next to the highland zone, semi-arid, subhumid and arid zones support 16, 16 and 14% of cattle population respectively (Table 1).

Table 1. *Human and cattle distribution in the major agricultural systems of Ethiopia.*

Agro-ecological zones	Human population (%)	Crop–livestock integration	Major agricultural systems	Cattle population (%)	Major livestock output
Arid	5	Pure livestock	Pastoral	14	Milk and meat

Semi-arid	42	Livestock–crop	Sorghum, millet, livestock	16	Milk, power, meat
Subhumid	5	Crop–livestock	Maize, sorghum, livestock	16	Meat, milk, power
Humid	2	Crop–livestock	Roots, forest, permanent crops	8	Peri-urban milk, manure, meat
Highland	46	Well integrated crop–livestock	Teff, wheat, livestock	46	Power, meat, milk, manure

Source: Modified from Jhanke (1982).

Research establishment and approach

As Ethiopia is dominantly an agricultural country, the well-being of its people and the country's economic development largely depend on the efficiency and strength of its agricultural system. Agricultural research in Ethiopia was institutionalised in 1966 when the Institute of Agricultural Research (IAR), now renamed Ethiopian Agricultural Research Organization (EARO), was established as a national institute with the following objectives:

- to identify farming system constraints
- to generate appropriate technologies to increase agricultural productivity across different agro-ecological regions
- to demonstrate technological packages.

IAR commenced its research undertakings at 5 major centres, which represent five agro-ecological regions of the country. The mandate programmes vary according to the ecology (Table 2). The beneficiaries of the research results are smallholder and commercial farmers.

Table 2. *Major research centres representing different mandated agro-ecological zones.*

Centre	Agro-ecological zone	Main research focus
Melka Werer	Arid lowland	Cotton, lowland oil crops, livestock and natural resources management
Nazareth	Semi-arid	Horticultural crops, lowland pulses and agricultural mechanisation
Bako	Subhumid mid-altitude	Crop, livestock and natural resources management
Jimma	Humid mid-altitude	Coffee, spices and crops
Holetta	Highland	Crop, natural resources management, livestock

During 1966–92 the IAR/EARO research was mainly focused on three major areas—crops, natural resources and livestock. The research was discipline oriented and agro-ecology focused. However, current research approach (since 1992) is mainly commodity oriented (multi-disciplinary). At present there are 26 commodities distributed to the federal and regional research centres.

Highland farming scenario

Current situation of highland resources and farming may be summarised as

- highly utilised, developed and over populated
- small farm size due to fragmentation
- reduced land productivity
- cultivation of steep slopes and over-grazing
- wide scale soil erosion and land degradation
- food deficit endemic
- destructive deforestation common.
- Livestock farming in the highland has the following characteristics
- the climate is favourable (temperate type) for human, livestock and crop
- high human and livestock population zone
- smallholder mixed farming is the dominant mode of production
- average farm size 1–5 ha
- average herd size 4–5 heads of animals
- cattle are sources of draft power, milk, meat and manure
- high fraction of the bovine biomass are oxen (30%)
- oxen are used for draft purpose 60–70 days per year
- draft power determine crop production
- cattle productivity is very low (draft, milk and meat)
- acute feed shortage and reduced grazing land.

Research achievements in the highlands

Natural resources management

Drainage improvement

Traditional farming has developed a wide range of drainage practices (drainage furrows, ridge and furrows, hand made broadbed and furrows, soil burning) and the use of low yielding crop varieties and late planting practices to avoid water logging period in Vertisols. It has been recognised that, with the exception of hand made broadbed and furrows, the technical efficiency of the traditionally applied surface drainage techniques is not sufficient to allow full use of the potentials of Vertisols (Mesfin Abebe 1982).

The use of improved drainage techniques such as the broadbed and furrow system (BBF) on these soils to remove the excess water in the main rainy season allows the possibility of re-using the drained water for irrigating the second crop after the harvest of the early planted first crop, thereby enhancing the utilisation of these potentially productive soils. Research results indicate that camberbeds of different widths for draining excess moisture and application of N and P fertilisers highly increase the yields of crops on Vertisols (Berhanu Debele 1985).

Fertiliser efficiency was highest with wheat with improved drainage (Table 3). Data in Table 4 demonstrate that both grain and straw yields were increased by planting under enhanced surface drainage conditions compared to flat planting. Grain yield increases of 33% and 100% were obtained over flat planting by using ridge and furrow, and broadbed and furrow methods of seed bed preparation, respectively.

Table 3. *Influence of drainage and fertiliser on grain yields of wheat, teff and chick-peas, Ginchi, 1975–77.*

	Grain Yield ($Kg\ ha^{-1}$)			
	Undrained		Drained	
Crop	F_o	F_1	F_o	F_1
Wheat	360	670	720	1530
Teff	740	1140	840	1470
Chick-pea	850	900	1220	1400

F_o :No fertiliser;
F_1 :60/20 (N/P) kg ha^{-1} for wheat and teff ; 27/30 (N/P) kg ha^{-1} for chick-pea. Source: Hiruy Belayneh (1986).

Table 4. *Effect of method of seedbed preparation on the grain yield of durum wheat at Debre Zeit, 1987.*

Method of seedbed preparation	Yield ($kg\ ha^{-1}$)		Increase over flat planting (%)	
	Grain	Straw	Grain	Straw
Flat	1528	3102	–	–
Ridge and furrow	2037*	3843*	33	24
Broadbed and furrow	3009*	8095**	100	161

* Significantly different from yield on flat seedbed at P = 0.05 level.
** Significantly different from yield on flat seedbed at P = 0.01 level.
Source: Tekalign Mamo et al (1993).

Nutrient management

Sustainable agricultural production can be achieved only by proper use of soil resources, which includes the maintenance for the enhancement of soil fertility. Attempts have been made to improve the productivity of Ethiopian Vertisols through N and P fertilisation. Spectacular response to N and P fertilisation have been obtained by many crops including durum wheat, teff, barley, bread wheat and faba bean, and in most cases application of as high as 90 kg N ha^{-1} resulted in maximum yield (Table 5). The high response to N is understandable because total N in most Vertisols is low. The efficiency of the N fertiliser applied could be improved through the use of nitrate forms of fertiliser and deep placement of split application of the ammonium fertiliser.

Table 5. *Grain yield (kg ha^{-1}) of crops at different levels of N fertiliser in Vertisol of Ethiopia.*

Location	Crop	Applied N (kg ha^{-1})				
		0	30	46	60	90
Ginchi	Noug	750	–	860	–	880
Ginchi	Linseed	800	–	960	–	970
Ginchi	Teff	720	–	730	–	1120
Ginchi	Wheat	1690	–	2320	–	3790
Holetta	Phalaris	3794	–	4216	–	3630
Holetta	Wheat	2900	3410	–	3540	4110
Holetta	Barley	3001	2960	–	3200	3480
Holetta	Faba bean	1360	1830	–	1790	2020
Sheno	Barley	1448	1716	–	2018	2164

– = not applied.

Source: Desta Beyene (1988).

Many crops have also obtained responses to P fertilisation. At Sheno, barley reached a peak yield of 2057 kg ha^{-1} with the application of 13 kg P ha^{-1} (Table 6). Significant P responses were obtained for teff and bread wheat at Ginchi.

Soil conservation

Runoff and soil loss studies were conducted under different soil covers at Holetta. The experiments were conducted on land with 6% slope in 1986 and 1987 using runoff plots. The different soil cover treatments showed significant differences ($P<0.01$) in the amount of both runoff and soil loss (Tables 7, 8).

In the grass-covered plots soil erosion was less than 1 t ha^{-1} per year and was least compared with other treatments. Bare-fallowed plots experienced the highest soil erosion, 28 t ha^{-1} per year, owing to the absence of any cover to protect the soil in the earlier part of the rainy season (Asrat Abebe 1992). Runoff also had similar effect to the cover crop treatments and was positively correlated with soil loss. Runoff was higher for bare-fallowed plots followed by wheat and teff-covered plots. Natural grass cover resulted in the lowest runoff as a result of the retarding effect of the dense grass growth throughout the season.

Table 6. *Grain yield (kg ha^{-1}) at different levels of P fertiliser in Vertisol of Ethiopia.*

Location	Crop	Applied P (kg ha^{-1})				
		0	13	20	26	40
		Grain yield (kg ha^{-1})				
Ginchi	Noug	670	–	900	–	920
Ginchi	Linseed	750	–	1010	–	960
Ginchi	Teff	380	–	970	–	1220
Ginchi	Bread wheat	1690	–	2590	–	2250
Holetta	Phalaris	3794	–	4610	–	4570
Holetta	Faba bean	2870	3410	–	3730	3960
Holetta	Barley	1500	1690	–	1910	1890
Holetta	Faba bean	2560	2900	–	3590	3560
Debrezeit	Chick-peas	1910	1470		2120	1930
Debrezeit	Lentils	513	513		472	576
Sheno	Barley	1748	2057	–	1856	1843

– = not applied.
Source: Desta Beyene (1988).

Table 7. *Effect of different soil covers on soil erosion (t ha^{-1}) at Holetta.*

Treatment	Year		Mean
	1986	1987	
Bare fallow soil	32.6	22.9	27.8[a*]
Wheat broadcast	28.1	12.3	19.2[b]
Teff broadcast	17.7	14.4	16.1[b]
Grass covered	0.9	0.3	0.7[c]
LSD (0.05)	9.6	5.9	5.8
CV (%)	18.0	23.9	20.4

Mean followed by the same letter in the column are not significantly different at $P<0.05$ using Duncan's multiple range test.
Source: Asrat Abebe (1992).

Watershed management

A watershed is made up of the natural resources in a basin, especially the water, soil and vegetative factors. In order to make the improved practices more widely applicable and ensure that the recommended packages are environmentally safe, research has been started at watershed scale in Ginchi to develop the result of the plot based research into recommended watershed planning, because water drained from individual field plots can cause widespread land degradation elsewhere. Such improved watershed-based drainage system will enhance cropping systems options and overall production in a more sustainable way. Watershed research involves systematic development of soil conservation and water control techniques that will be appropriate to the farmer endowments.

Table 8. *Effect of different soil covers on runoff (m^3 ha^{-1} per year) at Holetta.*

Treatment	Year		Mean
	1986	1987	
Bare fallow soil	785.6	612.0	698.8
Wheat broadcast	684.5	624.2	654.3
Teff broadcast	737.1	466.3	601.7
Grass covered	143.9	106.0	125.0
LSD (0.05)	9.5	107.4	67.9
CV(%)	0.8	11.9	7.3

Source: Asrat Abebe (1992).

It was evident from the work in the Ginchi watershed conducted under the Joint Vertisol Project with Ministry of Agriculture, ICRISAT, ILRI and Alemaya University of Agriculture that farmers were aware of the advantages and need for improved field drainage. Ginchi farmers appreciated the need for a communal drain which will solve the problem of waterlogging.

Extension of the BBF in the Gimbichu area showed that the mean grain yield of durum wheat ranged from 2900 to 4300 kg ha^{-1} for 50 farmers (Table 9). Results of bread wheat and teff demonstration at Ginchi watershed site indicated that the range in grain yield of wheat variety ET–13 was 1480–2560 kg ha^{-1}, whereas the grain yield of teff ranged from 1210–2200 kg ha^{-1}.

Table 9. *Wheat grain yields from Gimbichu BBF technology transferability study, 1995.*

Grain yield (kg ha^{-1}) range	No. of farmers	Mean yield (kg)
2500 – 3000	3	2900
3000 – 3500	10	3400
3500 – 3800	20	3700
3800 – 4600	17	4300

Livestock feed improvement

Crop residue utilisation

Crop residues represent a large amount of feed and are regularly conserved in the dry season as a sole feed for animals in the highlands of Ethiopia. About half of the animal feed in this zone comes from crop residues (straws, stubble and chaffs). Teff, wheat and barley straws are major residues used.

In addition to animal feed, crop residues are also used for other purposes like fuel, construction materials and mulching soils. According to Seyoum Bediye and Zinash Sileshi (1989), 63%, 7%, 20% and 10% of the cereal straws produced in the central Shoa zone are used for animal feed, bedding, fuel and house construction, respectively.

Crop residues in the Ethiopian highlands are usually fed to animals without supplementation. When offered as a sole diet, crop residues cannot fulfil even maintenance requirement of animals due to their low palatability, digestibility and intake (Table 10). They are also low in protein, energy and some important mineral nutrients (Seyoum Bediye and Zinash Sileshi 1989). Chemical composition, and energy values of the major crop residues used as animal feed in the highlands of Ethiopia are given in Table 11.

Table 10. *Energy and protein supply from an average quality straw when fed alone to ruminants.*

Animal	Liveweight (kg)	DM intake (% LW)	Nutrient supply		Maintenance requirement	
			Energy (mg/day)	Protein (kg/day)	Energy (mg/day)	Protein (kg/day)
Sheep	15	3.0	3.7	0.04	3.0	0.036
	25	2.6	5.4	0.34	4.3	0.053
	30	2.4	7.0	0.44	5.6	0.068
Cattle	250	1.8	37.5	0.237	30.9	0.337
	350	1.6	46.5	0.294	40.9	0.432
	450	1.5	56	0.355	49.5	0.528

Source: Seyoum Bediye and Zinash Sileshi (1989).

Table 11. *Chemical composition, digestibility and energy values of some crop residues.*

Residues	Chemical composition				
	CP	NDF	ADF	Lig	*In vitro* OMD (%)
Cereal straws	4.5	79.4	43.1	7.3	51.1
Pulse straw	7.0	62.9	47.1	10.4	63.1
Oil crops straw	5.4	66.3	56.2	10.9	–

Source: Seyoum Bediye and Zinash Sileshi (1989).

Table 12. *Teff straw intake, daily live weight gain and total DM intake of male Horro sheep as affected by different protein supplements.*

Protein sources	Straw intake (g/day)	Average LW gain (g/day)	Average total DM intake (g/day)
Leucaena	668.3[a]	80.0[a]	1010.3
Giliricidia	562.4[abc]	58.0c[d]	907.4
Siratro	592.5[abc]	67.0[ab]	993.5
Dolichos	576.3[abc]	46.0[bcde]	936.0
Vetch	538.0[abc]	40.0 [cde]	894.0
Desmodium	485.1[bc]	60.0[abc]	943.1
Style	425.4[c]	28.0[e]	906.4
Noug seed cake	474.3[c]	33.0[cde]	758.3
Urea	714.2[a]	26.0[e]	880.2
Negative control	658.1[abc]	31.0[e]	808.1
CV (%)	8.4	15.2	–

Mean followed by the same letter in the column are not significantly different at0.05 using Duncan's multiple range test.

Source: Lema Gizachew (1993).

Improved forage crops development

Malnutrition and under nutrition are the major constraints lowering the productivity of livestock in Ethiopia. Natural pastures provide more than 90% of the livestock feed but cannot fulfil more than half of the nutritional requirement of the animals mainly due to their poor management, low productivity and poor quality (Table 13). Crop residues and agro-industrial by-products are also poorly utilised. This results in over all low productivity of the animals. This situation can be improved by introduction of improved forages into the farming system.

Table 13. *Yield, CP content and* in vitro *organic matter digestibility of different classes of feed.*

Feed source	Yield		Quality	
	Mean forage yield (DM t ha–1)	Yield increase over natural pasture (%)	CP content (%)	IVOMD (%)
Improved grasses	9.0	157.0	5–9	–
Herbaceous legumes	7.0	100.0	>15	53–74
Tree legumes	11.0	214.0	18–24	38–71

Natural pasture	3.5	214.0	4–6	–

To seek technical solutions for the indicated feed shortage problems, IAR/EARO in the past three or so decades has made considerable effort to test the adaptability and yield potential of different species of pasture and fodder crops under a range of environmental conditions to select suitable species for different agro-ecological zones of the country. As a result, six improved grasses, four herbaceous legumes and two tree legumes were selected for the highland zone. In general, the selected forage crops were found to be higher yielding than naturally occurring swards and are proven to have higher nutritional value (Table 13). The length of growing period (green stage) is also longer for improved forages than for native pastures. Among the selected grasses, Napier grass (*Pennisetum purpureum*), Rhodes grass (*Chloris gayana*) and *Panicum coloratum* were more productive, their annual herbage yields ranging from 10–15 t ha^{-1} DM.

Inspite of all this potential, the utilisation of improved forages on farm is very minimal. Fodder production on arable land for livestock feeding is not practised by smallholder farmers except in very few areas where commercial dairy or beef fattening enterprises are undertaken by few individuals near urban centres where market outlets are available for sale of the produce.

Cereal–forage crops integration

The major constraint to plant and animal production in the highlands is deficiency of nitrogen (Jutzi et al 1987; Tothill 1987). Nitrogen deficiency can be overcome by application of fertiliser, manure or biological nitrogen fixation by leguminous plants. Application of commercial fertiliser is expensive and is often erratically available in subsistence oriented smallholder farming system. Except in very limited homestead areas, the use of manure for production of major crops is also minimal in the highlands due to its several other uses. Thus, leguminous plants such as herbaceous and tree legumes may be economical and feasible nitrogen sources of significance for such farming systems. Legumes have two major functions in mixed farming systems. They enhance soil fertility thereby improving crop and forage yields, and improve quality of forage for animal production.

