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Chapter 6

COMMUNITY BASED INDICATORS FOR SUSTAINABLE DEVELOPMENT : A FRAMEWORK AND AN APPLICATION IN AN ETHIOPIAN COMMUNITY

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ABSTRACT

Development is a human problem aimed at enriching the quality of people's lives through behavioural transformation and environmental stewardship. Throughout history, human societies have evolved and developed by acquiring and applying new knowledge to increase output, income and other aspects of welfare. However, poverty and malnutrition are still major problems in a large part of the globe and the socio-ecological sustainability of science-based agriculture and rural development efforts in the areas of health, education, nutrition etc are being questioned. Such questions arise because of the ineffectiveness of approaches that emphasize food security as the primary vehicle for improving rural people's welfare and of the various partial or disjointed efforts in education, health, nutrition and infrastructure development. Many integrated rural development efforts have also been unsustainable as they are often top down and not participatory. It is argued that improving human well-being and promoting sustainable and convivial human communities requires a holistic and integrated approach that links agroecosystem management, agricultural practices and human nutrition, health and well-being. Moreover, the people and the communities making key decisions about technology and policy choices and their outcomes must participate fully in the research and development process rather than merely as recipients of research results, development ideas and resources from outside. Such an approach should also recognize that a community may contain people with a variety of non-equivalent perspectives on issues that concern them and their welfare, so whose perspectives are considered, how they are

incorporated in the research and development process will determine the outcomes. The aim of the participatory approach should be to reconcile these various perspectives for maximizing the welfare of the community at large. In this paper, the basic principles of this approach are outlined and the outcomes from the application of the approach in a rural Ethiopian community are described.

Keywords: *agroecosystem health, participatory research and development, transdisciplinary research, community perspective, human welfare*

INTRODUCTION

Poverty, malnutrition, low agricultural productivity and resource degradation are major problems in much of the developing world. Inappropriate crop, soil, water and livestock management practices continuously exacerbate these problems. The expected increases in the population in the coming decades and increasing urbanization in the developing countries are not likely to be matched by crop and livestock production with current management practices (Rosegrant et al., 2001). This has serious implications for sustainable development and achievement of the millennium development goals in terms of human nutrition, health and welfare. Sustainable development is as much about increasing productivity and incomes for the current generation using current resources as it is about preserving the stock and quality of these resources for the benefit of future generations. If in order to maximize current productivity, resources are used in such a way that they are severely depleted and degraded, soon productivity improving efforts will be ineffective to maintain long-term productivity and meet needs of the increasing population. Therefore sustainable development requires choice of appropriate technologies and supporting policies to enable prudent long-terms management of the natural resource base on which agriculture fundamentally depends.

In the empirical measurement of sustainability, biophysical scientists have used changes in soil quality (N, P, K, organic matter levels), biodiversity and vegetation density, and water quality as indicators (e.g., Frye and Blevins, 1989; Flach, 1990; Xu *et al.*, 1992; Faeth, 1993). These indicators have been generally measured at plot or farm level and rarely at higher geographic levels. On the other hand, economists have used changes in total factor productivity at enterprise, farm or other higher level aggregation to assess sustainability (e.g. Lynam and Herdt, 1989; Ehui and Spencer, 1993; Islam, 1996; Ehui and Jabbar, 1997). Both sets of indicators are partial measures of sustainability as none of them fully capture the changes in the quantity and quality of resources and their outcomes for human welfare. Few attempts have been made to combine both sets of indicators, assess their interactions and implications for sustainability in a holistic framework, and apply them at various decision making levels such as the farm, the watershed or the community (Becker, 1997).

The UNDP's Human Development Report for 2001 states that during 1975-99 there has been a substantial shift of the world's people from low to medium and from medium to high levels of human development yet human development challenges remain large in the new millennium as across the world, millions of people are suffering from unacceptable levels of deprivation in many aspects of life (UNDP, 2001). The Human Development Index is constructed by linear aggregation of some indicators or criteria - longevity, knowledge and a decent standard of living plus human poverty index, gender-related development index and

gender empowerment measure- without regard to possible trade-offs among different criteria e.g., emphasis on longevity at the expense of quality of life. Consequently it does not consider the degree to which the 'better-off' countries are borrowing from the future through unsustainable exploitation of the world's natural resources. These criteria or indicators are outcomes of human activities and choices made to utilize natural, economic, human and social resources but the indices themselves do not automatically explain how the activities are organized and the choices are made in a country or society.

The report recognizes that "human development is about ...creating an environment in which people can develop their full potential and lead productive, creative lives in accord with their needs and interests. ...Development is thus about expanding the choices people have to lead lives that they value. ...Fundamental to enlarging these choices is building human capabilities – the range of things that people can do or be in life. The most basic capabilities for human development are to lead long and healthy lives, to be knowledgeable, to have access to the resources needed for a decent standard of living and to be able to participate in the life of the community" (UNDP, 2001). Though, participation in the life of the community is recognized as a major indicator of human development, this is not included in any of the indices apparently because of lack of adequate data of this nature. In reality, participation may be more a means than an end in human development. How human activities are organized and the choices are made by a society, especially at the local level, may ultimately determine the degree, pace and distribution of human development.

So many people still suffer from deprivation in spite of many efforts in the areas of health, education, nutrition, rural development and science-based agriculture largely because of the partial and dis-jointed nature of these efforts, and the lack of participation of local people in making choices that affect their lives and livelihood. If the remaining large challenges of human development and well-being are to be addressed properly, a holistic and integrated approach to human life and work has to be taken with adequate and appropriate attention given on participation of people in charting their own destiny. In this paper, the basic principles of this approach are outlined and the preliminary outcome from the application of the approach in a rural Ethiopian community is described.

THE THEORETICAL FRAMEWORK: A COMMUNITY BASED PERSPECTIVE ON HUMAN DEVELOPMENT

The Human Development Report emphasizes the need for 'building human capabilities – the range of things that people can do or be in life' as a means to enlarge people's choices to improve human well-being. From a practical and operational point of view, several questions arise. What does building human capabilities mean, particularly at the individual and local community level? What is the scope of such development? Who is responsible for building such capabilities and how? To what end? Only material gain or also spiritual? Most theories of collective action are based on the dominating economic principle of working together to seek personal gain but people's willingness to serve neighbours and others without expectation of any material gain is embedded in local cultures and institutions, which are the foundations of social capital. These questions arise because many development projects in health, education, sanitation, agriculture and rural development have been designed and

implemented in isolation from one another, sometimes without consideration of externalities, i.e. positive or negative consequences of one spilling into the other. Also such projects have been designed on the assumption, more often implicit than explicit, that individuals and communities were incapable of diagnosing their own problems and needs, defining and finding solutions to their problems or that they lacked the resources required to solve those problems. The unsustainability of many such projects may be largely explained by these assumptions.

In reality, building human capabilities to widen their choices requires two main considerations. First, a holistic and integrated approach to people's life, work and well-being as human activities take place within a complex mess of multi-scalar, multidimensional interactions. For example, the WHO defines human health as "the physical, social and emotional well-being of an individual and not merely the absence of disease and infirmity". This definition implies that improving health will require dealing with an agenda much broader than health per se to include water, food, agriculture, nutrition, environment and income, among others. People's health and well-being is basically determined by the agricultural and natural resources endowments available to them, the environments or ecosystems in which they live and from which they derive their sustenance. Even where rural communities produce goods and services using technology and inputs from the market and sell part of the output to the market, they may expose themselves to risks of diseases, price and market variability, which may undermine the locally based foundations of good health. Therefore, improving human well-being and promoting sustainable and convivial human communities will require a holistic and integrated approach that links agroecosystem management, agricultural practices, human nutrition, health, sanitation, education, and markets and policies.

