Tracking the Ecological Soundness of Farming Systems: Instruments and Indicators

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ABSTRACT. Many farming practices degrade agroecosystems. High-external-input or modern farming tends to degrade by pollution whereas traditional, low-input systems generally tend to degrade by erosion. Smallholders in Sub-Saharan Africa, the focus of this paper, are forced to degrade their natural resource base just to keep pace with growing populations. Out of fourteen cases from Senegal, Nigeria, Gambia, Tanzania, Zimbabwe and Kenya only one, from Upper Machakos in Kenya, managed to restore soil fertility. Not surprisingly then, topics concerning environment and agroecosystem health find themselves getting much more attention now than ten years ago. Of particular interest are methods to evaluate and monitor changes in the ecological health or soundness of

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a farming system. While a number of methods exist most are too complex for farmers to understand and operate by themselves. Not only do most methods require 'experts' to run them, they also take too much of the participating farmers' time. Many of these monitoring and evaluation methods also assume a level of knowledge concerning ecologically sound farming that farmers, and many of those who advise them, often do not have. In most cases, both farmers and researchers must learn what changes to the farming system are needed to make them more ecologically sound. This paper discusses possible methodologies and presents a proposal on how to design a multistakeholder learning process for agricultural development. Methods are discussed for measuring the direct environmental impact of new farming approaches and the stakeholder partnerships that influence the outcome. Examples of possible indicators are provided for this evaluation process. Farmers can use these methods and indicators to guide the transformation of their farming systems towards a more ecologically sound future. Examples of such transformations using this approach are taken from studies of smallholder farmers in Ghana and Malawi. Two conclusions are drawn. One conclusion is that ecological soundness can bring economic growth and secondly, learning requires special social processes and institutional structures to be effective.

KEYWORDS. Agroecosystems, collaborative learning, ecological health, farming system indicators, Ghana, Malawi, smallholders, soil fertility, stakeholder partnerships, sub-Saharan Africa

INTRODUCTION

Too many farmers of both resource-rich and resource-poor environments ultimately degrade their farming systems. In harsher environments, farmers are often poor and face burdening population growth with all of the concomitant pressure it exerts on the use of agricultural land. Sheer survival dictates reduction or total abandonment of traditional fallow practices, crop rotations and diversity. Families can not afford to leave land fallow if there is less land to go around. Effort is concentrated on ensuring sufficient staple food crops are produced which often results in less area to grow other vegetables and crops. Loss of fallow practice and crop diversity results in 'mining' of soils and often rapid soil degradation and erosion. In addition, agricultural development and market pressures have encouraged mono cropping for cash production over family food production thus often exacerbating depletion of agricultural resources. Land pressure problems also lead to the break down of traditional and social norms protecting forests on common land. Rapid deforestation occurs, leading to erosion of hillsides, siltation and increasing seasonality of streams with subsequent drying up of spring lines. As degradation deepens and rehabilitation costs rise, it becomes more difficult for local people to break this vicious cycle.

Breaking 'poverty-cycles' requires rebuilding of social organisation and institutions for local empowerment. This is an essential precursor to reverse trends of agro-ecological degradation and ensure that rehabilitation of these farm systems and associated markets meets the needs of local communities. Such an approach leads to a more careful development of appropriate technologies and markets suited to each specific locality.

We say careful development because much of the destruction of agroecological niches in favourable environments has been driven by modern technology and market opportunities. Pesticides and fertilisers, when inappropriately applied, pollute environments like irrigated rice fields, and damage human health (Conway and Pretty, 1991; Pingali and Roger, 1995). Modern technology also reduces agroecosystem diversity. The landscape is homogenised to exploit the economies of scale from mechanisation and mono cropping, to satisfy markets that favour large volume suppliers. Farmers clear cut, burn, plough and level large fields, fallows and wetlands, to plant rows of a single crop. Commonly, high external input mono cropping is the kind of agriculture promoted by government extension agencies and supported by government policies. Farmers in the Philippines have transformed diverse agroecological niches including rice-fields, fish ponds, vegetable gardens, and orchards into intensive high external input vegetable or pig operations (Lightfoot, Dalsgaard, Bimbao and Fermin, 1993). Economic survival motivated this destruction. Farmers knew that in a few years they must sell their land to industrial development and, with no future in agriculture, they decided to generate cash as quickly as possible. Salaried labourers on nearby industrial sites provided a ready market for high priced meat and vegetables. It made sense to exploit this immediate market opportunity and use modern technology to maximise farm production. Fortunately, the short duration and small scale of these operations meant that there was little pollution or damage to human health. However, older and larger pig, poultry, or vegetable operations surrounding most Asian cities are more persistent and may be a long-term threat to the environment.