Forage legumes can be integrated into the highland farming system in different ways. Growing them in rotation or inter-cropping them with cereals, alley cropping and sequential cropping are some of the approaches (Jutzi et al 1987). With these types of cropping systems, both crop and livestock derive benefits exploiting the assets of forage legumes. Higher grain yields are obtained from the crop and yield of crop residues are improved for livestock feeding (Table 14).

Table 14. *Mean grain and straw yields of wheat grown in rotation and inter-cropping with forage legumes at different IAR centres.*

	Rotational cropping		Inter-cropping	
Wheat	Sole crop	Forage rotation	Sole crop	Forage undersowing
Grain yield (t ha^{-1})	4.51	4.91	2.50	2.82

Straw yield (t ha^{-1})	5.41	5.93	2.45	2.69
Forage yield (t ha^{-1})	–	–	–	2.7

Source: IAR unpublished data.

Legume plants have the ability of fixing atmospheric nitrogen as a result of symbiosis with soil bacteria. As the nodules and legume roots decay, the nitrogen they contain is mineralised and becomes available thus increasing the yield of crops growing in association or rotation with the legume.

As a result of experiments done at Holetta, some suitable annual forage legumes such as *Trifolium* spps and *Vicia dasycarpa* have been selected for cropping in rotation with barley and wheat thus increasing grain yields of the cereals. Several other studies conducted at various IAR/EARO Centres have also demonstrated the possibility of successfully producing forage legumes in association with cereal food crops without imposing much reduction on yields of the associated crops (Table 14).

Cattle production improvement

Indigenous breeds characterisation and crossbreeding

From 1966–1974, the Department of Animal Sciences concentrated its research efforts on characterising three indigenous zebu breeds at three research centres. The major findings indicated that for the local breeds, age at 1st calving on the average was 43 months, milk yield on the average was 618 kg per lactation and lactation length was 150 days.

From 1974–1988, IAR/EARO conducted crossbreeding studies crossing three indigenous breeds with three exotic dairy breeds (Friesian, Jersey and Simmental) under four varying agro-ecological conditions. Major findings are: age at 1st calving—36 months, milk yield—1792 kg, and lactation length—320 days.

Crossbred dairy cows for draft

From 1989–1992, IAR/EARO in collaboration with ILCA/ILRI conducted studies on-station focussing on power output of crossbred dairy cows, effects of draft on milk yield, feed intake, and reproduction. The major findings were:

- milk yield: 1770 kg per lactation
- work output: 269 MJ/cow per annum
- oestrus manifestation delayed by 200 days for working crossbred cows.

As a follow up of on-station results, since 1992 crossbred cows were distributed to farmers around Holetta for on-farm studies. The following results were obtained:

- milk yield (305 days): 1501 kg per lactation
- work output: 135 MJ/cow per annum
- oestrus manifestation delayed by 221 days.

Oxen traction study

The power output of the male animals from different crossbreds and local oxen were studied at Holetta. Results are summarised in Table 15.

Table 15. *Working speed, power and work outputs of local oxen and its crossbreeds.*

Breed	Speed (m/s)	Power output (kw)	Work output (MJ/day)
Local	0.53	0.47	8.45
Simmental × local	0.66	0.97	17.60
Jersey × local	0.64	0.78	14.03
Friesian × local	0.66	1.05	18.64

Source: IAR unpublished data.

Summary

IAR/EARO during the past 3 decades of research services have generated technological packages to increase agricultural productivity. However, to support attainment of national goals of food self-sufficiency, poverty alleviation and environmental protection through sustainable technology packages, the research approach should focus to:

- integrate crop–livestock production systems
- strengthen research–extension linkage
- prioritise research programmes in the highlands
- increase trained manpower and research facilities.

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R&D experience in KARI, linking livestock system improvement, human health and NRM

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Abstract

The paper describes the research activities of the Kenya Agricultural Research Institute (KARI) showing its focus on technology and disciplinary orientation. The paper also argues that human health has not been directly addressed in the research agenda because of the lack of an integrated approach.

Introduction

The Kenyan economy is based on agriculture which contributes 30% of the gross domestic product and provides livelihood to over 80% of the population living in rural areas. Adverse ecological and climatic conditions limit the available amount of good quality agricultural land. Only 7% of the land is of high quality, receives adequate and reliable rainfall and has good soils. About 11% is of medium quality while an additional 5% is arable but subject to periodic droughts and crop failures. Of the remaining land, a large part is only suitable for extensive livestock production.

Past agricultural research achievements

Over the past three decades, agricultural research has made tremendous achievements. Ndiritu (1994) cites the following examples:

1. high yielding and disease/pest resistant crop varieties such as maize, wheat, sorghum, beans, pyrethrum and potatoes
2. improved crop production technologies including dates of planting and weeding, fertiliser/manure application, inter-cropping, crop-livestock systems, disease and pest control
3. improved livestock production and health technologies including pasture and fodder crop management and utilisation, utilisation of farm by-products, zero-grazing, vaccines against livestock diseases and methods of livestock disease diagnosis based on recombinant DNA technology.

Current agricultural research challenges

1. High population growth raises the need to greatly increase food and raw material production.
2. Subdivision of land in the high and medium agricultural potential areas into smallholdings for which appropriate production technologies are not always readily available.
3. Expansion of agricultural production into marginal rainfall areas for which little or no research work has been carried out.

4. Rapidly declining soil fertility in some areas due to soil erosion or continuous cropping.
5. Frequent droughts and diminishing water resources due to destruction of vegetation in catchment areas.
6. Increasing costs of agricultural inputs such as fertilisers, pesticides, machinery and implements.
7. Negative impacts of structural adjustment programmes leading to high cost of agricultural credit and inputs, decreased government allocation and less dependable release of funds for agricultural research.

Organisation of livestock research

Livestock research in KARI is undertaken in three major divisions: animal production, animal health, and rangelands.

Animal Production Division is concerned mainly with increased productivity of milk, meat and eggs as the primary products. In the higher potential areas smallholder mixed farming of both livestock and crops (food, cash and fodders) takes place. For those areas, research thrusts focus on nutrition and feeding of dairy cattle, management of poultry and pigs. In the semi-arid areas, research thrusts focus on semi-intensive finishing of beef cattle, nutrition and management of poultry and to a lesser extent pigs, and breeding, nutrition/feeding and management of small ruminants. Current research emphasis are on-farm research, diagnostic surveys on top of on-station experimentation. On-farm research concentrates on fodder crops and forages such as dual purpose sorghum, sweet potato vines, multi-purpose fodder trees as a replacement to commercial rations, fodder legumes, alley cropping, silage making on smallholdings (KARI 1994; KARI 1995).

Animal Health Division concentrates on the prevention and control of animal diseases. Animal health research looks into practical and economic aspects of preventing and controlling a number of major livestock diseases of economic importance such as tick-borne diseases (East Coast fever, Theileriosis), viral diseases (foot-and-mouth disease, Rinderpest, lumpy skin disease), Helminthiasis in young stock and small ruminants, and contagious bovine and caprine pleuro pneumonia. On-farm activities include diagnosis and treatment of tape worm, resistance to worm infestation, immunisation and treatment against tick-borne diseases, sero-monitoring and surveillance of viral diseases. There is a strong emphasis on epidemiology on the modes and economics of disease transmission. A project on infection-and-treatment of ECF in the coast has been highly successful. Efforts to produce stabilates for other parts of the country are ongoing (KARI 1994; KARI 1995).

Rangelands Division is concerned with livestock production in the arid and semi-arid areas which account for more than four-fifth of land mass and a fifth of the human population of Kenya. Livestock is the most important source of food and livelihood for majority of pastoralists. With increasing population pressure, land tenure system is changing giving rise to the need to meet livestock productivity and management challenges. The current rate of utilisation of the pasture, fodder, shrubs and trees in those areas exceeds the rate of replenishment. Research strategies aim to increase offtake rates of slaughter animals and conservation of environment to ensure sustainable production in the future. Studies focus on performance of camels and their calves, characterisation and improvement of indigenous livestock, characterisation of animal health constraints and factors which influence their occurrence under arid conditions. A research programme on range ecology addresses issues related to soil and climatic factors as they affect vegetation in those areas. A programme on livestock ecology addresses various aspects of meat production from rangelands on a sustainable basis. Several studies also focus on the socio-economic aspects of pastoral communities, indigenous knowledge and ethnovet (KARI 1994; KARI 1995).

Concerns in high rainfall areas and research efforts

Concerns in high rainfall areas hinge on the production of food, cash and fodder crops in smallholdings (mixed livestock-crop production systems). Other concerns emerge from the huge diversity of production systems (biophysical and socio-economic) within those production systems. Availability of inputs and access to markets are chronic problems as well as seasonal availability of livestock feeds.

Livestock types produced in the arid and semi-arid areas are camels, cattle, sheep and goats. The main concerns are livestock/crop production in the highly fragile and harsh environment. Other concerns are erratic availability of feeds and water, and lack of or poor access to markets.

Ongoing research efforts in high rainfall areas include:

1. prioritisation of research activities within research programme (e.g. dairy, maize, wheat, sorghum, horticulture, natural resources management)
2. characterisation of production systems (production zones by commodity using geographic information system (GIS))
3. identification of production constraints involving farmers
4. on-farm pre-extension/demonstration, testing of technologies for adoption under farmer's agro-ecological and socio-economic conditions (e.g. dairy, maize, sorghum, millet, vegetables and fruits)
5. integrated pest management
6. impact assessment (e.g. maize, sorghum/millet and horticulture and dual purpose goats (DPG))
7. assessment of household and market demand for commodities by sectors.

A project on recapitalisation and replenishment of soil nutrients between KARI and ICRAF (International Centre for Research on Agro-forestry) addresses declining land productivity due to low soil fertility in western Kenya. It incorporates organic matter management and heavy dosage of phosphorous as means of recapitulating and replenishing the soils.

Concerns in arid and semi-arid areas and research efforts

Ongoing research efforts in arid and semi-arid areas include:

1. prioritisation of research activities within research programme (e.g. animal health, maize, sorghum, millet)
2. characterisation of production systems (production zones by commodity using GIS)
3. identification of production constraints involving farmers
4. improved pasture management
5. assessment of property rights and behaviour of pastoral societies
6. impact assessment (maize, sorghum/millet, horticulture and DPG).

Research on human health

Although KARI has been involved mainly in improving production of crops, livestock and conservation of natural resources, it has been indirectly involved in human health issues. It has contributed to improved human health through the development of various types of foods and production technologies which increase farmers' income. The following two cases can be cited as areas where KARI is contributing more to human health.

First, a community based pilot research technology transfer project in collaboration with ARAMAT, a local NGO in Mosiro aims to: (1) increase food self-sufficiency and security using sustainable farming practices, conserve the indigenous ecosystem and environmental quality, (2) increase the income base and access to resources including co-operative credit, (3) bridge the communication gap between scientists and farmers, and (4) increase dryland options for cash and low input technologies.

Research activities include studies on:

1. identification of constraints to crop/livestock production
2. assessment of the impact of new technologies using social and economic indicators including market and household behaviour
3. diversification of food products and eating habits
4. improved sustainability in mixed dryland farming systems
5. appraisal of soil fertility status
6. planting, management and maintenance of local acacia and other trees to reduce wind erosion
7. reseeding local pastures with improved grasses and legumes
8. crossbreeding to improve local cows and goats
9. soil and water conservation through terracing and planting of appropriate grasses on the terraces.

These activities have led to the introduction of crop production in predominantly pastoral systems and have improved the food and well-being of many families. The adoption of sorghum, cowpea and maize varieties was dramatic within a few seasons. Milk and meat yields improved from improved feeding and crossbreeding of the indigenous cattle with Sahiwal cattle.

Second, an adapted drip-irrigation system has been widely adopted in semi-arid areas to improve food security. This system has minimum water requirements and the simplest version uses a bucket and can recycle household waste water thereby reducing wastage and the need to fetch extra irrigation water. This has ensured year round availability of vegetables and fruits. These indirectly contribute to increased intake of vitamin A, iron and carotene which improve human health.

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A Kenyan experience on R&D efforts linking crop and livestock improvement, NRM and human health

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Abstract

The paper summarises the research efforts in crop–livestock systems in Kenya, identifies their deficiencies in terms of disciplinary, commodity and component orientation and emphasises the need for a more holistic, integrated approach.

Introduction

The agriculture sector in Kenya plays a vital role in the economic development, contributing about 27% of the gross domestic product (GDP). In addition, the sector is estimated to have a further indirect contribution of 30% through linkages with manufacturing and other service related sectors. The sector also accounts for about 80% of the national employment mainly in the rural areas. In years of good weather, the sector produces nearly all the country's food requirements except wheat, sugar, rice and edible oils.

The livestock sub-sector which is an integral part of the agricultural sector, contributes about 10% of the GDP and accounts for over 30% of the agricultural GDP. The sub-sector employs over 50% of the agricultural labour force and is responsible for ensuring self-sufficiency in livestock products. This has been achieved except in extreme drought years.

There is an increasing demand for the agriculture sector to produce more food to feed the rapidly growing human population, produce adequate raw materials for the agro-industries, and export to earn foreign exchange. This has led to intensification of crop and livestock production particularly in the high potential areas where land scarcity is a major problem due to the high human population pressure. The intensification has been through use of high yielding crop varieties and improved livestock breeds, fertilisers, various agro-chemicals for both crop and livestock enterprises, and intensive livestock rearing systems among others. These efforts have resulted in positive impacts including increased yields, employment, food security and income.

However, some negative effects have arisen due to lack of proper input management, particularly the usage of agro-chemicals, thereby resulting in environmental and human health problems. Some of these include soil and water pollution which pose a serious threat to human health. In some cases, poor handling and failure to use proper protective clothing when applying these agro-chemicals has resulted in human health problems, e.g. skin diseases. Poor land use practices particularly in the medium and low potential areas have resulted in soil erosion, land degradation, deforestation and loss of bio-diversity. This has led to poor productivity from the land, thereby resulting in malnutrition, famine and increased poverty.

The root causes of these problems include: lack of consideration for environmental and natural resources management issues in crop and livestock improvement packages, lack of close collaboration among the various partners working on crop and livestock improvement, public health, natural resources management, and generally lack of an integrated and holistic approach in designing agriculture research and development programmes. In order to have sustainable crop and livestock improvement programmes, it is imperative to change these past approaches and instead adopt more integrated and holistic approaches.

Land use and farming systems in Kenya

Kenya's total land area covers 576,076 km^2. Of this only 20 per cent is of high and medium potential with adequate and reliable rainfall for arable agriculture. The remaining 80% is either arid or semi-arid land (ASAL) receiving little and erratic rainfall.

The bulk (98%) of the farm holdings in Kenya are small (<10 ha) and lie mainly in the high potential areas. The medium and large scale farms account for about 2% of the holdings, but cover about 54% of the area farmed (Table 1). Nationally, the average farm size is about 2.5 ha. The number of holdings is increasing fast due to the continued sub-division of both small- and large-scale holdings.

In the high potential (HP) areas, mixed crop–livestock system is practised. The major enterprises are cash crops (coffee, tea, horticulture) and dairy production. The main food crops grown are maize and beans. There is high human population density and land scarcity is a major problem. Consequently there is continued migration of people from the HP areas into the medium and low potential areas.

In the medium potential (MP) areas also mixed crop–livestock system is practised, but the crops involved are low rainfall crops. The main livestock enterprises are beef and small ruminant production.

Livestock production, mainly beef and small ruminants are the major enterprises in the low potential arid, semi-arid areas. The livestock is reared mainly under nomadic pastoralism and limited ranching. In the pastoral areas, there is no individual land ownership, and grazing land is communally owned. Drought, water shortages and some diseases such as East Coast fever (ECF), Contagious Bovine Pleuro-Pneumonia (CBPP), Contagious Caprine Pleuro-Pneumonia (CCPP), and Rift Valley Fever among others, are the main constraints to livestock production in these areas.

Table 1. *Distribution of farm holdings by size (1994).*

Size of holding	Number of holdings (million)	Percent holding by class	Percent of national total
Small (<10 ha)			
Under 2 ha	2.23	83	81
2–10 ha	0.74	17	17
Total holdings	2.97	100	98
Total Area (m. ha)	3.20	–	46

Average size (ha)	1.20	–	–
Medium			
10–20 ha.	33.30	60	1.2
20–60 ha.	19.70	40	0.7
Total holdings	53.00	100	1.9
Total area (m. ha)	1.04	–	15.0
Average size (ha)	20.00	–	–
Large			
60–200 ha	1.641	47	0.05
Over 200 ha	1.787	53	0.06
Total holdings	3.430	100	0.10
Total area (m. ha)	2.700	–	39.00
Average size (ha)	77.80	–	–
National Total			
Holdings	2.75	100	
Area (m. ha)	6.90	100	
Average size (ha)	2.50		

Source: Unpublished data (Ministry of Agriculture).