Second, a recognition that individuals and communities have inherent capabilities to assess the condition of their own ecosystems and problems, and find solutions to a certain degree based on available resources but such capabilities can be enhanced through education, training, dialogue and participation. The people and the communities making key decisions about technology and policy choices and their outcomes must participate fully in the research and development process, in the diagnosis of problems and possible solutions rather than merely as recipients of research results, development ideas and resources from outside. A community usually contains people with a variety of non-equivalent perspectives on issues that concern them and their welfare, because of age, sex, religion, ethnicity, wealth status inter alia, so whose perspectives are considered and how they are incorporated in the research and development process will determine the nature of outcomes. For example, without incorporating poor people's perspectives in designing research and development agenda and strategy, poverty alleviation efforts are unlikely to be very effective. The aim of the participatory approach should be to reconcile these various perspectives by the stakeholders themselves for maximizing the welfare of the community at large.

Generally, integrated rural development projects have been designed in the past by deriving principles from the social sciences, and sometimes from both social and some of the other sciences. However, in order to pursue a holistic, integrated, community based participatory approach to human development, as described above, a framework or paradigm is required that is transdisciplinary and follows a systems approach in which people are considered as part of their ecosystems. Transdisciplinary approach starts from the premise that any problem or complex reality can be viewed and interpreted from a variety of non-

equivalent perspectives; within each perspective a problem or reality can be understood from a range of spatial and temporal scales (Rosenfield 1992; Smit et al 1998). Ecosystem health paradigm provides such a framework. The word 'health' is used here as a metaphor. Health is generally defined in terms of current overall functioning of an entity and its capability to deal with future stresses. The goal of health is flourishing, that is, the creative expression of a group or individual's genetic and social potential. 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. Therefore, the term is amenable to use in the context of socio-ecological systems (Smit et al., 1998; Waltner-Toews et al., 2000).[1]

The principal characteristic of ecosystem health approach to human well-being is that it considers people as part of their agroecosystems. An agroecosystem can be defined as a geographically and functionally coherent domain of agricultural activity, including all living and non-living components and the interactions among them. Determining its precise physical boundary is rather arbitrary and depends on the purpose of the analysis. In reality, populations of smaller agroecosystems are nested in a hierarchy of larger systems e.g. fields, farms, communities, watersheds, regions, countries and ecoregions. Agroecosystems interact with each other and as such are not closed systems (Peden, 2000). At each level, "it is a holistic, structural-functional construct of agricultural activities which internalizes all of the complex socio-economic, political, human health, biological and environmental interactions among the elements of which it is comprised" (Waltner-Toews and Nielsen, 1995).

The second feature of the ecosystem health approach is that the stakeholders, i.e., people living with the agroecosysem and other outsiders who have a stake in it, are in the best position, and are responsible, to characterize the system and its dynamics, to identify the needs, potential interventions and likely implications. Involvement and participation of stakeholders at all levels is the key to develop sustainable agrocosystems (Smit et al., 1998). While characterizing the agroecosystem and its health, and designing interventions for improvement, the indicators of health of the human (individual, family, community) and biophysical (natural resources, ecosystem, agricultural practices) dimensions of an agroecosystem are considered. The indicators are yardsticks by which the quality of an agroecosystem is measured or assessed including how it changes over time, varies across space, and responds to external factors.

Identification of operational and measurable indicators of agroecosystem health at the local level at a point in time is an empirical issue and may be community specific to some extent because indicators developed by scientists and experts using standard scientific concepts and jargons may have little meaning for the local people whose participation and involvement is essential for identifying, measuring and testing indicators (Smit et al., 1998). For example, Human Development Index (HDI), Human Poverty Index (HPI) and Gender Development Index (GDI) are constructed on the basis of three dimensions of human development at the national level – longevity, knowledge and decent standard of living, each having specific quantitative indicators or meaning within each index. To a local community,

[1] Based on a major review of past integrated natural resource management research agenda and approaches it has been concluded that to meet the challenge of poverty and environmental sustainability, research will need to embrace the complexity of systems by redirecting the objectives of research toward enhancing adaptive capacity, by incorporating more participatory approaches, by embracing key principles such as multi-scale analysis and intervention, and by the use of a variety of tools. Integration across scales, components, stakeholders and disciplines will be key to the new approach (Sayer and Campbell, 2002).

these three dimensions may or may not be the most important or relevant for assessing human development, if one or more is important or relevant, the quantitative indicators or their meanings may or may not be relevant or the same as that at the national level. For example, percentage of people not using improved water sources has been used as an indicator of human poverty, but for a local community, the definition of 'improved water sources ' may depend on what is available at present and what may be feasible in the near future.

Pragmatically, one may start with community-based and community preferred criteria and indicators for assessing ecosystem health, and match them with equivalent standard scientific criteria and indicators for assessing improvement and sustainability. For example, a community may have its own qualitative criteria to judge water quality and adequacy, which may be compared with a public health worker's standard criteria or of the national government's criteria; a soil scientist may use N, P, K and a host of other indicators to assess soil quality but the local community may have their own criteria which may match the soil scientists' standard criteria; a community may have its own criteria for defining the 'decent standard of living', which may or may not be equivalent to one or two dollars income. Communities themselves may be better able to assess both problems and progress made with interventions if it is done on the basis of their own perceived criteria and indicators. With experience, communities may find that good indicators of ecosystem health are good indicators of sustainability (Becker, 1997). This way they may also enhance their own capacity to diagnose problems, identify suitable solutions and seek them, rather than fully depending on external professional help to identify problems and external resources to solve them.

From the foregoing, it may appear that the theory and application of ecosystem health paradigm may involve concepts and processes, which may be found in many other participatory approaches to sustainable development. Therefore, the paradigm itself may not be considered unique rather as a systematic organising framework incorporating ideas and concepts from different approaches.

An Application of the Approach: The Case of Yubdu Legabatu in Ethiopia

Evolution of the Agenda : From Vertisols Management to Agroecosystems Health

The Yubdo Legabatu Peasant Association (YLPA)[2] is located about 80 km west of Addis Ababa in the Dendi wereda (district) of Oromiya region. The PA covers an area of 2500 hectares and had a population of about 5000 in 845 households in 1998. The landscape is undulating with relatively flat bottomland, a large portion of this being vertisols (land type A), moderately slope land in the middle (land type B) and steep slope land at the top (land type C). Of the total households, 270 were located in land type A, 135 in land type B and 440 in land type C. A government forest that originates in nearby communities over the hill continues into the upper part of land type C. The forest was once very dense. Harvesting for

[2] Peasant Association is the lowest tier of civil administration in Ethiopia.

industrial use and poaching by nearby communities for wood and fuel has depleted the forest. Even now, this is a major source of fuel wood for the YLPA community. Loss of vegetative cover has made this land type highly degraded. An analysis of aerial photos of a transect of the community taken in 1957 and 1994 shows that in 1957 about one third of the land area was under crop, the remainder was under forest, pasture and other uses while in 1994 the use pattern had completely reversed as 68% of the land was under crop. The length and breadth of the gullies, the principal form of soil erosion, also increased 14 times between the two periods. This is a general indication of the seriousness of the community's land and agricultural problems.