Experiences on research and development efforts linking crop and livestock improvement with NRM and human health

In response to the growing demand for the agriculture sector to produce more food to feed the rapidly increasing human population and produce adequate raw materials for agro-industries and for export, several research and development efforts have been undertaken in the sector.

In the high potential areas, the research and development efforts have emphasised intensification of crop and livestock production. This has been done through the use of high yielding crop varieties and improved livestock breeds, fertilisers, various types of agro-chemicals for crop and livestock enterprises, intensive livestock rearing such as zero-grazing dairy production system, intensive poultry and pig production among others.

In the medium potential areas, the research and development efforts have concentrated on integration of livestock and crop production activities, soil and water conservation, growing of drought tolerant and early maturing crops. In some areas, irrigation schemes have also been set up to enhance crop production.

In the low potential areas, development efforts have focused on water harvesting through use of earth dams and water pans, provision of stock routes and holding grounds to facilitate livestock marketing.

The research and development efforts which have been undertaken have resulted in positive impacts such as increased yields, employment, food security, and income, but some negative effects have arisen in some cases. These include direct and indirect adverse effects on human health, and some serious environmental problems. This has been largely due to lack of proper use of inputs, particularly the agro-chemicals as illustrated below.

Intensification of livestock production in the HP areas

This has mainly involved the intensification of dairy, poultry and pig production on the smallholder farms in peri-urban areas. The main objective is to maximise production from the limited available land. The intensification of diary production has been done through use of zero-grazing systems by small-scale farmers. The system is based mainly on Napier grass grown on the farms and utilised under cut-and-carry system. The intensification of the dairy production has been backed by several years of research and development on Napier grass production and utilisation on small-scale farms. The National Dairy Development Project which operated in several high potential districts, has supported the diary intensification for several years.

The intensification of poultry production has been done through use of deep litter and slatted floor housing systems. Like dairy production, poultry production has been supported by the National Poultry Development Project for several years. The project has been promoting the upgrading of the local birds using exotic breeds through a cockerel exchange programme. The project has also been facilitating the availability of broilers and layers day-old chicks to the farmers especially those far away from the hatcheries.

The intensification of livestock production has been backed-up by increased use of various types of agro-chemicals for animal health management. These include drugs such as dewormers, acaricides, coccidiostats, bacteriacides; and various types of vaccines.

The intensification of livestock production in the high potential areas has resulted in several positive impacts which include:

- increased production of milk, eggs, meat and other livestock products that in turn helped improve the nutritional status of the farmer and his family and increased income from sale of these products
- increased employment in the rural areas and peri-urban areas
- land saving
- complementarity between livestock and crop production; for instance, the manure from the zero-grazing and the poultry rearing units has been used for fertilising crop enterprises thereby leading to high crop yields.

Although intensification of livestock production has resulted in several positive impacts as noted above, there has been some negative effects as well. These include:

- acaricide pollution of the soil, water sources and other natural resources. Some of the farmers practising zero-grazing system of dairy production in the high potential areas,

spray their cattle in the open using acaricides for tick control. This is common in areas where cattle dips are not functional. After spraying, the acaricide seeps into the ground and some of it is washed by rain water into water sources such as dams and water wells. This causes pollution of the soil and the water sources which is a serious threat to human health in these areas.
- drug residue contamination of livestock products such as milk and meat. This has arisen in cases where the safe withdrawal period is not observed after the administration of various drugs to the animals. This is a health hazard to the people utilising these livestock products.

Intensification of crop production in HP areas

Like livestock production, intensification of crop production in the high potential areas has been undertaken to maximise yield from small-scale farms. Some of the major crops whose production has been intensified include cash crops such as coffee, tea and horticultural crops. The food crops include maize, beans and vegetables among others. The crop intensification has also been backed up by increased use of various types of agro-chemicals such as fertilisers, herbicides, fungicides, pesticides etc.

In the coffee growing zones of the high potential areas, several research and development efforts have been undertaken to improve coffee production. Through introduction of high yielding varieties and increased use of fertilisers and various types of agro-chemicals to control coffee diseases and pests.

There has been increased use of various types of agro-chemicals to enhance horticulture production. This is particularly so for the high value horticultural crops for export such as cut flowers, French beans etc.

The positive impacts which have resulted from intensification of crops like coffee and horticulture include: high yields of the crops, high quality crop produce, increased income derived from sale of the increased crop yield, increased employment in the rural areas, improved standard of living arising from higher income.

The adverse effects of intensification of crop production include:

- increase in pollution of the natural resources such as soil and water sources which is a threat to human health. The agro-chemicals sprayed on coffee and horticulture crops in the field drip down and seep into the soil. Some of it is washed by rain water into rivers and other water sources such as dams.
- contamination of food crops with agro-chemicals. It is common for some coffee farmers to inter-crop coffee with food crops such as beans, vegetables and others. This is particularly so when the prices of coffee go down. In such situations, the agro-chemicals sprayed on the coffee contaminates the food crops thereby posing a serious threat to the health of the people utilising these food crops.
- in coffee processing, some factories have been known to drain their effluent directly into rivers which are used as sources of water for human and livestock downstream.
- in some cases, poor handling of some of these agro-chemicals has resulted in human health problems such as skin diseases and other related conditions.

Crop irrigation schemes in MP and LP areas

Some irrigation schemes to enhance crop production have been set up in medium potential areas. Examples of these include Bura and Mweya Irrigation schemes. The positive impacts of irrigation include: increased crop yields, increased income accruing from the sale of the high crop yields, and increased employment in the irrigation schemes.

The adverse effects include increased cases of human disease such as malaria, bilharzia, cholera etc in the irrigation schemes and the surrounding areas. This is due to the proliferation of disease vectors which use the irrigation structures such as dams, furrows and basins as breeding grounds.

New settlement schemes in MP and LP areas

The scarcity of land in the HP areas has resulted in increased migration of people into new settlement schemes in the MP and LP areas. These immigrants usually start crop and livestock production using their farming knowledge gained in the HP areas where they came from. This include growing of high rainfall crops in low potential areas, inter-cropping, intensive tilling of the land etc. In most cases, these practices result in crop failure, famine, malnutrition and increased poverty which have a negative impact on human welfare.

Strategies for sustainable crop and livestock improvement efforts

The root cause of the problems arising from crop and livestock improvement efforts is the lack of an integrated and holistic approach when designing research and development programmes for crop and livestock improvement. In the past, most research and development efforts have been focused on specific aspects without considering the many other issues which are inter-related with it. Collaboration has also been weak between the crop and livestock improvement agents and their colleagues in public health, natural resource management, soil sciences and social sciences among others.

Therefore, for sustainable crop and livestock improvement, it is imperative to learn from the mistakes of the past, and adopt new strategies. These include:

- adoption of an integrated and holistic approach when designing crop and livestock research and development programmes
- close collaboration among the various partners and stakeholders not only in the crop and livestock fields, but also in other fields such as human health, natural resources management, soil science, social sciences etc
- strengthening of extension efforts with respect to input use, particularly agro-chemicals, land use practices and other related issues
- incorporation of environmental and natural resources management issues in crop and livestock improvement packages.

Research and development experience of FARM–Africa (Ethiopia)

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Abstract

The paper describes the community participatory research and development activities of FARM–Africa, a non-governmental organisation, in Ethiopia. Special attention is given to the role of stakeholder participation in sustaining the benefits of projects beyond the life of a project.

Introduction

FARM–Africa (Food and Agricultural Research Management–Africa) set up in 1985 is a registered charity in the United Kingdom. It started operation in Ethiopia in 1988. FARM–Africa is committed to helping poor farmers and herders of Africa to help themselves. In partnership with the community and local institutions, FARM implements community-based agricultural and community development projects to try and demonstrate viable strategies and techniques in crop, livestock husbandry and forestry to produce more food, in a sustainable way and with due consideration to the environment. In so doing FARM also strives to influence agricultural development policy at national and international levels.

Wherever possible FARM works with or through other development groups and African governments, providing technical expertise, training and other inputs. FARM currently operates a total of 12 projects in Africa: six in Ethiopia, two each in Kenya and South Africa, and one project each in Tanzania and Uganda.

FARM's overall goal is to enable marginal farmers and herders to make sustainable improvements to their well-being through more effective management of their renewable resources with the following principles of operation:

a. FARM–Africa works in close partnership with communities and their institutions

b. wherever possible it tries to test new ideas and approaches for increasing the productivity of the natural resources

c. it facilitates the dissemination and adoption of its successful experiences, and

d. it pays particular attention to the role and welfare of women.

FARM's projects in Ethiopia

Dairy Goat Development Project

The Dairy Goat Development Project was started in 1988. It aimed to improve the welfare of families in the densely populated highlands of Ethiopia through improving the production of their goats. The project also aimed to strengthen the capacity of Ethiopian institutions to carry out research and development on goats.

In the densely populated agricultural highlands, the growing human population pressure on the already scarce agricultural land results in decreasing resource of the subsistence smallholder farmers to earn their living. There is an obvious urgent need for the development of viable development options for these smallholder farmers. An intensive goat enterprise was identified as one option allowing such families to improve their welfare in the eastern and southern Ethiopian highlands where the goat has already been used as a suitable small multi-purpose animal.

Some of the direct benefits from this project have been more milk for home consumption and sale, increased cash income for food in emergencies and basic necessities, improved food security during the lean periods of the production year, and some accumulated capital invested in the form of livestock. Raising goats have assisted families to obtain milking cows, ploughing oxen and manure for crop production. By encouraging participating women to organise themselves into self-help credit groups, and by enabling them to manage revolving credit funds and basic animal health care, the project tried to empower women to take a more direct role in receiving extension services and household decision making.

Some of the other less obvious benefits are: soil and water conservation through growing forage crops for goats; stall-feeding of goats leading to reduce the demand on children and allowing them to attend school, and enhancement of women's skills and status in their community. The project was designed to focus on women as they traditionally look after goats in Ethiopia. The project resources were directed to the most needy families identified by their communities.

Components of the Dairy Goat Development Project extension package include: improved forage development, basic goat health care, extension training, organisation of self-help women groups, revolving credit and crossbreeding.

In its nine years of implementation in selected sites in seven districts of eastern and southern Ethiopia, the project has made remarkable impact on the lives of 1500 families. Extension of the technology package to similar adjacent districts is being planned. From lessons learned so far with rural communities, the technology package is now made more comprehensive by including components of human health and nutrition as well as family planning.

Farmers' Research Project

Farmer's Research Project was started in 1991 in the North Omo Region of South-Western Ethiopia covering about 35,000 km2. The population was estimated to be about a million with a third concentrated in Welayta, which cover only 10% of the land area.

The purpose of the project is to establish sustainable systems for developing appropriate agricultural technology involving farmers in research. It is hoped that this will lead to improvement in incomes of resource-poor farming households. The major assumption that underlies the project is that Farmers' Participatory Research (FPR) is a cost-effective way of generating and spreading appropriate technology. FPR promotes research in which peasant farmers play leading roles in identifying and designing research as well as carrying it out and evaluating it.

To advance FPR, the project established links between farmers (and their communities), researchers and government and NGO extension workers. It carried out research and training activities; conducted detailed studies of the project area, ranging from participatory needs assessment to detailed topical and special studies of particular agricultural commodities and problems and published project documents.

The project is now in a winding down phase and another extension phase is under preparation.

Community Forest and Wildlife Conservation Project

The natural forests of Ethiopia are disappearing at an increasingly fast rate. With the loss of these forests comes increased soil erosion, loss of bio-diversity, and ultimately, reduced water flows in streams and rivers. Poor natural resources management practices and declining agricultural yields are intimately linked.

Since October 1992, FARM's community forest and wildlife conservation project has been working with farmers in four pilot sites in central highlands to find ways to protect and conserve the remaining natural forest and wildlife through the co-operation and involvement of the people, rather than by restricting access.

In 1996 the project entered a new phase. The new phase will both broaden project activities to include land-use planning and on-farm trials to improve agricultural production at existing sites; as well as extends joint forest management to state forests of Chilimo and Bonga; and an eco-tourism venture on the shores of East Langano lake.

Tigray Community-Oriented Rural Development Project (CORDEP)

The community-oriented rural development project in Tigray started its main development phase in October 1994 after a two-year period of survey and pilot activities. The aim of the project is to improve the welfare and income of about 70,000 people in the dry highlands of the northern part of Tigray close to the Eritrean border. It attempts to do this in a way which emphasises and enhances the ability of local rural people and their community institutions to plan and manage their own development. CORDEP is mainly involved in water development, agriculture, household income support, training and community development.

Food-for-work has been used for constructing 160 km access roads opening up hitherto inaccessible parts of the districts. This enabled merchants, grain millers and government officers to provide services to these remote communities. Water is a scarce commodity in Tigray and farmers, especially women, regularly walk up to six hours a day to collect water that is often of poor quality. Work on 43 water points and gully plugging has been carried out.

Establishment and support of community nurseries and paravets are also undertaken side by side. Further the project works with the farmers to solve specific local problems. This includes involving them in selected trials such as crop variety trials to select for drought resistance, and screening sorghum varieties for tolerance to the parasitic weeds (specifically Striga). Each of the 135 poor women selected by the community was provided with two breeding female goats on credit basis to help them start a small goat enterprise.

The training programme lies at the heart of the project's aim to enhance the skills of the peasants and the government staff who serve them. To date 10 technical papers and two results of diagnostic studies have been published while results of other six studies are in the process of publication.

The project will finish its first phase in December 1998. However, review of the first phase of the project has shown its significant impact on the socio-economic life of the rural people. Hence it is planned to extend its activities to other areas in the region who seek such support.

Afar Pastoral Development Project

The Afar Pastoral Development Project has just been launched in two zones of the arid and semi-arid lowlands of the Afar Region. Focusing mainly on the camel, it also operates in areas of cattle and small stock development. The project framework was based on FARM's experience in a similar project in northern Kenya which has been implemented since 1989.

The project provides livestock development services using a mobile out-reach pastoral development approach. It also tests interventions to develop suitable packages to replicate in similar areas and at a wider scale. Further the experience gained in the initial two-year pilot phase will be tested in the Borana and Somali rangelands of the neighbouring regions.

Konso Capacity Building Project

FARM established a strong collaborative relationship with the people of Konso special Wereda and their institutions through its Dairy Goat Development Project (DGDP) and Farmers Research Project (FRP) programmes, since 1994. As a result, FARM was invited again by the Wereda administration in 1996 to expand some of the components of Farmers' Research and Dairy Goat Development projects and also launch a new initiative focusing mainly on capacity development.

It is, thus, in line with this request and FARM's knowledge about Konso's agricultural problem—that the project commenced in January 1998, in close collaboration with Konso Development Association (KDA). The purpose of the project is to build the capacity of local people, their leaders and organisations, to plan and manage measures against drought related disasters. As an initial step for the two-year pilot project, a participatory rapid appraisal (PRA) workshop was conducted with the local staff of Konso local government offices and KDA officials. During the period February to April 1998, a socio-economic base-line study was carried out in two of the 30 peasant associations in Konso.

Sustainability of projects and community participation

FARM's projects are designed as long-term initiatives which may extend up to 10–15 years, but each of them have short-term (3–5 years) operational plans, objectives and goals. Apart from the short time involved in the implementation and evaluation of projects, the specific goals and objectives of these projects are formulated taking into account concerns and expectations of donors.

Long-term continuity of introduced technologies is assured from the very beginning through the direct involvement of local partners in the planning and implementation of the projects. Local partners will have to however depend on the available financial and technical resources to continue promoting introduced technologies. This means that project activities may not continue with the same vigour and focus after phasing out of projects. This also relates to evaluation of long-term sustainability of the projects, which in the main remains to be the responsibility of collaborating local institutions. Projects during their life-time may evaluate adoption patterns of the introduced technologies; but these do not necessarily constitute assessment of sustainability in the context of this workshop.

FARM's projects are mostly designed to support certain disadvantaged parts of the community, depending on the issues projects are set to address. Taking a wider view of the identified problem, not all members of the community that are influenced (directly or indirectly) by the problem are involved at the early stage in the project planning and implementation. Beneficiaries of projects are selected either by the community itself, as in the case of the Dairy Goat Development Project, or by using certain socio-economic criteria. All stakeholders of the projects may thus not be taken on board.

This certainly has implications in assuring long-term sustainability of the projects. NGOs like FARM may either be duty-bound or expected by their donors to focus development projects at certain sectors of the society. The issue of community participation may still be upheld, though from narrower perspective. But there are indications that even under such circumstances new projects try to consider a wider involvement of the community.

Concluding remarks

FARM–Africa has learned a lot with regard to community development in the implementation of these projects. These lessons are taken into account in putting together new projects to improve long-term sustainability of the introduced technologies. The tendency now is to try to address selected key problems along with related socio-economic circumstances of the community leading to broader recommendation domain.

Human health and resources management: AMREF experience

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Abstract

African Medical Research Foundation is a health related non-governmental organisation targetted to poor people. In this paper, the organisations' participatory approaches to health delivery and health management in relation to specific programmes are described along with experiences and lessons learned.