In order to address some of these problems, the Joint Vertisol Project (JVP) started some work with the community in 1989. The JVP was a consortium comprising the Ethiopian Agricultural Research Organisation (EARO), Ministry of Agriculture, International Livestock Research Institute (ILRI) and the International Crops Research Institute for the semi-arid Tropics (ICRISAT) as partners. The JVP was formed in 1987 in order to develop technology for better and more productive use of vertisols and contribute to reduce, if not eliminate, poor Ethiopia's huge food deficit. The reason for targeting vertisols management as a priority option was prompted by the fact that out of about 12 million ha of vertisols in Ethiopia, only about 30% are used because these productive soils suffer from poor internal drainage and resultant waterlogging during the rainy season consequently they remain under utilised and less productive. Traditional management systems of vertisols also lead to severe erosion. The consortium developed a technology package that helps better drainage and gives higher crop yields and less erosion than traditional vertisols management practices. After on–station trials, the JVP chose YLPA as one of the five field sites in 1989 for on-farm testing and evaluation of the technology package. This testing was done in partnership with the farmers in the community and the YLPA executive committee. The Dendi wereda bureau of agriculture was also an active collaborator.

During 1989-97, out of 845 households, a total of 200 participated in a large number of trials, not everybody participated in each trial in each year. Some of the trials were complementary to the vertisol package, e.g. feed production in combination with vertisol technology, suitability of multipurpose trees in the farm system. The primary focus of these trials was to assess the biophysical and economic performance of the technologies, their effects on yield, income, labour and other resource use, resource requirements e.g. credit; their potential for adoption and pathways of adoption. However, these component technologies were initially tested mainly at the scale of animal, plot, farm and microwatershed, and often separately. A component technology intervention on a farm could generate different degrees of change, either positive or negative, in other parts of the farm system. Similarly an intervention on the vertisols part of the landscape could generate changes in the use pattern and consequent outcomes in other parts of the landscape. These and the multiple interventions and their integrated effects were not fully assessed, especially, the ultimate impacts of these technologies on food security, human nutrition and health, and resource conservation were not initially assessed. It was also evident that solving vertisols management problems was perhaps not the highest priority for everyone in the community as farmers living in different parts of the landscape could potentially face different types of problems (Jabbar et al., 2001)

However, these deficiencies of the assessment process and the need to look at the effects of technology intervention beyond the immediate or direct outcomes led the JVP research

team over time to recognise that nutrition, health, economic and other well-being of rural people depend primarily on the quantity and quality of natural resources they have access to, and the agricultural, public health and sanitary practices they employ to exploit those resources. For example, access to inadequate and degraded land leading to insufficient and poor quality food production may lead to food insecurity and poor nutrition; inadequate and poor quality water, inadequate and poor quality housing and living conditions, inappropriate sanitary and public health practices may lead to poor health; and poor nutrition and health may lead to reduced capacity of people to engage enough energy to produce food they need and lead a full and rewarding life. These potential inter-linkages imply that increased food production through vertisols technology or other means was necessary but not sufficient for improving people's well-being, and that any intervention in any aspect of the ecosystem could generate not only additive but multiplicative effects on output and income as well as on human health, nutrition and ecological welfare. There was, therefore, a need to apply a more holistic, participatory and integrated approach to research and development than had been done previously, and an appropriate research paradigm or analytical framework was also needed to undertake such integrated research. Ecosystem health paradigm developed and tested by the University of Guelph, Canada (Smit et al., 1998) was considered a suitable candidate for testing. The extended work was started in 1998.

Application of the Agroecosystem Health Framework

The application of the ecosystem health framework required several steps:

- Identification of beneficiaries and stakeholders in the YLPA community
- Stakeholder characterisation of the agroecosystem in the community
- Identification of ecosystem health indicators
- Validation of some indicators
- Analysis of linkages among indicators
- Identification of possible interventions and their implementation.

These steps were followed in an iterative manner: the initial characterisation was re-examined once health indicators were identified and verified; once linkages were established among available indicators and data gaps were identified, the charcterisation had to be modified; once interventions were identified and implemented, the initial assessment of problems and constraints were to be repeated to see what other changes would be required, and so on.

Results and Discussion

Identification of Beneficiaries and Stakeholders

The people living in the YLPA are the principal or direct beneficiaries as well as stakeholders. Like any other community in the country and elsewhere, the members of the

YLPA community have for generations done things for their own good and upliftment. They have also developed various informal institutions as social capital to help them in their individual and collective efforts. Also various formal agencies have been providing support, services and resources for their development. All of these are stakeholders in the community's welfare. However, not all stakeholders and beneficiaries were initially identified and involved in conceptualising this approach. The JVP, some other agencies with whom the JVP worked, e.g., the Ethiopian Health and Nutrition Research Institute and Addis Ababa University, and some farmers who participated in JVP trials, initiated the discussion. As the group widened their understanding and scope of the agenda, new stakeholders were identified and invited to join the group. Apart from the JVP and its partners, some of the other stakeholders identified and involved in the project include the YLPA executive committee, the Dendi wereda administration and its several bureaus e.g. agriculture, education, public health, forestry, police, and two NGOs including a church.

It was apparent during stakeholder discussions and meetings that these and other agencies servicing YLPA and other communities designed their projects, programmes and interventions in isolation from one another. In a few cases there were some collaborative activities between two or more agencies but those were also very minor and would not qualify for any definition of integrated development approach. It was unclear if these agencies were addressing the priority problems and needs of the community as they were rarely or highly inadequately involved in the identification of problems and in designing interventions. The result was that the community was often confused about what to expect from where, and they responded principally on the basis of what an agency would bring to them. So long as there was some benefit for them, they participated in the implementation of any project or programme though it might not address their most important problem. It was therefore necessary to involve the beneficiaries and stakeholders in characterising the agroecosystem of the YLPA.

Stakeholder Characterisation of the Agroecosystem

The stakeholder characterisation of the agroecosystem in the YLPA required an evolutionary process. One of the first tasks was to identify the various domains within the community and their components. Initial discussions with formal and informal community leaders as well as local institutional stakeholders indicated that the farmers saw their life, work and well-being being influenced by where they lived, what natural resources (land, water and forest) they had access to, their own assets (labour, livestock), the market and price of goods they sold and bought, the kind of support they got from government and other agencies, and the weather. While they saw some obvious link among some of these elements, they did not consciously divide the domains and their linkages in an orderly or systematic way. So it was decided to approach the construction of the structure and organisation of the overall agroecosystem of the community with its participation from two angles: describing the components, then linking and aggregating them, and describing the principal domains as defined above and looking for their components.

A mixture of participatory tools were used to build the community agroecosystem, which consisted of three principal domains: ecosystem or natural resources comprising land, water resources, and forest/trees; agricultural production system comprising crop,

livestock and homestead garden and tree production; and human well-being comprising housing and sanitation status, and human nutrition and health status (Figure 1, read without the linkage arrows). Policies, markets and institutions was an important domain outside the community but closely linked with the community. A map of the informal social organisations, which cuts across these domains, was also generated. These institutions vary in their specific objectives, capacities, influence on members and functions such as associations for burial, credit, and social activities, dispute settlement as well as for resource allocation and management. Some specific informal institutions in the community are described in ILRI (2002).

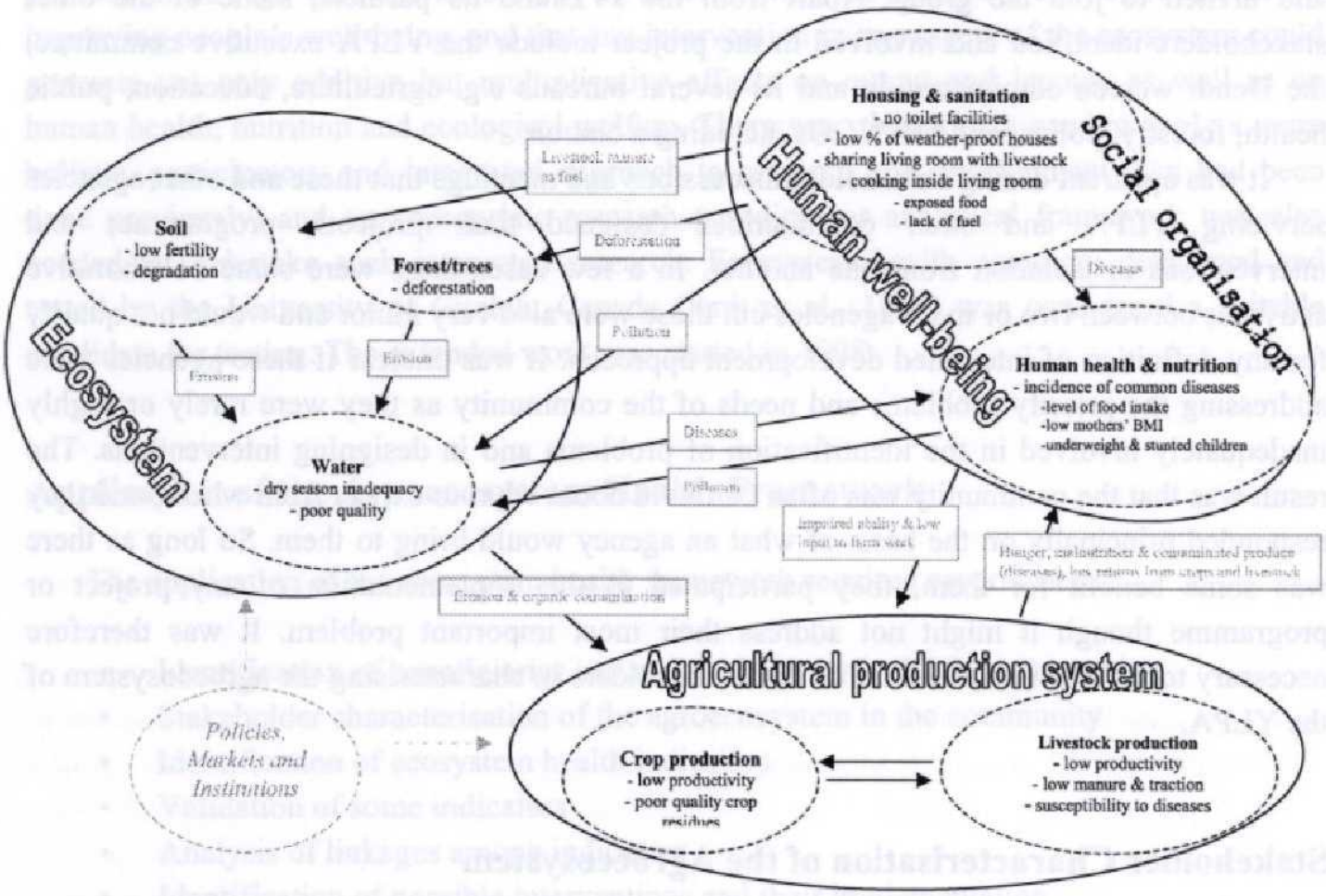

Figure 1. Agroecosystem of the Yubdu Legabatu community, Ethiopia

Some important points that emerged from the characterisation process are as follows:

- Although YLPA is a relatively egalitarian community compared to many developing country situations, yet there are significant differences between wealthy and poor households within the community. Relations between households are mediated through sharecropping, exchanges of land, labour, and capital in the form of livestock. Inequalities are also often partly based on generation with the older generation controlling access to land resources and younger generation having restricted access due to prevailing land laws.
- The community considers livestock, especially draught oxen, as the principal determinant of wealth status of a household and land does not really feature as a criterion though crop production is the principal source of livelihood. There are two

main reasons for this. Land in Ethiopia is a public property, farmers have only usufruct right and theoretically allocated land can be taken away anytime for redistribution among newly formed households, thus creating a degree of uncertainty. Also land was distributed by the *derg* regime on a per capita basis, so there is no real difference in land ownership. On the other hand, livestock is a private property, which can be sold and bought at will, and the number of draught oxen owned greatly influences a household's ability to derive output from cropland. Ownership of other livestock is not based on land as other than crop residues, feed is also derived from common land, roadsides and other such places.

- The community identified three categories of households namely, rich, poor and those in between (medium). Rich households were those that owned more than a pair of oxen and other livestock. Medium households owned a pair of oxen while poor households were those that had one ox or no ox or one or two young bulls. An open discussion and classification of all the households by a representative group of community members revealed that about 45% of the households in land type A were ranked as rich against only 5% of households in land type C .
- Like other societies of the highlands, YLPA community appeared to be culturally diverse with the population consisting of different ethnic groups. While Oromo, Amhara and Gurage are said to be the common ones, there are other groups such as Kambata and Tigre. Non-Oromo residents were said to have come to the area during Italian occupation to work in a wood-milling factory in the nearby village and for harvesting trees from the forest for the factory. After the Italians, different foreign companies successively contracted and kept the mill running until the revolution of 1974. After the contractors left, the ex-workers of the wood mill stayed behind. The 1975 land proclamation granted land to these workers for settlement in and around the forest. Currently, the heterogeneity of the residents of the PA, especially those living by the forest (land type C) is attributed to this historical fact. Although the original settlers have accepted the newly settled groups into the community, there was also an apparent feeling that without them the land pressure in the community would be much less.
- During the villagisation programme of the *derg* era, a central village was established within the community and many households were resettled there, though some were allowed to stay where they were. The present government gave people the option to go back to their original location, so most of the households moved and rebuilt new houses, some at their original sites and some at new sites. The process is still on-going. At this stage, it is unclear which households were affected by the villagisation and de-villagisation programmes, but an understanding of this might be necessary to appreciate peoples' behaviour in relation to some issues e.g. deforestation/removal of homestead based trees, recent replanting of trees etc.
- The traditional predominance of male values and interests tends to restrict the role of women largely to the domestic domain, although women are observed to play a crucial role in certain agricultural activities and especially in livestock rearing and the production and processing of livestock products, and for collecting fuel wood and water which are scarce in the community, so the burden on women increases. Therefore, introduction of any new technology or natural resource management

strategy may change gender roles in the household and in the community with consequent changes in their welfare: in some cases positive while in others negative.

Identification of Agroecosystem Health Indicators

Once the community agroecosystem – its domains and components- were identified, the next task was to identify appropriate indicators of health for the various components. However, when the issue of identification of indicators for different components of the agroecosystem was raised with the stakeholders in formal and informal discussions, precise or clear descriptions were not forthcoming from the villagers and the local institutional stakeholders. When in repeated meetings and discussions rather than directly referring to health indicators, they were asked to indicate what was good or bad about a system component that influenced their life and living, or what was the problem or constraint to achieve a better life and living in relation to that component, the community identified a general list of problems/constraints without ranking them in any order.