What is AMREF?

AMREF (African Medical Research Foundation) is a health related non-governmental organisation (NGO) based in Africa with its headquarters in Nairobi, Kenya. It was founded in 1957. It is one of the few international NGOs based in Africa. AMREF's mission is to improve health care for the underserved in Africa through training, research and service delivery, in partnership with communities, governments and donors (AMREF 1996). The Foundation's goal is sustainable and equitable improvement in the health and well-being of the most disadvantaged population of Africa.

The organisation has country offices and projects in Kenya, Uganda, Tanzania and South Africa. In addition, it implements projects in Somalia and Ethiopia.

The evolution of the concept of health

The definition of health has changed and evolved over time. This change has come as a result of deeper insight into factors that contribute to human health.

Hippocrates urged physicians to look at dietary and exercise habits, the water they drink and in general, the nature of environment in which they live. However, initial successes in treating some important diseases such as tuberculosis and eradicating small-pox caused a lot of excitement and hope in the biomedical model. The concern of the health sector was mainly narrowed to treating and eradicating diseases.

With the era of primary health care (PHC), the approach of the health sector changed. The World Health Organization (WHO) defines health as 'the physical, social and emotional well-being of an individual and not merely the absence of disease and infirmity.' This definition of health has broadened the health agenda to include water, food, environment, and income among others. The new concept of health has led to several shifts in our perception of human health and how best health can be promoted. The first focus shift is from curative to health promotion. The second is from a focus on diseases to disease prevention. And the third is the change from looking at health per se to a broader view which embraces factors that influence health.

Several reasons have influenced these changes. Among the most notable ones are:

- the recognition of the strong relationship between health on one hand and social, economic, environmental and political factors on the other
- the realisation that improved health status, nutrition, and education are not ends in themselves, but healthy and educated human beings are also the principal means for achieving development
- the growing concern with sustainability: Sustainability has been defined by the World Commission on Environment and Development as 'development that meets the needs of the present without compromising the ability of the future generations to meet their own needs.' It was realised that in order to achieve sustainable development, a holistic approach to health must be adopted.

The above reasons explicitly imply; first that human health is but only part of a much broader ecosystems health picture. Second, there are resources which must be developed and effectively managed to help achieve good health. Third, the statements demonstrate the strong inter-relationship between human resources and other resources.

Health in Africa: A situation analysis

In the period after independence, health policies of East African governments resulted in some significant improvements in the health status of their people. However, in parts of Africa, the first ten years have witnessed serious challenges and constraints reversing some of the earlier achievements. By 1990 gains were slowed, or even reversed, compared to the other regions of the world. East Africa today has high crude deaths and high infant mortality rates (IMR), as well as large population increases each year.

In general, a deterioration in health status can be attributed to declining economic growth, limited public and private capital, rapid population growth, poor management of natural resources, increasing unemployment (especially among school leavers).

Climatic factors have resulted in drought conditions throughout parts of East Africa since the early 1980s. This has had serious implications for marginal populations and the livestock upon which the people are dependent. Malaria is now a threat to over 2000 million people or 40% of the world's population.

In East Africa malaria accounts for nearly 30% of outpatient visits and 20% inpatient admissions to health facilities. Although estimates of mortality are poor, malaria probably accounts for between 15–20% of all deaths.

The greatest challenge today is the epidemic attributed to Acquired Immune Deficiency Syndrome (AIDS). The AIDS scourge has contributed to an erosion of health benefits made by governments in East Africa. In 1992, it was estimated that 7.6 million Africans may have been infected with this invariably fatal disease. Estimates show that overall figure will rise to over 10 million in the late 1990s.

Demographic surveys show that the continent has a high percentage of children below the age of fifteen. There are also many women in the reproductive age (15–49). Both groups form about 70% of the populations in the countries of East Africa. This obviously calls for more emphasis on strategies which improve health for women and children. Maternity related problems are causing great concern for women and children. Maternal mortality rates (MMR) are high. Few births are attended by trained health workers.

Women and children in the region also suffer from malnutrition. About a third of pre-school children suffer from chronic malnutrition. Poor nutritional status among pregnant mothers leads to low birth weight in Kenya, where 18% of babies are born with low birth weight. For Tanzania it is 13% and for Uganda 10%. The average for developed nations is 7%.

Human health and resource management

The World Bank in its report 'From Crisis to Sustainable Growth' notes that people are both the ends and means of development (World Bank 1989). The components of human and other resources are linked in a mutually reinforcing way. Providing clean water reduces infections in children and improves their nutritional status. A healthier population can produce more food and generate higher incomes, which can lead to further improvements in nutrition, health and education. Similarly, clean water and sanitation produce more benefits when provided along with health education.

It is therefore imperative that in the quest for improved human health to recognise the synergistic relationship that exists between human health, poor accessibility to potable water, poverty, poor food and nutrition security, and environmental degradation.

AMREF's experiences

AMREF's focus and strategy

In keeping with AMREF's goal of sustainable and equitable improvement of the health and well-being of the most disadvantaged populations of Africa, the Foundation has adopted an integrated approach to health promotion (AMREF 1997). Based on comparative advantages and skills, AMREF focuses on the following priority programmes.

- communicable disease control
- sexual and reproductive health (incorporating family planning and family health)
- environmental health
- clinical services and emergency response
- health policy and systems development

Strategies used by AMREF include the following:

1. building partnerships with communities, other sectors and donors: This strategy aims at ensuring that the community, project staff, staff of relevant ministries and the donor work together on an equal relationship basis, based on respect to each others concerns, priorities, capacities and strengths. This strategy recognises the major role of communities in promoting their own health and the inter-relationship of factors that influence the health and well-being of communities. Community mobilisation forms an important element of this process
2. community participation: Community participation as a strategy is aimed at enabling the communities participate fully in problem identification, prioritisation, planning and

implementation of actions, monitoring and evaluation of interventions. Identification of problems, solutions and strategies is conducted through participatory methodologies

3. community empowerment through education and training: Community empowerment recognises that communities have very rich indigenous knowledge and skills. These are built on and used. An attempt is made to preserve the positive ones. Gaps in both skills and knowledge are filled in by education and training
4. addressing gender concerns and issues: The participation of women is severely curtailed by their low status in society and poor level of education and yet they are the major managers of resources such as water, food, environment and human health. This strategy therefore aims at addressing gender inequalities and inequities that prevent women from participating fully in development activities. Gender analysis tools are used to identify gender concerns, which are then integrated into the implementation process.

The themes or activity areas

Human resource development and management

Empowerment of communities through information, education and communication (IEC). This is in recognition of the important decisions made by the individual, family, and community regarding their health. In its education efforts, AMREF ensures that the learning is learner-centred and provides opportunities for learners to analyse problems, identify causes of the problem and appropriate solutions and design a plan of action. The education is aimed at disease prevention and health promotion. It emphasises the relationship between health and the interacting factors.

East Africa's health care systems cover a small percentage of the population with personnel having poor basic training. AMREF runs several training courses for mid-level rural staff. The training emphasises a holistic and integrated approach to health. Appropriate training materials are developed to facilitate training. Last year a total of 30 participants took the one-year diploma in community health course. They came from Uganda, Kenya, Namibia, Tanzania, Ethiopia, Ghana, The Gambia, Sierra Leone, The Netherlands and Finland.

Management skills among extension workers, project managers, senior staff of government departments and NGOs are poor. This often leads to poorly designed and managed development projects. AMREF provides training in community mobilisation, education and management of projects. This training targets participants from the African region.

Environment and water

AMREF targets the most disadvantaged areas many of which are either in the arid and semi-arid ecological zones, poor rural and urban areas, and resettlement schemes in the African region. The complex relationship, for example, between the Maasai, their livestock, the ecology of the area they occupy, and the common diseases seen here have one common origin: lack of water. The Maasai spend most of their time tending their livestock and will move from place to place in search of water, making it difficult for development workers and other service providers to reach them. This lack of water has resulted in high rates of trachoma and other water-related diseases in the area.

AMREF in collaboration with the Arid and Semi-Arid Lands Programme (ASAL) has been working to improve access to safe and affordable water for domestic and livestock use with support of local water management committees. The community pays 50 percent of the repair costs, ASAL covers the remaining costs, while AMREF provides technical support. To ensure clean and safe water sources AMREF gives advice and technical support on the installation of hand pumps, construction of aprons (for draining away waste water) on the wells. In addition, the foundation provides a water storage and education on water storage and water storage management at the community level.

Training is a major component of AMREF's water initiative. On-site training in operation and maintenance of the hand pumps is done during the installation. Workshops are also held to train the community in good management and hygiene. In this area, AMREF has rehabilitated 50 bore holes, and constructed 65 shallow wells. In addition 20 bore holes and shallow wells assistants have been trained in financial and other resources management. These efforts have reduced long distance walks in search of water for communities and their livestock.

Rapid and unplanned urbanisation has led to immense water supply and sanitation problems in eastern Africa which in turn are a ground for water-born diseases. AMREF is now conducting health promotion and education activities for sustainable improved water supply, personal hygiene and sanitary environments. Ventilated pit latrine, waste water drainage, soak ways and water supply facilities are some of the facilities being improved on a cost sharing basis between the community and the project. Local artisans have been recruited and trained in appropriate technology that is affordable.

Malaria is intensified by changes in man's immediate environment, such as irrigation, opening up of new lands to agriculture, road and railway construction, open cast mining, forest exploitation and mineral protecting. Kirnyaga District on the lower slopes of mount Kenya, is one such example: a successful governmental rice irrigation scheme had turned the lives of the community into a nightmare.

AMREF introduced insecticide-treated nets for malaria prevention. The programme uses local manufacturers for production of nets. This initiative is combined with education on malaria prevention, training of key selected people for sustainability of the programme and establishment of local community-based manufacture and supply of treated bed nets.

Food production

In Kibwezi, a semi-arid area, the Applied Nutrition Project has responded to child malnutrition and poor food security through food production education, promotion of drought tolerant crops, improved goat production and health, and the establishment of seed banks at the community level. The initiative is a collaborative effort between the community, Ministry of Agriculture and AMREF. AMREF closely works with community groups such as women groups and self-help groups.

As a result of this initiative, there is a gradual shift in production practices from a focus on maize as the only major crop to the drought tolerant crops such as the millets, cassava and pigeon peas among others.

Financial resources

Income generation is promoted at the community level. AMREF is very conscious of the close synergistic relationship between poor health and poverty. While poverty is a cause of poor health, poor health reduces the production ability which leads to reduced income, inability to cope with stress and poverty.

Strategies to increase income at the household level target the most disadvantaged groups such as women, people with disabilities and out-of-school youth. This initiative uses several strategies which include providing skills training in income generation and provision of small loans. Training and loan provision are not an end in themselves but are aimed at creating life-long attitudes and practices such as a culture of saving and investment for the future and the ability to take risks.

Lessons learned and challenges ahead

1. Communities must identify their own priority problems, analyse them and propose practical solutions. This process promotes a high level of community participation, improves financial, technical and social sustainability, and promotes ownership of interventions by local communities.
2. Communities have their own development structures, which should be used. Structures created by external agents rarely survive far beyond the period of the project.
3. Communities are willing to enter into a partnership with development agencies; but partnership promotion must start right from the beginning in order to avoid an attitude of dependence. This partnership must be built on mutual respect and recognition of one another's strengths and abilities.
4. Community empowerment means making communities realise their potential and ability to change their own circumstances and not merely the provision of resources and development of infrastructure. Community education is therefore very central to all development efforts.
5. Reaching the most disadvantaged is difficult, many of them have lost faith in themselves and development systems. Special efforts must be made using participatory research methods to identify them and learn from them about how they think their lives can be improved.
6. Health is not always on top of the agenda of communities. The health sector may sometimes have to use an entry point that is not health, in collaboration with another sector and the community, and introduce health issues at a later stage.
7. Ensuring equitable health promotion is a highly desirable goal but in order to achieve this goal there is a need to look at the health of the ecosystem as a whole. This is a major undertaking, it requires inter-sectoral collaboration and a high level of commitment on the part of development workers, governments and donor agencies.

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Concepts of sustainability, agro-ecosystem health and applications to agricultural production[1]

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1. This paper draws on research supported by the Canadian research granting councils (Social Science and Humanities Research Council, Natural Science and Engineering Research Council, and Medical Research Council); and the Ontario Ministry of Agriculture, Food and Rural Affairs.

Abstract

The paper comments on a research proposal on the application of agro-ecosystem health. It is argued that both agricultural sustainability and agro-ecosystem health concepts provide broad frameworks for considering multiple dimensions of broadly defined agricultural systems and the interventions among those dimensions with the aim of improving their condition in the future. Neither provides a universally applicable suite of indictors nor a specific analytical methodology. Either approach may be used so long as stakeholders are involved in the characterisation of system dynamics, and in the identification of needs, potential interventions and likely implications.

Introduction

My comments focus on the draft research proposal 'Enhanced Human Well-being through Improved Livestock and Natural Resource Management in the East African Highlands' distributed by ILRI prior to this Workshop (ILRI 1998). My intent is to share lessons from recent work dealing with agricultural sustainability and agro-ecosystem health. In particular, I draw on the inter-disciplinary project report in Smit et al (1998) which defines and illustrates applications of agro-ecosystem health.

My understanding of the broad issue this research proposal intends to address is summarised in Figure 1. The focus is on production systems or farming systems in the East African highlands region. These crop–livestock systems have evolved over a very long period of time, and currently operate under distinctive biophysical and socio-economic conditions. These constraints include the terrain, soil and climatic resources which provide both opportunities for, and limits to production. The systems are increasingly stressed by the growing population. The macro-economic environment is also important as farming systems are sensitive to such conditions as markets, commodity prices and input costs. The political, institutional and cultural environments represent powerful constraints on the characteristics of farming systems through land tenure and ownership, infrastructure, established cultural practices, and so on.

The characteristics of production systems which are of particular interest to the research proposal (ILRI 1998) can be seen as 'outcomes' of the production processes (Figure 1). One area of concern is environmental degradation, notably soil erosion and low and/or declining fertility. Also of concern is the productivity of the farming systems, where low productivity is understood to be associated with resource conditions, degradation, and management practices.

A distinctive feature of the research proposal is that the prime interest is not with productivity in its own right (as is commonly the case in agricultural research), but with human welfare, or well-being, which is seen to be related to productivity, the farm management systems, and environmental degradation (Figure 1). Human welfare reflects concerns over malnutrition and poverty, and can be defined according to physiological, social and economic attributes of individuals, families and communities.

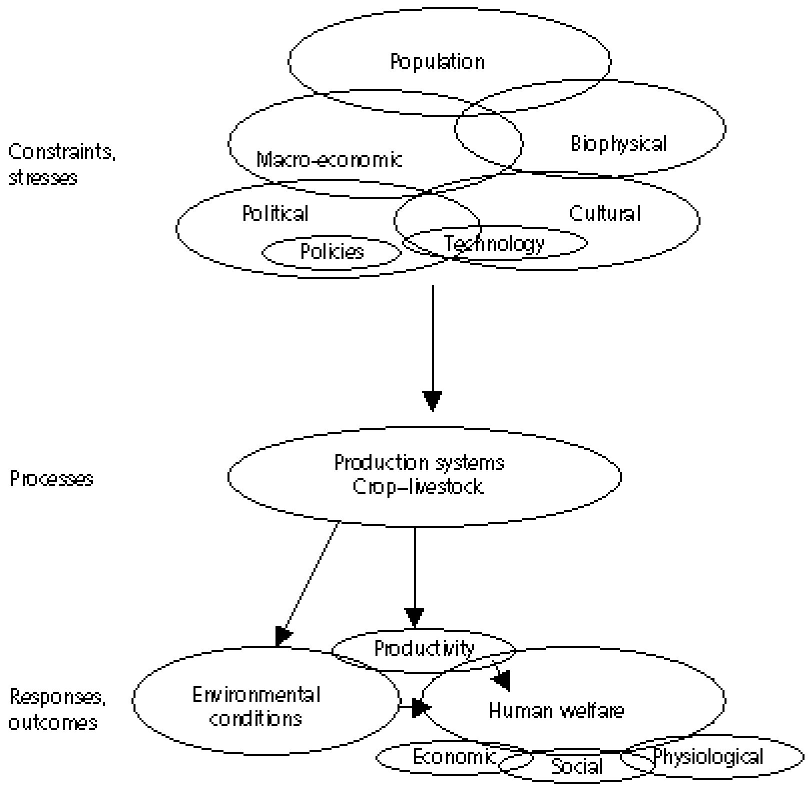

Figure 1. *Production, resources management and human health in East African highlands: A summary of the issues as outlined in ILRI (1998).*

Production systems, and their forces of change and their responses, can be specified at various spatial scales (e.g. field, farm, community, region, nation, etc), and at different temporal scales. The elements of Figure 1, including what is considered a constraint or a system variable, depend upon these spatial and temporal scales. Of course, Figure 1 is a gross simplification, with many disaggregations and feedbacks not specified.