- Food shortage
- Feed shortage
- Increased severity of Malaria, especially in the last 2 years
- Inadequate potable water in dry season, lack of water harvesting techniques for domestic and agricultural use
- Elementary school not available in the vicinity
- High livestock mortality, especially last two years due to Anthrax and other diseases
- Inadequacy of improved seeds, fertilizers and credit, lack of fertiliser rates for specific soil types and crops
- Insect, pest and diseases of crops, lack of suitable improved varieties of crops, weeds in crop fields
- Soil erosion and gully formation, waterlogging
- Incidence of measles, night blindness and water borne diseases
- Collapse of local institutions, e.g. *idir,* due to high expenditures
- Lack of forests and trees

Though food shortage has always been mentioned first, the problems cut across almost every aspect of life including health, education, technology for crop and livestock production and natural resource management. The community and other stakeholders used these general and agricultural problems and constraints as a basis to define a set of health indicators for different components of the agroecosystem (Table 1). Obviously some of the indicators were not precise enough for quantification and they also did not match with any standard definition used by professionals and development agencies such as UNDP but they conveyed the meaning or essence quite well for general understanding of what the community considered as healthy and desirable.

Table 1. Agroecosystem health indicators identified by stakeholders in Yubdu Legabatu community

Domain	Component	Indicators (and remarks)
Natural Resource/ Ecosystem	*Soil*	– Fertility (nutrient status), erosion/degradation, crop yield – Length of fallow period possible, ratio of cultivated/grazing land/fallow land at present compared to the past
	Water	– Adequacy and ease of access (sources and quantities) for household and livestock use – Quality (clean/clear, not stagnant)
	Forest/Trees	– Forest/tree cover/adequacy for fuel and timber – Degree of access to forest for fuel – Incentive to plant trees
Agricultural Production	*Crops*	– Optimal distribution of crops to appropriate soil types – Good yielding crops, pest and disease incidence – Using manure & fertilisers, pesticides – Application of drainage techniques – Good price for products, less price fluctuation
	Livestock	– Number of oxen, cows, other livestock (in that order) – Diseases of livestock – Adequacy of feed – Good and stable livestock prices
Human well-being	*Food and Nutrition*	– Food availability – household self-sufficiency in cereals, pulses, milk and vegetables – Food quality/balanced diets (of little concern to farmers but to Public health officials)
	Health	– Incidence of common diseases such as malaria, internal parasites, water borne diseases and dysentery – Ability to do farm work regularly and timely – Family member's appetite for food and water – Children sleep well
	Housing and sanitation (Mainly suggested by non-farmer stakeholders)	– Housing for livestock and human – Adequacy of ventilation in the house – Cooking place – Sleeping place and materials for adults and children – Availability of fixed toilet facilities – Quality of floor (wet or dry) – Frequency of bath
	Gender roles & Education	– Schooling facilities for children, especially girls – Work burden of female

As the dialogue progressed, it became apparent that the agro-ecosystem health framework was in line with the Oromo cosmology of well-being. Among the Oromo, health is usually

defined as *fayyaa* (literally means well-being). However, its specific meaning depends on the context in which it is used. It broadly refers to peace, health, well-being of the physical environment, livestock and human relations and the family. It is common to hear the Oromo uttering the word *fayyaa* in causal greetings in reference to the well-being of the family, crop, cattle and the whole community. This indicates that the concept of *fayyaa* is comprehensive, referring to a balanced and harmonious relationship between human beings, nature and *Waaqa-Rabby*.

Validation of Selected Health Indicators

A good number of the identified health indicators of various components of the agroecosystem were validated and their linkages established both through participatory approaches and formal surveys. Some of the important ones are discussed below (for more detailed accounts, see ILRI, 2002).

Food Availability and Consumption

Food availability was identified as a major problem and an indicator of household and community health. Through key informant participation, a calendar of food availability was prepared showing months in the year when different food items were in adequate supply or in deficit from local production. The calendar reveals that there are periods of serious deficits or hungry periods in the community (Figure 2).

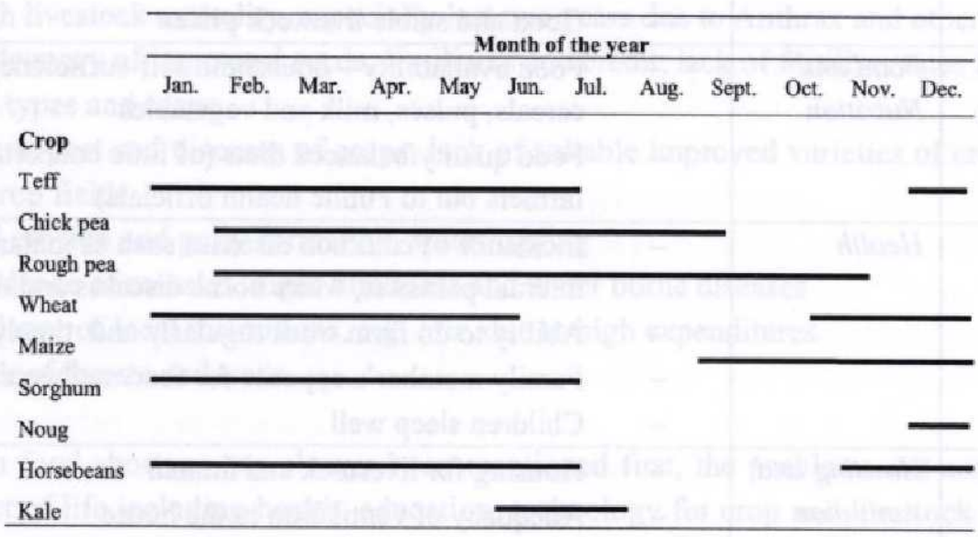

Figure 2. Calendar for food availability (from local production) in the study community as determined by members of the community during a participatory research meeting.

(Continuous lines indicate when the community is 'self-sufficient' in the corresponding crop i.e. not buying that crop from other communities when net exchanges are considered. When blank, community is in net deficit for the crop and needs to buy more than it sells, expect for Noug and Maize. Noug is a cash crop, which is produced and generally sold immediately; maize is primarily consumed fresh during its harvest time).

Second, a stratified sample of 246 out of 845 households in the community were individually interviewed to establish the degree of sufficiency of different home produced

food items for the whole year, after adjusting for purchases and sales. Sufficiency was not pre-defined precisely at any level of consumption of various food items but was left to the perception of farmers. It appeared that farmers perceived these as quantities required for 'living and working in a reasonable manner'. The results show that a vast majority of the households were food insecure: most of the poor people were food insecure but not all rich were food secure (Table 2). Also the degree of sufficiency for different products varied across land types. [3]

Thus the two steps for measuring the dimension of the food problem confirmed that this was indeed an important indicator of the community's and households' 'health'.

Table 2. Percentage of households self-sufficient in food all the year round as determined by respondents in various land types and wealth classes in Yubdu Legabatu community

	LANDTYPE (%)			WEALTH STATUS (%)			All
Food type	Bottomland	Mid-slope	Steep-slope	Poor	Medium	Rich	
Cereals**	43	24	25	6	32	57	31
Pulses***	43	22	25	5	32	57	31
Vegetables	3	0	4	3	2	5	3
Milk	11	19	10	11	19	10	11

***, ** & * indicate 1%, 5% & 10% levels of significance for Pearson χ^2 tests for cross-tabulated data (Note that only the hypothesis that at least two of the three land types and wealth classes differ from each other has been tested).

Adequacy and Quality of Water

Water is one of the most important requirements for life and healthy living. Participatory mapping of all the water resources used by the community showed that the community had access to 28 water sources including rivers and springs distributed unevenly across three land types. From visual observation, most of these sources were found unsuitable for human consumption as livestock has open access to all the sources at any point in time and all along their course with the exception of one - a force pump spring built by a church.

In the individual household survey mentioned earlier, women—the ones normally involved in fetching water for household use—were asked their criteria for using a particular water source. About 43% of the women said they used a particular source because of lack of alternatives, 18% did so because of nearness of the source, 17% because the source had 'clean/clear' and flowing water, and the rest of the women for a combination of the above reasons. In effect, only about 17% had serious concern for cleanliness of the water and even

[3] Later more detailed food intake and anthropometrics data were collected by the research team from the same 246 households in three rounds for three main seasons (rainy, summer, short rains) during the survey year. The food intake data shows that if 2200 kcal/AE/day was considered as the threshold, 54% of the households had maintenance level diet and there were variations between land type, wealth status and season. If intake of 2750 kcal/AE/day was used as the cutting point, only 28% of the households had sufficient food consumption, and this figure was close to the percentage of self-sufficient households as perceived by the farmers themselves during qualitative data collection interviews without defining a level of consumption. The child anthropometrics data revealed that 42% of the children under 5 years were underweight, 9% were severely

then it was only 'un-aided' visual judgment of quality. Thus, it was evident that vast majority of the households did not have access to any source of 'clean/clear' water for household use.

In order to verify the actual quality of these water sources and link quality with any waterborne disease incidence, water sample were collected by the research team from 22 out of the 28 water sources and analysed for coliform count. The households fetching water from each source were also identified, and incidence of waterborne diseases was recorded. Analysis shows that during the main rainy season most of the water sources contained coliform counts beyond acceptable levels for human consumption while after the main rains i.e. during the summer, the extent of coliform presence was less but still at unacceptable levels. The situation was worse for water sources located in land types A and B where no source of clean (potable) water was available during the main rains. It is thought that human faeces washed down the slopes (also see below) and animal dung similarly washed down the slopes or deposited directly into the water sources during washing/watering serve to initiate and replenish organic contamination. A cycle of pollution-diseases-further pollution is established when inhabitants use these same sources for drinking, washing utensils and processing milk. In particular, contaminated milk products are known to boost microbial multiplication and aid spread of associated diseases. Nevertheless, since run-offs are lowest or even non-existent during the summer period, contamination from the above sources becomes limited to mainly to animal dung deposited during watering.

Housing and Sanitation

Only about 30% of the houses in the community had galvanized metal sheets as roofing materials, the rest were of grass. Walls consist of an internal framework of timber plastered with mud, which is made weather-resistant by adding livestock manure and chopped grass. The floor is almost generally made from mud. Adults and children sleep on these cold, sometimes damp floors, with little insulating material, in 15% and 39% of the cases. In land type A, which is least elevated and wet, 54% of the households have children sleeping on the floor. Cooking is done within these poorly ventilated houses by 73% households—most of which are not yet fully built-up.

Within a housing unit there are about $30m^2$ of habitable space. In 62% of the cases, this space is shared between livestock and human beings although human get a larger share of $25m^2$ per household or $5m^2$ per person. This situation is most pronounced in land type B where 75% households share their dwelling with their livestock and have a living space of $4m^2$ per person. Residents say that although the animal mess up the house and the smell of their dung and urine are offensive, the trade-off is that their presence warms the house. Some claim that the animals provide an alternative host for mosquitoes. However, we found that this practice is not common in the rainy season perhaps because of two reasons. During the rainy season, the urine and dung do not dry up, as quickly as in the summer, so it is difficult to keep the floor and inside of the house clean. Also, during the rainy season, movement of animals is difficult, slow and limited by very deep mud of the vertisols, a situation that reduces the risk of theft of animals, so keeping them outside is less risky. Since households with large herds keep their livestock outside because of lack of space inside, it will appear

underweight, 55% were stunted and 23% were severely stunted. These rates were higher in land type C and among poor households. These levels of malnutrition were among the highest reported for Africa.

that households with fewer livestock – usually the poorer households - practice this, most importantly to safeguard their wealth from theft.

Since no household uses any fixed toilet facility, washing away of human faeces to water bodies used for domestic purposes creates one source of disease, as mentioned earlier. Another route is for flies to carry germs and transmit through cooked food, as food and drinking water are not always covered. In 13% households, deposits of faeces were found within the compound, which would be a more direct and immediate source of contamination through flies. Adults in the village take bath once a month while children are given a bath once a week. These are likely to be highly inadequate to save them from infectious, especially skin diseases.

Health and Diseases

Reference has been made about the synergy between agroecosystem health and the Oromo cosmology on health and well-being. When specific reference was made to understand what constituted good human health, 75% of the households indicated that a household's health was good if adult members were able to go for farm work when required, had good appetite for food and drinks, and children slept well, had no fever, no diarrhoea and no worms in their stool. There were others who stuck to a broad definition – general feeling of well-being.

In order to assess disease and health conditions in a more objective way, initially a calendar of the prevalence of common diseases was prepared with the participation of the community. During the exercise, malaria, gastritis, upper respiratory tract infections, tuberculosis and mumps were mentioned and described according to their period of prevalence over the last five years. Then in the detailed household survey, the incidence of these diseases was estimated.

High coverage of immunization against diseases of childhood is a safeguard for better health. The public health department of the Dendi bureau and the Metche Catholic mission have been providing immunization facilities against several common diseases. However, the proportion of children who had been fully immunized against all diseases was only 33%-48%, 29% and 27% in land type A, B and C respectively. Land type C is the least accessible part of the community from health centres and this may have contributed to the low vaccination coverage. Among wealth classes, 17% of poor, 38% of medium and 44% of rich household children completed immunisation even though vaccination was free of charge.

Records on morbidity show that about 49% children in the study area fell sick within the survey period. Coughing/cold (35%) and diarrhoea (27%) were the most prevalent among the reported illnesses. The occurrence of such illnesses may have contributed to the observed high level of childhood malnutrition as frequent illness has a negative effect on nutritional status. The rate of illnesses is surprisingly lower among children of the poor, which may be due to under-reporting and/or lack of understanding of illness condition among poor parents (a level of illness among poor households may be considered normal—not worth reporting—while the rich may report that as illness). Also, sample stool examinations showed markedly high rates of various intestinal parasite infestations, among mothers and their children, which could aggravate the situation of malnutrition.

Adoption of Improved Agricultural Technologies

Since food is a major indicator of health of the community, the level of adoption of new food production and related technologies within a community could indicate the status of its health, and low adoption rate could indicate an entry point for intervention. It could be said that not many new technologies have been taken to the YLPA community by research and extension for adoption, but among those presented, adoption has remained low: only 12% used the BBM for vertisol management, 28% used high yielding crop varieties especially wheat, 18% planted multipurpose trees, and 4% planted cereal/legume intercrops for increasing food and feed together. In all cases, a higher proportion of the rich households adopted these technologies. The BBM technology is inappropriate for use in land type C where the slopes are steep and prone to erosion, and waterlogging is not a problem. Those who adopted these technologies might have benefited through increased income, consumption and less disease incidence.