Given the scope of the issue indicated in Figure 1, the research questions in the proposal deal with the sustainability of these systems. How can sustainability be measured? Can the agro-ecosystem health paradigm do a better job than the concept of sustainability in documenting change in environmental condition and human welfare in a holistic fashion, in identifying the processes and system characteristics which seem to be associated with improvements or deteriorations in human well-being, and in assessing the implications (or impacts) of policies or technologies which might be (or have been) developed and adopted in an effort to improve resource management and human well-being? (Figure 1). The research proposal also indicates that these should all be done with local participation. In order to do all this there is interest in conceptual or organisational frameworks.

Agricultural sustainability and agro-ecosystem health

One of the basic hypotheses in the research proposal is that the agro-ecosystem health paradigm will provide a superior conceptual framework than agricultural sustainability, which has remained 'without much empirical content because of the lack of a comprehensive definition and analytical methodology' (ILRI 1998). Of course, it is possible to distinguish between the two concepts, but for the practical purposes of this research proposal they are fundamentally similar, essentially synonymous (this comparison is developed in more detail in Smit and Smithers (1994a)).

Once the term 'agro' is appended to 'ecosystem' we have explicitly included human components, such that 'agro-ecosystem' is fundamentally equivalent to a broad definition of 'agriculture', which includes ecological and human components. Sustainable agriculture has been defined in many ways (Smit and Brklacich 1989; Cai and Smit 1994; Smit and Smithers 1994b), but most cover the same essential features. Consider two representative definitions:

> agri-food systems that are economically viable, meet society's need for safe and nutritious foods, while conserving natural resources and the quality of the environment for future generations (SCC 1992),
>
> and
>
> agricultural system that can indefinitely meet demands for food and fibre at socially acceptable economic and environmental costs (Crosson 1992).

In both of these, agricultural sustainability is defined with respect to

- societal needs or demands for food, including nutrition, and hence implying human health
- economic viability, referring to the maintenance of production systems, and
- environmental quality, addressing the condition of biophysical resources.

Definitions of sustainability also note the maintenance of these features over time ('future generations' or 'indefinitely'). Definitions of agro-ecosystem health cover essentially the same features. Waltner-Toews (1994) and Smit and Smithers (1994b) describe agro-ecosystem health as incorporating

- human well-being
- economic performance, and
- ecological condition.

In fact, the essence of the agro-ecosystem health (AESH) perspective is that it recognises the existence of, and interrelationships among, these several domains of agricultural systems (economic, human and ecological), and that the overall 'health' of the system is a function of the condition, of and interdependencies among, these components.

A simple conceptualisation of agro-ecosystem health is given in Figure 2 (from Smit and Smithers 1994b). The diagram indicates three main dimensions, which interact (hence overlapping sets), which manifest at different scales (hence the different sizes of sets), and which can be employed in numerous applications, including a) using indicators to compare systems or document changes in AESH, b) identifying and specifying relationships among dimensions to understand dynamics and determinants of AESH, and c) assessing responses in AESH to stresses, both those associated with external environments (such as climatic variations or macro-economic conditions) and those reflecting interventions or policies.

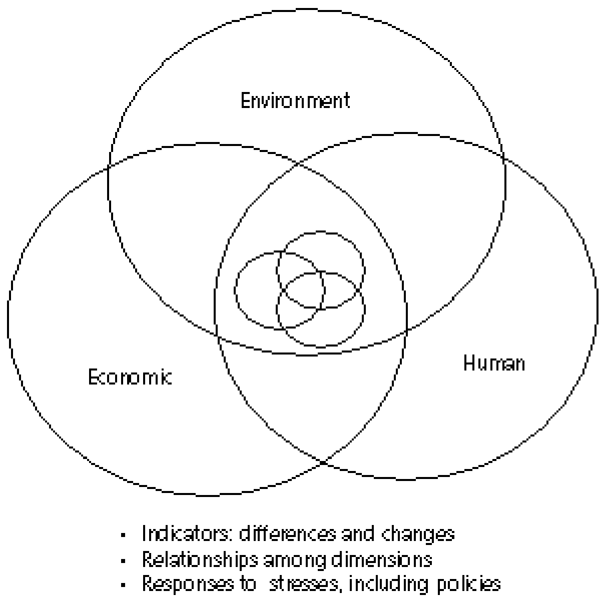

Figure 2. *Agro-ecosystem health: A sample diagramatic representation.*

The conceptual foundations of these two paradigms, AESH and agricultural sustainability (AS), are fundamentally synonymous. Both are explicitly evaluative of the overall conditions of rural environments, economies, and peoples. It is noteworthy that the goals of CGIAR also mirror these components

- increase food security
- alleviate poverty, and
- protect environmental quality.

In other respects as well, AESH and AS are very similar. Both are applicable at different spatial and temporal scales (Smit and Smithers 1994a). For both, considerable effort has been expended in developing indicators, and similar kinds of indicators (often very long lists) have been proposed. Indicators can take a wide variety of forms, including state and functional indicators, diagnostic and early warning indicators (see Smit et al 1998). There are also many examples of particular empirical studies employing indicators, especially of sustainable agriculture (see Smit and Smithers 1994a), but also for agro-ecosystem health (see Smit et al 1998).

However, neither of these frameworks can supply a single, comprehensive measurable indicator which can adequately capture the scope of these systems. Nor do either of them provide a specific set of analytical steps to document change, assess responses, or evaluate interventions in these systems. The noteworthy contribution of the agro-ecosystem health concept is a metaphor, providing a broad framework which facilitates the consideration of multiple dimensions and the interactions among them.

Approaches to agro-ecosystem health indicators

What is the route by which a metaphor or concept can be applied to something so that researchers or practitioners can use in the field? For example, there is the interest in indicators, or measurable properties which indicate the health of an agro-ecosystem. For indicators, which represent only one element of any analysis, three distinct approaches have been tried (Smit et al 1998).

Holistic

This approach, of which several versions have been proposed, aims to define a set of very generic 'criteria', essentially from first principles, which will be applicable to all dimensions. Thus, we get such 'holistic indicators' as integrity, efficiency, resilience, effectiveness, response capability, balance, richness, transformation ability, self-regulatory capacity, flexibility, stability, and so on (Figure 3). A particular appeal of this approach is the expectation that the selected criteria will lead to measurable equivalent indicators on each of the dimensions. An example of this approach is given in Table 1 of the research proposal (ILRI 1998), which also illustrates the limitations of the approach. There is no logical or systematic basis for selecting the criteria. Because they aim to be holistic and generic they tend to be similar to the (supposedly more holistic and generic) concepts of health or sustainability, and the definitions often appear tautologous or imprecise (Smit et al 1998). For example, Table 1 gives 'effective land use' as an indicator of 'integrity', yet there is another category called 'effectiveness'.

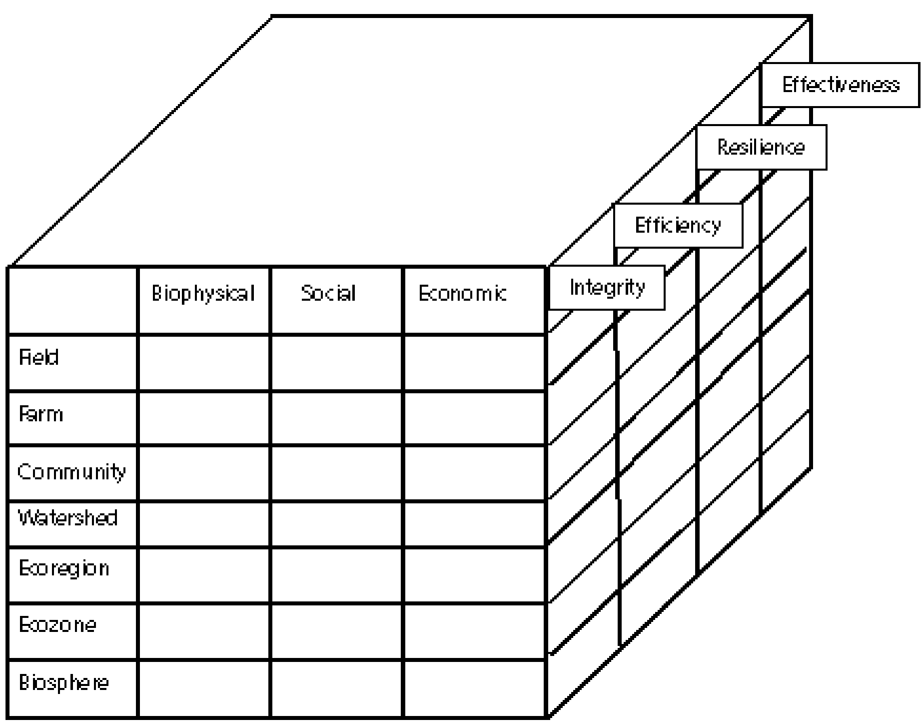

Figure 3. *A conceptual framework for agro-ecosystem health.*

This holistic approach adds another level of concepts which seem to confuse as much as clarify, which are difficult to apply in practice, and which are probably not necessary anyway.

Disaggregated

In this approach, the indicators of the various dimensions of agro-ecosystem health are supplied by scientists and practitioners in each of the disciplines involved. Indicators developed via this route tend to reflect the variables which are conventionally analysed in the various disciplines. Thus, economists provide indicators such as gross margins, benefit–cost ratios, or net income. Sociologists will list measures of household and community structure, power relations, equity, gender roles, and so on. From the human health and nutrition fields come indicators of morbidity, longevity, other physiological features and measures of nutritional status or functionality. From the geophysical and biological sciences come equally long lists of ecosystem variables which have been of theoretical interest or have been used before.

This approach certainly generates an ample smorgasbord of indicators. The weaknesses of this approach are that the lists are impractically long, there are no established principles for selecting from among the many possibilities (they may all be 'scientifically valid'), and they often are not readily understood by the people in the agro-ecosystems.

Community-based

The essence of this approach (also called stakeholder-derived) is that the indicators are identified with the active participation of the people who live in the agro-ecosystem. A variety of methods are available for this kind of participatory approach, in which the researchers necessarily play at least a facilitatory role, but where the indicators are certainly meaningful to local people as well as to the analysts.

Although this approach is not refined in Smit et al (1998), the experiences there and elsewhere suggest that it has several benefits. These include a practical and efficient way of selecting key indicators, allowing researchers to learn about communities' priorities and alternative measurements (sometimes supplied directly by residents), and promotion of people's involvement in (and 'ownership of') both analysis of agro-ecosystems and any management initiatives to improve their health.

Applications to the East African Highlands Project

Whatever you choose to call your framework, it would appear that you already have one which is consistent with the model of agro-ecosystem health. The key components, closely interconnected, are

- the **crop–livestock production system,** whose productivity (a subset of agro-ecosystem health) you seek to improve
- the **biophysical environments,** which provide constraints on, and opportunities for, production, and which are subject to degradation, and whose quality or condition (a subset of agro-ecosystem health) you seek to maintain or improve

- the **human communities** which are both dependent upon the other two components and greatly influence them, and whose condition or well-being (according to economic, nutritional, physiological elements, all representing subsets of agro-ecosystem health) you seek to improve.

It would seem that there is no need or utility to attempt to develop holistic criteria for agro-ecosystem health from first principles. To illustrate a practical approach to a composite view of health, consider an individual person such as myself. My health is the composite of the condition of my skeletal structure, cardio-vascular functioning, mental condition, psychological state, ability to perform tasks, and so on. On some of these I am in better shape than others. These attributes are not independent, but they are measurable separately, and when looked at together define my overall health. Given the three broad components of agro-ecosystem health of interest in the East African highlands, a practical approach to identifying a manageable set of indicators with the participation of local people would seem appropriate.

Of course, the challenge is a lot more than just identifying indicators of the health of the highlands agro-ecosystem. As apparent in Figure 1, there is a need to document changes in the health indicators of the components of the agro-ecosystems, and identify and describe the interrelationships among and within components so that changes can be better understood, so that the role of external forces can be assessed, and so that the likely effects of interventions can be ascertained. This type of systems analysis will necessarily involve a mix of research methods, including observation and learning from the 'field' (especially of human decision-making), theory and models, and experiences from elsewhere. This scholarship needs to be both relevant and rigorous.

Conclusion

The key features of both the agricultural sustainability and the agro-ecosystem health concepts are that they provide broad frameworks for considering multiple dimensions of broadly-defined agricultural systems (and the interactions among those dimensions), with the aim of improving their condition in the future. Neither provides a universally applicable suite of indicators nor a specific analytical methodology.

The East African Highlands Initiative, by defining its scope across production, biophysical and human health dimensions, is entirely consistent with these frameworks. The movement towards more involvement of stakeholders in the characterisation of system dynamics and in the identification of needs, potential interventions and likely implications is also consistent with recent lessons in the agro-ecosystem health field.

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Challenges and opportunities for incorporating gender within IDRC's ecosystem approaches to human health programme initiative: Opportunities in the Ethiopian Highlands Project

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Abstract

The paper outlines the evolution of the gender dimension of research and development from women in development to gender and development, and the way the concept has been incorporated within the agro-ecosystem health approach to research and development for improving human welfare. The opportunities and approaches for addressing the gender issue within the agro-ecosystem health project in Ethiopia are also outlined. Key concepts and issues in gender analysis are briefly described in an appendix.

Introduction

'Despite progress over the last two decades, the harsh reality is that women are nonetheless more likely to be under-nourished, under-educated, over-worked and under-paid than their male partners. They are also more likely to be poor: of the 1.3 billion people living on a dollar a day or less, 70 percent are women,' said James D. Wolfensohn, President of The World Bank in his address to the Fourth UN Conference on Women, Beijing, September 15, 1995.

These dismal statistics quoted above have compelled nations and international development organisations to reconsider the way they conceived programmes to improve women's status and well-being. Initially, international development programmes focused on men as primary actors, believing that the benefits of these projects would filter down from men to their families.

The purpose of this paper is to make suggestions for improving the health and well-being of people in Ethiopia, one of the poorest countries in the world, by including gender and social analysis into development research. It is hoped that such analysis will assist researchers, development organisations, and government to understand how to mobilise particular vulnerable and invisible groups such as the poor, women and children. The fact that the poor are largely women and children, who have been 'benignly' invisible in development research, justifies to an extent, the efforts that many researchers and development institutions have made to focus on their plight. However, development history demonstrates quite aptly that efforts to benefit women and children by creating separate programmes moves their issues away from the mainstream and dominant political agenda of development and thus in the end marginalises them and isolates those individuals and organisations who work on their issues. Probably the only exception to this is UNICEF, the UN organisation that focuses primarily on issues of women as mothers and children.

The paper is divided into four parts. The first section will be a brief history of efforts to include women in the development agenda which will also provide some background information on the situation at IDRC; second will be a brief description of the Ecosystem Approaches to Human Health Programme Initiative, and third the opportunities for social and gender analysis within that initiative; and finally some opportunities for this work within the International Livestock Research Institute (ILRI) will be discussed. The last section will draw on literature from the International Livestock Centre for Africa (ILCA), which has been incorporated into ILRI in 1994.

An appendix is included at the end of the document, which includes definitions of key concepts and issues when conceptionalising or doing gender analysis.

Historical perspective

In the 1970s, attempts were made to draw attention to females' participation by organising women in development (WID) programmes both in national governments in the South and in international aid agencies. WID policies and programmes attempted to integrate women into development planning by adding WID components to larger sectoral programmes and projects. This 'add women and stir' approach included women, as both staff and beneficiaries, into as many sectors and programmes as possible. This did not fundamentally alter the priorities of these programmes because these efforts focussed largely on women's reproductive roles, totally obscuring the fact that women also have essential productive and community enhancing roles[1] (Boserup 1970; Moser 1993). There was little analysis of the disproportionate power relationships between men and women in society as well as the gendered division of labour. Separate programmes were developed targeting women only and these programmes often became marginalised as the men were still left to the 'real work of development'. WID was an approach preoccupied with issues of separate access to programmes, but did not emphasise an outcome in terms of expanding the power and autonomy of women in controlling their own lives and resources in the context of major development projects.

1. Reproductive roles refer to the bearing and rearing of children and labour within the household, while productive normally refers to income generating work. Community enhancing roles are those which promote social cohesion such as cooking or entertaining at communal events.

During most of this past decade, activists, policy makers and academics have argued for a new strategy which calls for gender equality in the opportunities of development and in decision-making processes as well as women's involvement in all spheres of life in the process of social and economic transformation. Many agencies changed the name of their programmes from WID to Gender and Development (GAD). They argued that while WID focussed primarily on women, a gender approach, focussing on the socially constructed roles of both men and women looks at people in the context of society and was better suited to cross-sectoral analysis (Rathgeber 1990; Moser 1993).

Within the International Development Research Centre, the 1995 Corporate Framework mandated that 'all research funded by IDRC must account for the differential impact that change will have on the lives of men and women'. The Expert and Advisory Services Fund instituted during that same year provided direct support to programmes to financing a range of activities including staff training and funding internships and consultants to support and promote these activities.