Linkages Among Health Indicators

Identifying, analyzing and understanding the linkages between agriculture, nutrition, human health and the environment are central to the application of the agroecosystem health approach. Identification and analysis of health indicators, in qualitative and quantitative terms, and establishment of their inter-linkages have been done as an iterative process: at every step of the characterization process, as some information came out through meetings and discussions or informal and formal surveys, the stakeholders discussed them and tried to establish linkages among them, identify information gaps and looked for more information. A reasonably complete picture was developed after results of more systematic analysis of the participatory learning and formal surveys became available for sharing with the community. These results were shared with the stakeholders in several small and large meetings. When qualitative and quantitative results with respect to specific health indicators, e.g. food availability and consumption, water quantity and quality, incidence of diseases, were presented for discussion, farmers generally indicated that the findings reflected the real situation of the area correctly, though they were not aware of the high scale of some of the problems and their causes. For example, they were aware that the water they were using was not ideal (not adequately clean), but they were not aware that it was contaminated beyond normal human acceptance from a public health point of view.

Once the major health problems or indicators of different components of the agroecosystem were identified, farmers were asked if they saw any linkage among those problems or indicators. Initially few farmers were able to show the linkages. A lot of farmers suggested that the problems/indicators were independent and were not interlinked. For example, they were not aware that their sanitary practice could be a major source of water contamination. They were not aware that children without immunization, sleeping on damp floor in the same house with animals and without proper hygienic practice could be vulnerable to certain diseases even with adequate food, let alone with inadequate food. They were not aware that even inadequate food could contribute to better health to some extent if clean water was consumed and other hygienic practices were adopted. However, once some these possibilities came to light, some indicators for a specific component of a domain, e.g. low food consumption, high incidence of certain diseases as indicators for health and

nutrition, were drawn on a board and farmers were asked to indicate which other component of the agroecosystem or which other indicators could be linked with these indicators. The answers were used to expand the diagram step by step, so that eventually an elaborate influence diagram was developed with major identified components and major linkages (Figure 1, read with the arrows). In order to reduce complexity of presentation, the three principal domains are drawn apart rather than as overlapping, which is to be expected in reality.

A more detailed analysis of these interlinkages point to a cycle of low agricultural productivity translating into hunger, malnutrition, diseases and inadequate income to ensure human health and proper nutrition. An unhealthy and under-nourished community with low income finds its ability to make necessary input into farm work compromised, guaranteeing even lower returns from agriculture, and they also fail to make adequate investment for improving the quality of housing and living and on medical treatments. The question of where and how to break this vicious cycle featured very prominently during the meeting of stakeholders (ILRI, 2002).

Way Forward for Addressing Problems of the Community

Once the health indicators were identified, verified and linkages established, discussion centred on possible solutions to the problems at hand. Members of the community forwarded different ideas and most of them indicated that their major problem was poverty or low income and food deficit. In addition to what were identified as problems from focused discussions during previous meetings and surveys, the issue of poverty and food insecurity kept recurring as they repeatedly pointed out that *dhabuu* (not owning enough) caused all problems. If enough assets had existed, they claimed, they would have protected their water sources, would have eaten good food, would have improved housing and would not have slept on floor near the livestock. While the majority of the participating households from land type C wanted all the problems to be solved by government or other agencies like the institutions conducting this research, most participants from land type A and B attributed the problems to themselves and they claimed to have the capacity and resources to solve most of the problems to a certain degree. There was a hot debate on this point. However, more detailed discussion revealed that ignorance, lack of motivation and initiatives due to failure to appreciate their own abilities to change things (how to do, when to do) aggravated these problems. So, they needed external assistance either from the government or other agencies such as the institutions doing the research to design appropriate interventions to alleviate their problems (in rural areas, people normally express such opinion to external visitors hoping that they have come with something to give away).

The research team encouraged farmers to think if there were some things that they could do on their own in the beginning rather than waiting for assistance to come from outside, and there was another hot debate. After a while, suggestions started coming from members about things they could do themselves easily e.g. preparing a platform for sleeping, digging pits for toilet, filtering water using existing local materials and labour without a need for external assistance. As the discussion proceeded, farmers started to realize that they could do many things on their own rather than relying fully on external assistance though on some aspects they would need external assistance of one kind or another, e.g. simple technical advice or

some material. The consensus was that alongside trying to improve food production for which some government and other forms of support were accessible at least some members of the community, direct measures to improve health and reduce diseases should be taken by improving housing, health and hygienic practices. To start with, housing and sanitation should be tackled urgently partly because of its linkage with water quality and diseases. Different ideas were forwarded on how to go about these interventions or changes in practices.

Farmers then formed two small committees, one for land type A and B and another for land type C, each composed of four male and two female members, to coordinate future activities that could be performed by the farmers themselves with or without assistance. These committees would act as the focal points for dialogue between farmers and the external stakeholders and for initiating steps for implementation of problem solving activities. The PA chairman was present during the meeting and assisted members of the community in forming the committees. Within the next few months, these committees held several discussions with their constituencies and increased their awareness of the problems and possible solutions even further. The responses so far indicate that even though farmers may not always think in a systems framework, if slightly assisted to understand the linkages between their different problems and how to find solutions or assistance for solution, they will start appreciating the linkages, both direct and indirect, among their problems and become motivated to find solutions on their own rather than waiting for external assistance.

As a result of these efforts, out of a total number of 297 households in the three hamlets within the community, 28 households hade built separate livestock sheds, 26 built separate kitchen outside the living room, 23 households constructed raised sleeping platforms for themselves and the children using local materials (straw, rough grass) within the first four months after the formation of the local committees in mid 2001. The research team withdrew about that time and left the community to decide what they wanted to do and how and where to look for assistance if required. By mid 2004, the number of households who separated livestock sheds from cooking areas increased to 164, those who raised their beds to save children from sleeping on the wet floor increased to 72. These are not fully mutually exclusive numbers as some households have done only one activity while other have done both.

Another area where the community wanted to make improvement was in terms of water quality for household use, given the high degree of contamination of the water sources they have access to. After discussion on several options, e.g., boiling, using water purifying tablets, simple straining with thin cloth and using a simple system of water filtration, the community decided to test a system of filtration. Several households volunteered to participate in the test trial. However, finding a suitable design for testing appeared the major problem in the beginning.

Given the extreme poverty of the community, a low cost design based on local material would be most desirable. If proved successful this could then be replicated elsewhere. To start with, a design of slow sand filer developed and tested in other parts of the developing world was derived from Dutka *et al* . (1996) for adaptation. A suitable material needed to be identified to make the main container required for this design. Initially, new 80-litre plastic containers available in the local market were considered as an option because of its optimal size for a family and its potential durability but its cost (400 Birr, approx. US$50) was not affordable by the farmers. Old containers and drums available in the market were cheaper but

these could not be trusted in terms of what previous use they might have been put to e.g. some were used for carrying agro-chemicals, which could prove harmful. Then the possibility of locally made clay pots was considered for two reasons. First, village people use clay pots for collecting water and local potters can make them though some changes in design including features for water filtration process and outlet would be required. The stakeholders felt that local potters would be able to make these modifications with some advice and guidance. Second, the cost would be affordable and additional income opportunity would be created for local potters.

Accordingly some local potters willing to participate in the design modification and testing were identified. Several designs have been made and tested for functionality and quality of filtered water (for details of the design, see ILRI, 2002). Preliminary reports indicate that coliform counts reduce by about 50% when the filter is used, and given that water from almost all the sources in the community have contamination levels way above acceptable minimum, make the current design promising. The design will be further perfected with participation of the potters on the one hand and the farmers using them on the other. Early indications are that the filter can be produced for about 35 Birr (approx. US$4) excluding cost for sand, so there is good potential for its wide distribution beyond the case study community.