At the most fundamental level, IDRC's policy meant that all programme initiatives would incorporate gender issues and analysis into their respective projects. The least controversial and most basic type of analysis was the disaggregation of data into separate categories for males and females, which fitted into the classic scientific mold. The incorporation of gender analysis to provide practical needs such as improved living conditions, health care and employment enjoyed some success. However, the progression towards equity in terms of decision-making and empowerment, and thus control, largely remained elusive.

IDRC's approach to human health

IDRC's new approach to human health, ecohealth for short, is a systems approach, which acknowledges the complex relationships that exist between the biological, physical and social environment. It recognises the synergistic relationship between human activities on the ecosystem, and just as importantly the impact of changes in the ecosystem on human health. This multi-disciplinary approach includes epidemiological research on risk and impact of ecosystem stressors on human health, but within a larger socio-political and economic context which includes employment options, income distribution, and access to and management of natural resources. This new approach to improving human health uses ecosystems as the contextual entry point for assessing and improving human health. In order to be effective and sustainable, interventions will focus on better management of both natural and human resources and thus not be reliant on the classic curative biomedical approach alone.

Within this programming climate, ecosystem approaches to human health attempts to pioneer a more inclusive and holistic, trans-disciplinary approach to development. This approach recognises that gender relationships, which often are unequal between women and men, is a subset of greater social inequities which also embraces issues such as class, ethnicity/tribe, caste and age. In order to incorporate these discrete and overlapping elements of equity imbalance, an evidence-based or knowledge based approach providing a holistic description of the relevant ecosystem is needed. This will provide a framework for the design of interventions, which need to progress at a pace synchronised with the local society. The systems approach is clearly also an adaptive approach, which takes into account the impact that progressive activities, even those at the assessment phase of a project, have on the local situation. This variation on the 'Hawthorne effect' (Webster 1993) is very relevant, but not often taken into account in development projects.

More importantly, by embracing change resulting from the adoption of new ways of thinking and problems solving based on clearly presented information, options and trade-offs, inertia is overcome. This may provide new entry points for incorporating 'difficult' areas of gender into the project design. These would focus on governance and power-brokering by women in such areas as financial decision-making and natural resources management.

Within the specific context of human health, by moving this sector into an ecological setting, the provision of improved 'facility-based healthcare' no longer has a monopoly. Thus preventative activities will dominate rather than curative measures which have human costs of suffering as well as purely economic costs. This approach is a vast improvement on uncontextualised studies of individual risk and behaviour change, which lean towards, 'victim blaming'. The approach should also incorporate a variety of immediate avenues for intervention to improve human health and the ecosystem at various ecological spheres; the individual, family, household, compound or homestead, village, district and nation. These options for immediate, short-term and not only for holistic, more complex and long term solutions are extremely important because the comprehensiveness of the ecosystem approach can leave people frustrated and overwhelmed by the sheer magnitude of inter-related causal factors.

Gender analysis within ecosystem approaches to human health

IDRC's innovative approach to human health looks at how reproductive/domestic, productive and community roles of women, men and children impact both on their health and that of the ecosystem. This is a major progression from studies that focus solely on women as actors in the domestic sphere and on men's involvement in the productive sphere. Such comprehensive studies will hopefully present a more complete picture of reality as well as opportunities for creative interventions, which will mobilise more human resources to productive activity for poverty alleviation, and the improvement of human health.

Achieving such a goal requires the active involvement of all segments of society in information gathering, sharing and analysis to understand the options and trade-offs. Issues of participation and governance should consider both traditional formal and informal leadership, and new forms such as a village, ward or district management committees which were instituted by decentralisation and social reform. These issues must be presented to the community in a variety of fora for consideration.

The interactions of women, men and children with each other and with different elements of the ecosystem must be grounded by field research utilising both qualitative and quantitative methods combining rapid and long term, ethnographic research. Ethnographies documenting the life of a community at a point in time are very useful characterisations of the interaction of humans, social and cultural organisation, as well as human interaction with their physical and biological environment (some relevant ethnographies about Ethiopia are by Shack 1966; Reminick 1973; Tsehai Berhane Selassie 1984; Hirut Terefe and Lakew Woldetekle 1986; Cassiers 1988; Pankhurst 1989; Pankhurst 1992).

Opportunities within the Ethiopian Highlands Project

ILRI, and its predecessor ILCA, has a distinguished history of research using a systems approach to agro-ecosystems that the present study can draw upon. A study conducted in the Borana Plateau of Southern Ethiopia during 1980–91 by an interdisciplinary team outlined both the strategies and tools of systems research and its limitations. It also included a major section on suggestions for specific development interventions in this lowland area. The report clearly stated the necessity for specific situation analysis which include social and cultural factors because of the great social, cultural and economic diversity of pastoralists living in one region of Ethiopia (Coppock 1994).

The system discussed in the report is a rather open one, which does not focus on just the lowland range, but also includes linkages with peri-urban parts of small and medium sized urban centres and with the highlands. The strategies for sustaining the Borana lowland range include the development of peri-urban infrastructure specifically for the Borana peoples. The development of markets in the highlands for small ruminant mammals to be sold or traded for grain is also recommended. This document with its broad and well described systems approach has an extensive and varied assortment of interventions to offer in terms of strategies for improved food security, poverty alleviation and ultimately human well-being. The approach is quite generic and the document would be a useful guide for the present project.

More recently the idea of using an ecosystem approach for sustainable development of the East African Highlands received encouragement in a paper from ILRI. In this document the author calls for an 'integrative science which employs a holistic view of the (anthropogenic and natural) multiple stresses and interactions' (Mohamed Saleem 1995, p.115). In the same document, he acknowledges the necessity for community participation in this planning process by citing the historic Ethiopian precedent for land-use management through local organisations, procedures and customary rules.

The literature on Ethiopia is replete with studies on men's lives and labour, but there remains a real paucity of studies on gender and women. Part of the reason for the absence of studies on women is that the agrarian economy of Ethiopia and the political instability have focussed research on agriculture and politics, which are not perceived as the domains of women. However, their invisibility does not mean that they are not important in agriculture as their work is essential to keeping draft animals fed and watered, care of smaller animals, collection of fuel and trade. Ethiopian women contribute only a third of the agricultural labour, while their counterparts in East and West Africa contribute about 50% to 60% of agricultural labour (Whalen 1984).

Pankhurst (1992) in her study of gender, development and identity in northern Shewa, 300 kilometres north of Addis Ababa, carefully describes the differential roles of men, women and children in farm labour. According to her study, men did the ploughing with oxen, but this activity also required co-operation of women to do the crop processing and the watering of the oxen. Women performed the more difficult and less sought after jobs in livestock husbandry and work such as spinning and fuel production. This arduous and low status work demonstrated the way women were marginalised, while also illuminating their vital role in the local economy.

Coppock (1994) confirm the findings of researchers that African women are over worked. Specifically he confirms previous findings that pastoralist married women work longer hours (65% of the time between 0530 and 2000 hrs) than married men (43% of the time). They are commonly responsible for running the households, herding and other aspects of livestock care (Dahl 1987; Fratkin 1989). Naturally, wealthier women and men work fewer hours[2]. The alleviation of women's labour burdens is cited as an important goal for development both in the 1995 Beijing Women's Conference Platform for Action and by Coppock.

2. At the March 1998 meeting at ILRI, I heard that in more well-to-do families, the children of relatives would often come to stay and perform many of these chores.

Gryseels and Goe (1983) writing about daily household chores and energy expenditure for Ethiopian women in the highlands indicated that the top four activities engaging women were cooking (183 hrs per month), fetching water (91 hrs per month), collecting firewood (61 hrs per month) and collecting, preparing and drying cow dung (44 hrs per month) . The fifth most time consuming activity was going to market (20–45 hrs).

Whalen (1984) in a study of Debre Zeit, 50 km from Addis Ababa, indicates that only six percent of the population has access to clean water. Women and girls walk 30–40 minutes to a water source and as water is collected at least twice daily, two hours a day is spent in this activity.

Pankhurst (1992) comments on the complexity of gender relations in her largely Orthodox Christian, Amhara communities, which has direct implications for household composition, labour and access to land, and eligibility for various development incentives. There are six types of marriage, each with different roles, responsibilities and obligations. Although there were monogamous relationships, there were also polygamous, extra-marital relationships and separation. Divorce and remarriage were common. Coppock concurs that the variety of household composition among the Borana suggests that the term 'household' without further characterisation into household types is not a useful category for data collection or interventions.

Additional attention will be spent on Whalen's study because it does deal with issues relevant to ecohealth, food security, poverty alleviation and general human well-being in a highland area of Ethiopia. She concludes that there is a need for more information on the impact of crossbred cows on women, but adds that intra-household and inter-household processes be examined, which would include research on men and children. In particular she focuses on the specific utilisation of increased income and the impact on women's labour of new innovations.

Whalen provides some interesting suggestions for further research, which this present project may consider

- research on women's feelings about oxen as labour for making small water ponds to be used for human and animal consumption and for irrigation of home gardens
- research on increased efficiencies and income in butter and cheese making for household consumption and sale
- research to determine how increased income is spent and what kinds of health education are required for families to maximise income to improve human health
- research on use of biogas produced from animal manure as fuel to alleviate women and children's burden in fuel production.

This type of research requires different strategies and staffing. Efforts need to be made to include women in group meetings convenient for them where they will be comfortable. This may involve sex segregated meetings in homes rather than in public places. The employment of females at all levels of the research from design to field staff is essential to provide a more comfortable and encouraging environment for rural women.

Zein Ahmed and Kloos (1988) edited a huge volume on the wide range of topics associated with ecology and disease in Ethiopia. The first edition is dated 1988 and a new issue was to be out in the mid 1990s. This would certainly be an essential reference for the present project.

Conclusion

IDRC, ILRI and those organisations represented in this workshop are embarking on a very exciting research endeavour which has the potential for improving the well-being of poor communities in Ethiopia and possibly in Africa. However the mere presence of data is not adequate to change bureaucratic systems that do not understand the vision. Safelios-Rothchild (1983) observes that there are adequate statistics in Sierra Leone on the status, needs and potential of women farmers but planners and implementers, who are largely men, ignore them.

There is an old Chinese proverb, which says, 'Women hold up half the sky'. We must all work to harness this valuable human resource for the health and welfare of Africans. A systems approach which incorporates participatory and gender sensitive analysis within a consideration of larger social equity with the participation of a variety of stakeholders including community, activists, academic researchers and government is a move in the right direction for sustaining development.

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Appendix I. Gender analysis: Key concepts and issues[3]

[3]. The following documents were consulted in preparing this section of the paper: Manderson et al (1996); OECD (1998); WHO (1998).

Gender versus sex

Gender refers to women and men's roles and responsibilities, which are socially/culturally determined in contrast to sex, which refers to genetic and biological characteristics of a person. It also refers to the norms associated with characteristics, abilities and behaviours of both women and men. These roles and norms are diverse and dynamic; varying between cultures/societies and over time.

Gender is not homogenous. It needs to be further differentiated into other categories which society uses to organise social relationships, such as age, race/ethnicity and class.

Gender analysis

This examines the different disparities in the roles that women and men play, the power imbalances in their relationships, their needs, constraints and opportunities and the impact of the differences in their lives. With regard to human health, a gender analysis examines how these differences determine differential exposure to risk, access to the benefits of technology, information, resources and health care, and the realisation of rights.

Gender responsiveness, strategic interests, and gender mainstreaming

In the context of policy, planning, and research, gender responsiveness refers to a consistent and systematic response to gender inequalities and differences with the objective of achieving gender equality in access and results.

Strategic needs and gender mainstreaming are two concepts which are helpful in operationalising gender responsiveness. While gender analysis also includes women's practical needs, currently emphasis must be placed on women's strategic interests in the context of unequal gender relations and on the promotion of structural change to improve the position of women.

Moser (1993) uses the terms 'practical gender needs', and 'strategic gender needs' in reference to those terms. The integrationist, or practical approach addresses immediate basic needs, such as living conditions, health care and employment, but does not address the power differentials between men and women in society. The strategic approach, in contrast, focuses on gendered divisions of labour, power and control.

Gender equality and equity

Gender mainstreaming institutionalises ideas and practices in order to support the goal of gender equality. Gender equality is the absence of discrimination on the basis of a person's sex in opportunities and the allocation of resources or benefits or in access to services. Confusion has arisen because strictly speaking the term 'equal' means 'same.' Were the two sexes to be equal there would not be two sexes, but rather one. However, those who prefer the term, 'equality' focus on the provision of equal access to opportunities and resources for both men and women. Implicit is the ability of women and men to participate in all aspects of development, including decision-making.

Gender equity refers to fairness and justice in the distribution of benefits and responsibilities between women and men. Women and men have different need, and varying control and power to meet these needs. The disparate differences in ability to meet these needs must be addressed in a way that corrects the imbalance between women and men.

Gender equality is a more accurate term because it recognises that some men are also marginalised due to other social factors, such as class, race/ethnicity. Furthermore, everyone, men and women, need to be involved in problem-solving to redress social policies that do not contribute to sustaining ecosystems.

Most importantly, gender equality does not presume that there is one global model for gender equality. However, men and women must have equal participation and voice in determining what gender equality means in their social/cultural context and how that can be achieved through co-operation.

Issues for gender analysis

The disaggregation of data by gender is a necessary, but not sufficient activity for useful gender analysis. In any situation, health statistics, including specific health impact of different types of livelihood and lifestyle and interventions need to be disaggregated by gender and age. Toolkits or simple manuals may help the researcher ask some of the correct questions, but even those approaches require adaptation because situations differ. Below are some issues and specific questions to keep in mind when doing gender analysis. Some of the issues discussed are designed to help women, children and marginalised men feel comfortable speaking in public. Others focus on concepts such as the difference between equality and equity. Triangulation of data using different methods or ways to ask the same question is very useful in this type of research. A combination of qualitative methods along with a healthy skepticism with regard to available statistics will also help to illuminate the situation.

The gender division of labour

Societies assign different roles, responsibilities, and activities to women and men according to cultural norms. This is the gender division of labour. The work they do tends to be different in nature and in the way it is valued. These differences are central to gender relations.

Work can be put into three categories: productive, reproductive and community support and maintenance. Productive work generates income or meets basic needs, such as food, water and shelter. Reproductive work consists of giving birth and caring for children, preparing food, caring for those who are ill and teaching or providing information to the young. Community work supports the maintenance of the community both practically and in spirit. Examples include preparing for and participation in community rituals and meetings.

Access to and control over resources and benefits

Women's subordinate position can limit their access to and control over resources and benefits. In some situations, women may have ACCESS (opportunity to make use of something) to resources and benefits, but no CONTROL (the ability to define its use and impose that definition on others). For example, women may use the milk of cows to make cheese, but have no control over the money received from selling the cheese.

Influencing factors

Gender relations, including the division of labour, the type of work women and men do, and their different levels of access and control, can change over time depending on changes in the economy, environment, religion, culture, and political situation.

Condition and position

There is a difference in the day to day condition of women's lives and their position relative to men in society. Condition is the woman's immediate sphere of experience; in terms of the work she does, where she lives and gets basic needs for herself and her children such as clean water, food and education. Position refers to women's social and economic standing relative to men. It is measured, for example, by male/female disparities in wages and employment opportunities, participation in civil society, vulnerability to poverty and violence. Development activities have focussed on women's condition so they can carry out traditional roles and responsibilities, but it has been much more difficult to enhance women's position so they are better able to participate fully with men as agents of development and change.

Practical needs and strategic interests

Practical needs ensure family survival and are prerequisites to women's ability to deal with strategic interests which are key to sustainable development.

Levels of participation

Sustainable, gender sensitive policies require women's and men's involvement as participants, beneficiaries and agents of change. This involvement does not come passively, but requires strategies to overcome barriers to involvement. For example, many poorly educated women only speak in the vernacular whereas public meetings are often held in dominant, official languages. In addition, child care, separate meeting facilities from men, as well as transportation may be a requirement if women are to be involved in consultations.

Potential for transformation

Women's subordinate position is not static and is not experienced in the same way by every woman. Historically and around the world, women have challenged gender inequality and the limits it poses on their potential as human beings. Significant changes have been made through the work of women, sometimes with men's support. Examples of this are women's involvement in participatory assessments and water projects, women voting, education of women and young girls, and access to birth control.

Summary of group discussions and recommendations

Terms of reference for groups A, B and C

Thirty seven participants were divided into three groups and each group was asked to independently consider the following questions in relation to the project proposal

- are the stated hypotheses clear, valid and testable?
- are there other aspects that needed to be included as hypotheses?
- are the stated objectives clear and adequate to test the stated hypotheses?
- what technologies and policies the project needed to focus on?
- what temporal and spatial scales would be suitable for assessing sustainability of crop–livestock system improvements through technology and policy interventions?
- are the assumptions valid and realistic?
- what additional factors need to be considered for project implementation?

Summary of recommendations of groups A, B and C

The groups discussed the questions and presented their recommendations at a plenary. The principal comment from each group was that the agro-ecosystem health research need to be people-centred using a participatory approach and this needs to be reflected in the objectives, the hypotheses and the assumptions. After detail discussion on the group presentations, the plenary recommended to include a brief statement on purpose of the project and to revise the objectives, the hypotheses and the assumptions in the following manner.

Purpose

The purpose of this research initiative is to assess and improve human health through livestock and natural resource management in the East African Highlands. A community-centred, participatory agro-ecosystem health approach will be used to integrate health, agricultural and environmental domains.

Objectives

- To develop a framework to describe and characterise the agro-ecosystems at various scales in the highlands, focusing on the linkages between human, environmental and agricultural health from a community-based perspective
- To assess alternative participatory learning and action mechanisms for local people to identify and evaluate their own ecosystem health problems and to identify action plans for improvement
- To develop with all stakeholders verifiable and measurable indicators of agro-ecosystem health, linking environmental, agricultural and human health perspectives
- To assess the impacts and interactions of potential interventions on various elements and stakeholders in the system. Of critical importance will be to assess the linkages between different natural resources management strategies and human well-being including gender roles and equity.

Hypotheses to be tested

- improving natural resources management and livestock productivity will improve human health, which will positively impact on the health of all other aspects of the ecosystem (Objective 1)
- the capacity of formal and informal community institutions for assessment and improvement of ecosystem health can be improved and assessed through participatory learning and action programmes (Objective 2)
- the health of an agro-ecosystem can be assessed by a limited number of environmental, agricultural and human health indicators that can be validly measured (Objective 3)
- different interventions in the agro-ecosystem will have differential impacts on various elements and stakeholders in the system. Analysis of gender roles and equity related to these differential impacts can improve decisions on choices between alternative intervention strategies (Objective 4).

Underlying assumptions

- community and research stakeholders will actively participate in the agro-ecosystem health research process
- a manageable set of measurable indicators can be developed by this research process to meaningfully evaluate the health of the agro-ecosystem
- that this research process and some of the results will be applicable to other agro-ecosystems.

Terms of reference for groups D, E and F

Thirty seven participants were rearranged into three groups and each group was asked to independently consider the following questions in relation to the proposal

- are the proposed criteria and scales suitable to test the impacts of the proposed technology interventions, and how to correlate them to assess the impact on agro-ecosystem health?
- what should be the minimum set of indicators at each scale for assessing different criteria?
- where do the proposed technology options fit within the scale/criteria matrix (Table 1 in the proposal), where are gaps in knowledge?
- what measures need to be taken and who needs to be involved to provide/generate additional data on different criteria at various scales?
- how many sites will be required for a cost-effective validation of the agro-ecosystem framework?
- who should be the potential partners and how to establish links among the ongoing or future initiatives implementing similar framework?
- is the schedule of activities realistic and achievable?
- what should be the minimum budget for this proposal and what fund raising strategy should be adopted?

The groups adopted somewhat different approaches in their discussions to deal with the issues. Each group presented its recommendations to a plenary for discussion. The summary recommendations incorporating comments made by participants at the plenary are given below.

Recommendations of working group D

Members: Don Peden (Chair), Gianni Pastore, Alayu Haile, Abiye Astatke, Barry Shapiro, Susan Bureall Edwards, Alula Pankhurst, Hugo Li-Pun, Fitsum Hagos, Jemal Haider, Tej Partap, Workneh Ayalew

The group decided to address conceptual issues and 'gaps' in knowledge before explicitly addressing the eight questions posed for consultation.

Research approach

Appropriate participation by all relevant stakeholders is an essential prerequisite to the success of the proposed research programme. This participation must exist at all levels. The entire process must strive to be inclusive at all levels. Considerable thought and effort will be necessary to develop and apply an effective procedure that ensures effective participation by all stakeholders. Six steps are needed to carry out the research. These are

- formation of research team
- diagnosis and understanding. Before implementing any active research activity, an interdisciplinary effort is needed to enhance the collective understanding of the basic human–environment–agricultural system. This requires a review of relevant literature, appropriate use of existing research information and data, new surveys and characterisation research when necessary, and the development or use of appropriate models to describe the agro-ecosystem. This characterisation of the agro-ecosystem will include agricultural, social, and economic elements and the links among them. Special emphasis must be given to developing an in-depth understanding of the social structures, and decision-making processes particularly at the household and community levels. Appropriate and practical model(s) will be required to effectively describe and communicate the holistic agro-ecosystem structure.
- design of interventions. Although a systems approach is being taken, there is a need to test technical and policy interventions (when possible) as single interventions as well as part of multiple interventions. Testing single interventions is necessary to better understand the functioning of the agro-ecosystem and to develop models that can describe this. The impact of the multiple interventions can be first tested in an ex ante manner using the models. If they look promising the multiple interventions can be tested in the field.
- testing of interventions. On-farm testing of the single and multiple interventions is desirable. One approach to testing multiple interventions can be through validation of the models.
- monitoring and evaluation. Monitoring and evaluation of the interventions will be an essential component of the research. It will be necessary to plan for long-term monitoring and evaluation even if this activity takes place long after closure of the project.
- extrapolation and scaling up to new areas. Techniques for extrapolating from the site level to a broader range of environmental and socio-economic conditions will be needed. This will be an essential requirement in the context of the CG Centres' mandate.

Gaps in knowledge

A number of gaps in the knowledge and methodology require research. These include

- a broader understanding of the social and decision-making processes that take place at the household and community level
- a methodology for ensuring representivity of sites. There will be a need for one or a few sites where detailed data are collected on many variables and many sites where a few simple measurements are made
- a methodology for extrapolating from one or a few sites to a much larger areas
- a methodology for making cross-site comparisons
- a methodology for integration of data and information. There are several issues including appropriate data management procedures. Apart from these, integrated data collection will help prevent data collection fatigue that results when farmers are expected to assist in providing information to a sequence of unco-ordinated visitors all seeking related and often redundant data.
- ethical issues. The ecosystem approach to human health will raise a number of ethical issues. Some will be new to some stakeholders, but others must also be addressed. Key issues include
    - compensation for losses. There is a growing realisation that in the development field, that when agencies introduce a technology that results in harm or loss to the participating farmers, the agency must make provision for compensation
    - type of intervention and providing corrective assistance when problems are discovered. For example, if in the course of carrying out health research, the researchers discover that some of the subjects suffer from a serious and correctable health problem, they may have the obligation to introduce interventions to resolve it. This may force the research to deviate from the research plan in order to bring benefit to the subjects rather than completing the planned research and allowing harm to continue
    - data sharing and ownership, credit, and publications. All stakeholders (particularly researchers) must agree on a policy that ensures equitable access to data and acknowledgement for participants' contributions. Many interdisciplinary projects have failed because such a policy was not in place
    - participation by local people. Although many governments and agencies have policies governing the ethical standards required when local people are used as subjects in research, they may not be exactly the same. In particular, agricultural researchers may not have adopted the more rigorous standards that have become common in health research. Even where the standards exist, they may not always work. For example, the need for 'informed consent' is essential for many types of participatory research. However, getting informed consent is not always easy. Children often cannot give it. In many communities, one leader may speak for everyone. Often, men will speak for the women. [1]

1. In the agreement between ILRI and IDRC, there is a requirement that the ethical standards for the proposed research be presented to IDRC before the relevant research activities commence. Because ethical considerations are becoming a major issue, IDRC's intent is to engage in a learning process with other research partners. IDRC suggests that a collaborative article describing the ethical issues related to ecosystem management be prepared.

- data collection fatigue. Although previously mentioned, there is need to develop procedures to ensure that local participants do not tire of unnecessary intrusion by researchers into their lives
- improving participatory research. Great and sustained effort is needed to improve participatory research procedures. There will be a need to recruit an expert in this field if such expertise does not exist within one of the active partners. This individual must have formal training in participatory methods. Religious leaders should be included. If they embrace the mission and objectives of the participatory process, they can encourage many local people to become active participants. If they are opposed to the research and the concepts on which it is based, they can make progress impossible
- relation between policy, institutions, and technologies. Continuing attention and research is needed to encourage the creation and establishment of policy that enables effective inter-institutional arrangements and provides conditions that motivate farmers to adopt effective and relevant technologies
- grassroots indicators. Local people have the capacity to develop, identify and use indicators that describe the condition of their environment and health in a way that they can understand. Researchers need to work with local people to encourage their use of these indicators, to facilitate their use in making local action plans and to assist them to use them for assessing the impact of interventions. In addition, local indicators often correlate with the 'scientific' ones. Researchers can describe these correlations, and use them to assist in making cross-site comparisons and extrapolating from local to smaller geographic scales.

Response to questions in the TOR

1 Scale: Geographic and social

The most important social scale will be the household, but this must be defined in a site-specific context. Within households, all individuals appropriately classified by age, sex etc will be considered along with the interactions among them and the decision-making processes that they use. Aggregates of households will be important. These may or may not fit into a neat nested hierarchy, and the specific classification will depend on the structure and characteristics of the communities selected. Defining communities will be difficult, but it will be important. Groupings of individuals and households may include villages, associations, and peasants' associations. More study will be needed before selecting the most suitable units of study.

In terms of geographic scale, no numeric scales were chosen. However, whatever hierarchy of scales is chosen, it must be suited to the inclusion of households. For the purpose of this proposal, the usefulness of the Ginchi site was questioned even though it was recognised that it may have importance for the ongoing technology development work being conducted by ILRI. The larger Awash watershed was considered to be more suitable and it is expected that several 'communities' will be selected from within it. It is likely that social units may not fit neatly within the geographic scales and boundaries.

If an attempt is made to document adoption of technologies, the research will have to expand the notion of geographic and social scale to include people living outside the formal research study area.

2 Indicators

- Household measures. The inclusion of household measures of environmental condition and human well-being will be essential. These must take into account the perceptions of local people as well as formal 'scientific' indices.
- Minimum set. A minimum set of indicators is needed to avoid unnecessary costs of collection, analysis, and data fatigue. This set must be chosen after or during the diagnosis phase. Appropriate measures or indices to describe essential elements and processes that are included in any models that are used to characterise the agro-ecosystem. The indices should capture relevant local knowledge and relate this to pertinent scientific concepts.
- Time lags. Indices intended to assess interventions must take into account appropriate time spans. Some indices may describe changes over a very short period of time while others may take much longer.
- Attitudinal changes and harmful effects. Measures should consider attitudinal changes that result from interventions. Some changes will be harmful to some stakeholders even if advantageous to others. It will be important to consider the negative and positive impacts at all relevant levels in the agro-ecosystem.
- Specific indicators. It is premature to select a set of indicators if the research process is to be participatory. However, a few key indicators will likely be useful. These include:
    - time to fetch water and fuel
    - school attendance
    - investments in local clinics and other health care infrastructure
    - resilience and institutional strength and adaptability. This includes consideration of social security networks, concensus building, and dispute settlement.
- Women and children. Researchers need to ensure that gender, age and other categories that differentiate people within the agro-ecosystem are included in the survey and experimental design protocols used in this study.
- Health indicators. Taking advantage of the presence of health professionals, the group concentrate on health indicators. In general, the distinction between health and nutritional indicators was minimised. The following general indicators are suggested, but details will be worked out once the agro-ecosystem has been characterised:
    - morbidity
    - mortality
    - access to social services
    - school attendance
    - fertility
    - time budget (especially for women and children)
    - nutritional: weight, height, anthropometry, clinical (hair, eyes, neck, extremities), biochemical (Vitamin A, IDD, Haemoglobin), and dietary (24 hour survey and % of recommended daily amount).
- Economic well-being. Little time was spent considering this, but the following were considered important
    - income per hour and per unit area of land
    - off-farm income
    - gender disaggregated data
    - asset generation.

3 Fit of selected technologies in proposed criteria/scale matrix

Not addressed but see comment on 'design of interventions' above.

4 What measures to be taken for additional data?

Consultation with appropriate stakeholders to establish local priorities, to characterise the locally perceived health and environmental conditions and to determine local indicators will be needed. At all stages the process must be as inclusive as possible. Although the research process must endeavor to become fully participatory, a balance is needed to ensure that essential knowledge of specialists is not ignored.

Clear data management protocols will be needed in the terms of reference that will guide the participation of the partners. Data management must be co-ordinated and appropriate ethical standards followed in the collection, storage, use and dissemination stages.

5 How many sites?

The group recommends that several sites in addition to Ginchi be chosen. The criteria should reflect four or five key variables with one site chosen to represent the extreme range of each variable. Key variables might include population density, highland versus lowland, crop–livestock composition, and human health status. Although the intent is to be able to extrapolate to other areas within the East African highlands, this dissemination process must not fall into the trap of imposing solutions from one village on another one.

6 Partnerships

Although the present workshop made great advances in bringing diverse people together, some essential stakeholders were absent. The consultation suggested that the Ethiopian Environment Protection Authority, key decision and policy makers, Ministry of Health, and the International Union for the Conservation of Nature must be included. Regional or local government representation will also be important.

7 Is the schedule of activities realistic?

The schedule is not realistic. A long-term planning horizon is needed because it takes time to develop interdisciplinary and participatory research and the impacts will likely be of a long-term nature. Nevertheless, some exciting short-term results will be needed to maintain donor and political interest.

8 What is the minimum budget?

This issue could not be addressed during the workshop. However, it was recognised that rapid feedback to participants and their sponsoring institutions is needed to maintain and increase awareness and support for the concept of improving human well-being through better agro-ecosystem management.

Next steps

Most of the suggested points were captured during the closing session of the workshop. However, it was also suggested that there may be opportunities for researchers to learn from existing data sets and projects. For example, projects that deal with land degradation for natural resource management can be re-examined to re-interpret them in light of human health conditions. It may be possible to gain considerable understanding about correlations between the agricultural and livestock productions systems and the environment with human health.

There is also a need to avoid raising too many expectations until funding is in place for the new proposal.

Recommendations of working group E

Members: David Waltner-Toews (Chair), Robina Biteyi, Douglas Clements, Paschal Osuji, Alemu Gebre Wold, Michael Klaij, Alemu Tadesse, Samson Tafesse, Pradeep Tulachan, Michael Waithaka, Felix Kamau

The group took the terms of reference as a loose guide to debating what appeared to be the most important and substantive challenges facing the research project. The summary below is a synthesis across the two days, rather than a chronology.

Scale and criteria

Units of analysis

There was considerable debate on whether the smallest unit of analysis should be the field/ animal, as implied in the proposal, or the farm/household. In terms of a nested hierarchy, it was agreed that the smallest functional unit was probably the farm/household. Smaller units were analogous to organs in an animal, rather than animals in a herd (i.e. different types of things interact to make up a household).

Definition of household. The group then debated what was meant by a household/farm. All people under one roof? Multiple families in separate houses but with one head of household? What were the options? There was insufficient information in the proposal to refine this definition. The issue appeared to be further complicated by the fact that peasant land-holdings were scattered over a landscape sometimes over different sites. While this did not appear in the proposal, the group thought it should be acknowledged and clarified, as this has considerable implications for interpreting interactions and impacts of interventions on labour, time, energy and land use. It also needs to be accounted for when generalising from sites in Ethiopia to other countries.

After discussions both inside the group and the plenary it seemed to the group that the natural layers in the nested hierarchy above the household level were the peasant association and the Wereda. These rather than ecological boundaries were selected because the intent of the research is to identify beneficial management strategies and therefore it seemed appropriate to select management units.

The group took the three 'dimensions' of human well-being (which was understood to include health and socio-economic states, livestock and the environment) as being a useful way to separate out elements of interest to the research project. Livestock were seen to be part of natural resources, but separated from soil, water and vegetation in order to address specific research questions. Nevertheless, the terminology relating to these categories needs to be standardised and made consistent. The working matrix the group used is given below

Human well-being	Livestock	Environment
Household		
Peasant association		
Wereda		

Criteria

Having established the household as the smallest unit, the group recognised two distinct kinds of indicators at the household level: those that were peculiar to that scale (emergent indicators), and those that could be dis-aggregated. The distinction was seen to be very important. For instance, emergent household indicators of health might be distance to water source, where the children usually defecate, and whether or not the well was capped, given that defecation is probably scattered throughout the farmstead or fields. One might also use aggregate measures such as household income and disease or mortality rates. Although the interest is in the household as a unit, the way in which these latter indicators dis-aggregate provides important information about the health of the household. For instance, how is the income broken down by age and sex? Two households may have the same mortality rate (i.e. the same rating on the aggregate health scale). However, maternal mortality in childbirth, infant mortality, and adult mortality in the field are qualitatively different in terms of the interpretation given to them. In the livestock category, calf morbidity (indicator of future capacity) has different significance for agro-ecosystem health than adult (working animal) morbidity (indicator of current functioning).

The group looked in some detail at the first category of indicators for environmental integrity (soils). While some members of the group were quite happy with them, others pointed out that they were not functionally useful for farmers. The group asked if the farmers had their own indicators and were informed that farmers can classify soils by fertility, based on prior productivity, and can estimate fertiliser needs. The group then debated the broader question as to the end-use of the indicators, and the importance of having easily measurable, useful indicators at the household level. It was pointed out that some of these 'indigenous knowledge-based' indicators, such as the farmers' soil classification, may integrate several more specific researcher-based indicators, and therefore simplify general system model building. A particular kind of roof or house-type, for instance, might generally be correlated with increased wealth, better health etc.