These may appear very small steps and initial achievements in relation to the enormity of the problems facing the community but the fact that they have started to take charge of their own destiny in a more holistic way is a good indication that they will be able to make more profound changes in their agroecosystem health themselves and with appropriate external assistance. This also emphasises the need for greater coordination and integration of the various development activities in various fields from food production to health, nutrition, forestry and soil conservation *inter alia* being pursued by the institutional stakeholders involved in the project and others working the area. Policies that facilitate such coordination and integration will provide high pay-off on investment.

Lessons Learned for Multi- and Transdisciplinary Participatory Research and Development

If the agroecosystem health framework was applied in an area devoid of any prior external interventions, the logical steps of the framework could be applied in a theoretically ideal way but few communities will be found where no previous external intervention has been made. In the present case, the framework was applied in an area where a component technology oriented project was on-going and other development activities also have been on-going to some extent without adequate coordination. Therefore, the lessons learned for multidisciplinary and trans-disciplinary community participatory research process derived from the experience may be useful for similar projects or initiatives elsewhere. Some of the important lessons are as follows:

- Application of the agroecosystem health paradigm in the on-going Vertisols management project required a transition from component technology and watershed development research to a more integrated and holistic approach linking natural resources, agricultural production and human well-being. This also required

expansion of the team with new disciplines and stakeholders, and moving from disciplinary and multidisciplinary approaches towards transdisciplinary approaches.

- Neither of the above two changes was easy as members of the research team had different methodological backgrounds and experiences. Harmonising these within the agroecosystem health framework required learning by doing, hence longer time than if the team could be built at the start of the project from individuals with fairly similar methodological experiences in transdisciplinarity.
- Turnover of team members and inability of some team members to participate regularly in the team's deliberations, due to other commitments contributed to slow progress in generating transdisciplinary insights in an iterative and sustained way to guide the implementation of the project.
- Community participatory research requires adequate local knowledge of resources, their constraints and potential and health indicators of the system, as well as social organisation, local culture, norms and values, gender roles and equity issues. As would be expected, it was evident that the local community as a research partner had sufficient mass of knowledge but revealing these required continued dialogue, rapport and confidence building, using appropriate tools, language and communication mechanism, and therefore time. For example, the community speaks a variety of languages and dialects. Even some of the Ethiopian team members, let alone researchers from outside the country, are not conversant with those, so they sometimes needed interpretation help to communicate.
- The activities, tools and approaches for characterisation of the agroecosystem could not sometimes be pursued in an ideal sequence or simultaneously for all relevant components partly due to the need to learn by doing and partly due to the shortage of team members in certain disciplines. This uneven take-off of the various components of the project meant that learning and sharing could not always be done simultaneously to build sustained linear progress rather progress was uneven.
- As the participatory process of diagnosis of constraints and opportunities, and development of health indicators was getting longer, delaying possible intervention for improving well-being, it has been difficult to retain farmers' interests in the process as farmers being very poor were interested to see tangible outcomes while also discussing principles.
- In spite of the above problems, constraints and limitations, significant progress has been made by the team in its understanding and application of transdisciplinary tools and approaches.

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REFERENCES

Becker, B. .1997. Sustainability assessment: A review of values, concepts, and methodological approaches. *Issues in Agriculture* No 10. CGIAR Secretariat, The World Bank, Washington, D.C., USA. 63pp.

Dutka, B. J., Manz, D., Palmateer, G., Jurkovic, A. McInnis, R., Unger S. Kwan, K.K. (1996). Toxicant and parasite challenge of MANZ intermittent slow sand filter. *Paper submitted to International Development Research Centre*, Ottawa, in fulfillment of Contract File 02795/95-0206. November 1996. 24 pp.

Ehui, S K and D SC Spencer. 1993. Measuring the sustainability and economic viability of tropical farming systems: a model from sub-Saharan Africa. *Agric. Econ.*, 9: 279-296.

Ehui, S.K. and Jabbar M.A. (1997). "A framework for evaluating the sustainability and economic viability of crop livestock systems in sub-Saharan Africa." In: Roger Rose, Carolyn Tanner and Margot A Bellamy (Eds) *Issues in agricultural competitiveness – markets and policies*. Proceedings of the 22nd International Conference of Agricultural Economists, held at Harare, Zimbabwe, 22-29 August, 1994. (IAAE Occassional Paper No 7). Dartmouth Publishing, UK. pp. 406-414.

Faeth, P. 1993. An economic framework for evaluating agricultural policy and the sustainability of production systems. *Agric. Ecosys. and the Envoron.*, 46: 161-173.

Flach, K W. 1990. Low input agriculture and soil conservation. *J. Soil and Water Cons.*, 45: 42-44.

Frye, W W and R. L. Belevins. 1989. Economically sustainable crop production with legume cover crops and conservation tillage. *J. Soil and Water Cons.*, 44: 57-60.

ILRI. 2002. Enhanced human well-being through improved livestock and natural resources management in the East African highlands. Final Report to the IDRC, Ottawa, Canada. 70pp.

Islam, M S (1996) Strategies for the development of sustainable agriculture in Bangladesh. Unpublished PhD thesis, Oregon State University, USA.

Jabbar , M A, Tekalign Mamo, and Mohamed Saleem, M A. 2001. From plot to watershed management: experience in farmer participatory vertisol technology generation and adoption in highland Ethiopia. In: J K Syers, F W T Penning de Vries and P Nyamudeza (Eds) *The sustainable management of vertisols*. CABI with IWMI, Wallingford, UK. Pp.173-186.

Lynam, J K and R W Herdt. 1989. Sense and sustainability: Sustainability as an objective in international agricultural research. *Agric. Econ.*, 3:381-398.

Peden, D. 2000. Is there a doctor on the farm? Managing agroecosystems for better human health. Paper presented at the International Centre's Week of the CGIAR, 25 October. 48pp.

Rosegrant, M W, Paisner, M S, Meijer, S, and Witcover, J. (2001) *Global food projections to 2020: emerging trends and alternative futures*. International Food Policy Research Institute, Washington, D.C., USA.

Rosenfield, P L. 1992. The potential of trandisciplinary research for sustaining and extending linkages between the health and social sciences. *Social Science and Medicine* 35(11):1343-1356.

Sayer, J A and Campbell, B. (2002) Research to integrate productivity enhancement, environmental protection and human development. *Conservation Ecology* 5(2):1-13.

Smit, B, Waltner Towes, W, Rapport, D, Wall, E, Wichert, G, Gwyn, E and Wandel, J. 1998. Agroecosystem health – Analysis and assessment. Univeresity of Guelph, Ontario, Canada. 113pp.

UNDP (United Nationa Development Programme). 2001. Human development report 2001. UNDP, New York, USA. 265pp.

Walterner-Toews, D, Murray, T, Kay, J, Gitau, T, Raez-Luna, E and McDermott, J J. 2000. One assumption, two observations and some guiding questions for the practice of agroecosystem health. In: Jabbar, M A, Peden, D G, Mohamed Saleem, M A, and Li-Pun, H (eds) Agroecosystems, natural resources management and human health related research in east Africa. IDRC, Ottawa , Canada and ILRI, Nairobi, Kenya. Pp. 7-14.

Waltner-Toews, D and Nielson, N O. 1995. Assessing agroecosystem health. Agroecosystem health project discussion paper 23. Unversity of Guelph, Canada.

Xu, C, H Chunru and D C Taylor. 1992. Sustainable agricultural development in China. *World Dev.*, 20(8): 1127-1144.