The research project team should take the time to set out the indigenous indicators already known and which emerge during various participatory exercises and to correlate them both with each other and with other indicators, which may be of greater interest to researchers.

Steps in a research process

The group considered what might be appropriate steps in a research process to achieve the objectives discussed on the first day. The concensus was on the following:

1. characterisation of the study areas. This includes a literature review as well as interviews with key informants, traditional birth attendants and others to get a full, rich picture of the

sites. It was felt that the proposal lacked depth and/or focus in the health and socio-economic descriptions. The group further felt that this could be done by identified partners—that is, a health or socio-economic partner could be asked to do the characterisation of the research areas; this would both be a test of commitment and ensure that the review was done properly from a given perspective
2. responsible collaborators needed to be identified early in order that Step 1 could be done right and to ensure that key variables were not left out
3. since indicators are related to goals (i.e. health is measured in relation to expectations), the project needs to identify whose goals are being met. The project needs to decide who the appropriate stakeholders are. What about marginalised and disadvantaged groups? Who are they? Women, poor people? Should they be targeted? If so, this needs to be made clear from the start so their goals become part of the assessment
4. an initial set of indicators may be derived from previous research in the area or similar areas. These should be considered as guidelines for later work
5. work with community stakeholders at various levels needs to be done in order to derive functional indicators and relate them to indicators derived for research purposes
6. work with community stakeholders to explore solutions and options; this will build on information from ILRI and others. Technology options may be proposed to the farmers/communities at this point
7. both researchers and stakeholders need to develop their own systemic understanding of the situation. Then farmers, peasant organisations and Wereda decision-makers may introduce interventions at this time, in keeping with the best understanding of the system. The systems models will have allowed for predicted effects on various indicators and these then need to be monitored to determine if the models were an adequate description, or if key interactions were missing (See Waltner-Toews's presentation at the workshop for a description of this process in general).

(Note: experience in other sites such as Kenya suggests that many of the steps set out above are beyond research control, and happen simultaneously, and that researchers need to ensure that everything is done and probably revisited at various steps rather than trying to control the time order.)

Some issues arising out of the group discussion about the research steps and the proposal

1. With regard to participatory action research, the methods and procedures to be used to ensure appropriate representation need to be incorporated into the proposal. Need to get a 'professional' to address this.
2. Need a section in the proposal addressing the ethical issues and how they will be dealt with. This includes things like confidentiality, informed consent etc. Include the forms and procedures as part of the proposal.
3. Need to have a clear section addressing gender and equity issues. This should be done by someone who has the training to do this and should clearly address both possible positive and negative consequences, based on previous research and current understanding of the study areas.
4. Need to specify clearly in the proposal who the local collaborators are and what their roles in the project are. What are the roles, if any, for local NGOs and CBOs (Community-based organisations)?

5. Need to address how some of the specificities of the research area (e.g. land tenure/ fragmentation in the Ethiopian highlands) might affect the ability to generalise to other sites.
6. Should indicate in the proposal how this fits into the larger ILRI initiative to create a network of such projects to develop comparative studies.

Further comments

The group spent some time discussing possible sources of disagreement both in the project design and in the research system being studied.

A fundamental source of conflict arises from different views on the nature of the research. Health assessment is a description of the state of the system which may then be used to persuade decision-makers; this requires consultation, but perhaps not full participation. The assessment of technology interventions usually falls into this mode. This is conventional research and its role in general understanding is not in doubt. However, it inevitably runs into the problem of 'selling' research results to farmers and policy makers, whose complex many-faceted agendas and goals were not part of the assessment.

Health promotion (that is, research which seeks to promote health and sustainability) requires participation of those who will make decisions about outcomes. This is because health is related to expectations and the expectations of the decision-makers (farmers, policy-makers), which are based on their own perceptions of problems, opportunities and constraints, therefore need to be an integral part of the research process. Many researchers feel uncomfortable with this kind of activist research, and this should be acknowledged.

The group wondered about the wisdom of using both conventional and health promotion/participatory methods in the same communities. The full implications of this need to be thought through somewhat more clearly.

Beyond disagreements within the research approaches, there will be conflicts in the systems being studied themselves. As Gianni Pastore pointed out earlier, there are inevitable conflicts between different perspectives and across scales. From a research and promotion point of view, these need to be clarified and dealt with.

Some group members felt that the third dimension on the cube (effectiveness, integrity, efficiency, efficacy, equity) can be used as a guide to determine if key system characteristics are left out and/or to identify sources of conflict. (See Checkland and Scholes 1990, referred to in David Waltner-Towes's paper for definitions of some of these terms). For instance efficacy is defined as the ability of the holon (houshold, PA etc) to meet its own internal needs. Clearly, the major source of conflicting interpretations for efficacy indicators will be related to different systems perceptions by, for instance, husbands, wives and children. Understanding and resolving these conflicts requires participatory methods, as there is no scientifically optimal solution.

Effectiveness is the ability of the holon to meet the needs of the larger holon within which it is nested. Thus, this involves determining what the expectations are of the PA with regard to its member households, or of the regional government with regard to land under the control of various PAs. In these cases there will be, first of all, internal conflicts (i.e. the expectations of the larger region for the farmers' needs) to be negotiated among those with different perceptions.

This is usually the realm of politics, and involves reconciling differences among health, agricultural, and environmental policies. Effectiveness indicators can be determined externally to the holon being considered. Thus, we might ask what the national expectations for productivity, water management etc are for the Awash watershed. This requires consultation with national authorities, but not participation with local farmers.

There will also be cross-level conflicts since there is a unified regional or PA policy, though this may not be compatible with farm/household policies.

Conflicts with regard to efficiency measures will usually be embedded in conflicting perspectives of the same situation. Are we talking about economic or biological efficiency? With regard to which indicators (men's income? women's? children's? household? Nitrogen? phosphorus? Water?).

With regard to this discussion, integrity appears to be more related to the potential for health (with what natural, social, economic and human capital is the farm or area endowed? Are these resources expandable?—e.g. increasing human capital through education, or social capital through organisational strategies, both of which may offset natural resources deficiencies).

Finally, the group discussed the need to identify the rules for resolving conflicts. For instance, efficacy conflicts within households are usually resolved according to cultural norms, and effectiveness conflicts through political channels. Researchers need to ask if they believe in goals or norms which may over-ride local norms. For instance, we may believe that present cultural norms for intra-household decision-making are inequitable, favouring men over others. Or we may believe that the political rules are too dictatorial and infringe on local democratic or human rights.

It is not up to researchers to change the rules of decision-making in their study subjects. Nevertheless, it is important both to acknowledge our own biases, and to raise awareness in the community of their rules for decision-making, so that their rules are consciously chosen rather than simply accepted as given. This, it seems, would be inherent in the very idea of development and is certainly a part of agro-ecosystem health as it is for any health (i.e. increased self-awareness is an indicator of better intellectual health). In the case of agro-ecosystem health research, this critical self-awareness of biases becomes part of the learning process for both researchers and study subjects. It may therefore be useful to include somewhere in the research proposal allowance for a sociology or applied philosophy student (as was done in the Guelph AESH project) to examine the rules and biases of both researchers and subjects; this would then become an essential part of assessment of the agro-ecosystem health framework itself (Hypothesis 1 in the original proposal).

Recommendations of working group F

Members: Charlotte Neumann (Chair), John McDermott, Mamadou Diedhiou, Thomas Gitau, Barry Smit, Bon E. Cummings, Jeroen Dijkman, Asgelil Dibabe, Tekalign Mamo, Mohammad Jabbar, Robin Reid, Tsegaye Demissie, Takele Gebre

The group felt that the 'big process' had to be known before they could discuss the following issues in detail: site selection, schedules and time tables, budget, criteria and indicator selection.

The scope of the project was summarised as a dynamic system of three inter-related and interacting domains

- human well-being which includes health, nutrition and the ability to carry out the usual activities of daily living
- livestock health and their ability to be productive and perform expected functions (draft, milk production, reproductive etc)
- environment health and well-being of the environment.

Indicators

Criteria for and identification of indicators occupied much of the discussion. In reviewing Table 1 of the proposal document, the group felt that system descriptors e.g. soil type, slope steepness, topography, were mixed in with true indicators e.g. attributes that change over time with changes in the system, and that the two had to be distinguished.

Approach to selection

Community descriptors: These should be selected by the key researchers and should relate closely and likely influence the indicators (confounders or intervening variable).

General indicators: These should be non-site specific and selection should be expert-driven.

Specific indicators: These should be prioritised by the community. These will be selected and constructed jointly by both the community and by the experts, but starting with those prioritised by the community. The two groups must work jointly.

Scale-appropriate indicators within a study site

Scales governing indicator selection are: household/farm including intra-household focus on demography (sex, age, physiologic status); community (village level), watershed, ecozone e.g. highlands.

Several possibilities for delineating communities exist based on functional, locational, human, administrative, political considerations. The following considerations should be taken into account

- community structure (whether functional or locational) is to be made more precise during the characterisation phase
- there is a need to consider the 'externalities' that impact on the selected scale units
- the scale units need to be considered with respect to the potential for action/change e.g. policy legislative level.

Criteria for construction of indicators

The process for construction of criteria should include the following

- community-based characterisation is to be made by formal and informal groups. Indicators must be feasible to obtain, understandable, and a valid measure of the information to be captured
- initial analyses of common issues across communities should be carried out
- there should be integration of community defined indicators with 'expert' input from the three essential project domains, e.g. agriculture, environment, human well-being
- indicators will be used to reflect impact and to evaluate interventions (actions, policies programmes, technologies etc).

Suggestions for operational linkages with partners

Formal processes for linkages and partnerships between and among institutions will be needed. However, even greater importance will be linkages between and among individuals or small groups. Candidate institutions or entities (agencies, governmental or non-governmental etc) need to commit individuals who are to be involved on a permanent ongoing basis with a back-up person designated in absence of the lead person.

The formation of a steering committee was recommended to accomplish the following

- set the ground rules for collaboration
- define the roles and responsibilities of partners
- follow-up on commitments
- monitor and evaluate the actual collaborations.
- The candidates for the steering committee must possess the following characteristics
- experience to think in a 'systems perspective'
- ability and experience in working within interdisciplinary, multi-disciplinary team
- posses expertise, vision and perspective within their specific domain and within a broaden arena
- promotion of capacity building—individuals without all of the above attributes should be considered if mentoring from a more experienced person is available and can work as a team.

Team coordinator

It is strongly recommended that this critically important position be filled by a broad-minded individual with interdisciplinary working experience who is pragmatic, innovative and has the vision necessary to link all the domain related issues.

Gaps noted in the proposal

The background section needs a literature review inputs and rationales for the following areas

Human well-being, health, nutrition

Particularly needed is how human well-being interacts with the environment and with agriculture/livestock, examples of possible positive and negative interactions should be given and a simple model or diagram drawn. A thumbnail sketch of the common health and nutrition problems in the highland area is needed. The impact of HIV/AIDS on agriculture should be included if possible.

Gender

The literature and background on gender issues as these interact with health, nutrition, environment and agriculture and social, economic factors are sorely missing. This section should be written by an 'expert' and not given superficial treatment (tokenism or 'window dressing'). Areas of household decision-making, income generation and its control, work, time allocation, reproductive risks need to be included.

Social-cultural input

Factors, structures and how they operate within the three domains are absent in the background material.

Community expertise

A section is needed on methodology and approaches to community participation and working with communities in partnership.

The areas described above should be written by 'experts' who are recruited as part of the team or at least by 'experts' who are engaged to fill in the gaps in the proposal preparation.

The need for linkages among various AESH projects was stressed.

Domain areas and expertise that must be strengthened

Although the existing roster of scientific expertise is good there are serious weaknesses and gaps. These are in the following areas: environment; human well-being which includes community and public health, preventive/promotion health oriented; nutrition which is community oriented and applied and includes nutrition education, biochemical nutrition will be used as validation tool; social science, community participation approaches, gender issues.

Funding

1. A core fund is needed to co-ordinate and jumpstart the initial process
2. Funds are needed to support special expertise to deal with issues as they arise.

The expertise badly needed are gender, community health (public health), community participation and community-based approaches, sociology.

Possible funding sources include: USAID missions, Winrock International, BMZ, Rockefeller Foundation.

Possible partner institutions

The list of suggested institutions is useful but opportunities should be left for partnership to develop, expand and respond to needs. As a start, suggested institutions are: Ethiopian Environmental Protection Authority, universities, Ministry of Agriculture, Ministry of Health, Ethiopian Health and Nutrition Research Institute, AMREF, UNICEF, NGOs e.g. Save the

Children, Christian Children's Fund, World Vision, Plan International, USAID, GTZ, SIDA, Winrock International, African Leadership Education for Women in Agriculture.

IDRC–ILRI workshop on agro-ecosystem health 11–15 May 1998

Programme

Monday, 11th May

08:00–08:30 Registration

08:30–11:30 Field trip to Ginchi Co-ordinated by **Abiye Astatke**, ILRI

11:30–13:00 Leave Ginchi to Holetta and visit dairy/draft farmers

13:30–14:00 Lunch at EARO Livestock Research site, Holetta

14:00–16:00 Return to Addis: Visit Ethiopian Health and Nutrition Research Institute

16:30–Arrive ILRI campus

Tuesday, 12th May

Session 1: Conceptual issues

Chairperson: David Waltner-Toews, University of Guelph

08:30–08:50 Welcome to ILRI and workshop objectives **Hugo Li Pun**, Resident Director and Director of Sustainable Production Systems Programme, ILRI

08:50–09:10 Ecological approach to agricultural production and ecosystem theory **Gianni Pastore**, Istituto Nazionale Nutrizione, Italy

09:10–09:30 Concepts of sustainability and application to agricultural production **Barry Smit**, University of Guelph

09:30–09:50 Natural resources management and human health **Don Peden**, IDRC

09:50–10:20 Discussion

10:20–10:45 Coffee/tea and photograph

Session 2: Conceptual issues (continued)

Chairperson: John McDermott, ILRI

10:45–11:15 Agro-ecosystem health concept and application **David Waltner-Toews**, University of Guelph

11:15–11:45 Application of AESH concept in the field **Thomas Gitau**, Univ. of Nairobi

11:45–12:15 Ethnographic experience in AESH studies **Bertha Mo**, IDRC

12:15–12:45 Discussion

12:45–14:00 Lunch

Session 3: Country case presentations

Chairperson: Asgelil Dibabe, EARO, Ethiopia

14:00–15:30 Research and development experience linking crop–livestock system

improvement, natural resources management and human health

Ethiopia: EHNRI, EARO, MOA, SG2000, AAU

Kenya: KARI, MOA

(Each institution will make a 15 minutes presentation)

15:30–16:00 Discussion

16:00–16:30 Coffee/tea

Session 4: Regional perspectives

Chairperson: Don Peden, IDRC

16:30–16:50 Promoting production system and natural resources management improvements for better human welfare: East Africa, **AMREF**

16:50–17:10 Development experiences of the livestock production systems of HK-Himalayan region: Some lessons and some pathways for other regions, **ICIMOD**

17:10–17:30 Regional research consortia for highland agricultural development: AHI perspectives, **AHI**, ICRAF

17:30–17:50 Livestock development and impact on human health: CRSP experience **Charlotte Neumann**, University of California

17:50–18:15 Discussion

19:00–20.30 Cocktail—Resident Director

Wednesday, 13th May

Session 5: Development of research proposal

Chairperson: Tej Partap, ICIMOD, Nepal

08:30–09:00 ILRI involvement in research consortia: Technologies for highland development **Mohamed Saleem**, ILRI

09:00–09:30 Proposed framework for sustainability of improved technologies in the highlands and proposal for future work **Mohammad Jabbar**, ILRI

09:30–10:00 General discussion and formulation of working groups

10:00–10:30 Coffee/tea

10:30–12:45 Working group sessions (Groups A, B and C) (Objectives and hypotheses, Scale and assessment criteria)

12:45–14:00 Lunch

14:00–15:00 Plenary session: Reports from the Moderators of Working Groups A, B and C and discussion

15:00–15:45 Coffee/Tea /Proposal drafting committee meeting (Synthesis and preparation for the next plenary session)

15:45–16:15 Plenary session: Agreement on objectives, hypothesis etc. Formation of new working groups D, E and F

16:15–17:30 Working Group sessions D, E, F

Thursday, 14th May

08:30–10:15 Working Group sessions continued

10:15–10:45 Coffee/Tea

10:45–12:45 Working Group sessions continued

12:45–14:00 Lunch

14:00–15:00 Plenary: Working Group presentations and discussions

15:00–15:30 Coffee/Tea

15:30–17:30 Project drafting committee working session (Other participants may visit Addis Ababa town)

19.15–Ethiopian Gala Night: Crown Hotel

Friday, 15th May

08:30–11:00 Project drafting committee: Proposal finalisation (Other participants: Tour of ILRI facilities)

11:00–12:15 Closing session

Don Peden, IDRC

Hugo Li Pun, ILRI

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