Fourteen case studies on changes in agriculture from East and West Africa in the 70s and 80s indicate that smallholder farming systems have improved production and income. However, this has often been at the cost of the health of the agroecosystems concerned (Wiggins, 1995). Farmers have increased livestock numbers, often adding new species such as pigs, goats, donkeys and sheep. They now grow more crops, adding new vegetable species such as tomato and cabbage. Production methods have also changed to increase yields. Farmers have adopted Green Revolution technologies–high-yielding varieties, fertilizer and irrigation, as well as Low Input Technologies–manure, inter-cropping and rotation, sometimes adding animal traction as well. These changes, in what remain essentially mixed farms, have allowed production to keep pace with population, but often at the expense of soil and water resources. One notable exception was the case of Upper Machakos in Kenya. Here integrating trees and stall-fed dairy cattle along with land terracing resulted in production increases along with demonstrable increases in soil fertility (Table 1).

As farming practices in the north and south increasingly damage agroecosystems, interest is growing in new approaches for environmental monitoring and evaluation. Many methods exist but they often take up too much of the farmer's time and are often too complex for them to use. Many authors have argued that a learning approach is needed. Its aim should be to enable farmers to build their skills and capacity to deal with the complex issues of improving their farming environment (Daniels and Walker, 1996; Finger and Verlaan, 1995; Pretty, 1995; Roling, 1994). In this paper, we present examples of ways for enabling farmers and experts to learn together how to design more ecologically-sound farming systems. Examples from Malawi and Ghana illustrate this process and, in particular, the importance of indicators for monitoring the impact of new farming approaches.

The instrument and indicators presented here rest on the notion that the following attributes and subsequent outcomes are associated with ecosystem soundness:

Attributes of ecological soundness in a farming system

High diversity of enterprises (i.e., crops and/or livestock).

Extensive recycling of crop/livestock by-products and positive interaction and feedback loops.

Two possible outcomes of such attributes
Resilience to environmental perturbations.
Increased biomass production.

Theoretically, it is assumed that farms with high crop/livestock diversity and strong internal recycling of bioresidues from agricultural activity will tend to be more resilient to climatic, biophysical and economic perturbations. Enterprise diversity on farms tends to make them also more resilient to crop pests in comparison to farms with low diversity. Thus, there are always likely to be some crops and livestock that survive severe environmental conditions and hence are available as food or for sale. Strong internal recycling of agricultural wastes means less reliance on expensive external inputs to maintain farm production. Reuse of organic waste not only cuts costs for the farmer but will often lead to increased farm production through improved soil quality. Thus, a gradient of ecological soundness can be imagined from mono-cropping through multiple cropping and mixed farming to integrated farming as shown in Figure 1 (Dalsgaard, Lightfoot and Christensen, 1995).

INSTRUMENTS AND INDICATORS

Exercise for Collaborative Learning About Ecological Soundness

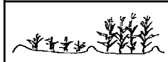
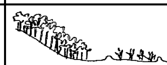
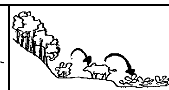
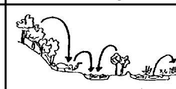
Bio-resource flow models of whole farming systems is one example of a learning exercise for farmers, researchers and extension agents to use for brainstorming about future farming systems that might prove more ecologically sound. Farmers draw diagrams to illustrate how they picture and manage their farming system at present. These diagrams or 'conceptual' models show not only the categories of land and water resources (agroecological niches) and species (crops, livestock, etc.) in the farming system, but also the flows of biological resources (fodders, fuel, waste and by-products) between niches and species. Moreover, contained in these models are major indicators for ecological soundness-species diversity, nutrient recycling flows, and soil and water resource quality. Such modelling for individual farms can also be used for analysing the use and management of common property resources used by a community.

The farmer's diagram provides a starting point for discussing possibilities for altering management practices. Everyone can see what kinds

TABLE 1. Changes in African Farming Systems from the mid 1970s to mid 1980s

Case Studies	Changes in Crops	Changes in Livestock	Changes in Methods	Changes in Soil Fertility
Northern Province Zambia	more HYV maize, less millet	more oxen	oxen traction, fertiliser, HYV seed, permanent fields	down, acidification
Iringa, Tanzania	more maize, less cassava and sorghum	more oxen	oxen traction, fertiliser, HYV seed, permanent fields	reduced
Mbozi, Tanzania	more maize, beans, coffee, less millet and cassava	more oxen	oxen traction, fertiliser, manure	under threat
Lower Machakos, Kenya	more maize, less millet and sorghum	large increase oxen, sheep, goats	oxen traction , manure	fear decline
Ibarapa, Nigeria	more cassava, tomatoes, pepper	more specialization	hired tractors	no major change
Kano, Nigeria	more grains, less groundnuts	loss due to drought, restocking	hand hoeing, more weeding	falling
The Gambia	less rice, more early millet	donkeys	donkey traction, fertiliser, manure	lower
Mid Senegal valley, Senegal	more rice, tomatoes, potatoes, less millet and sorghum		stock fed stover, pump irrigation	?
Namu, Nigeria	more yams, cassava, millet, sorghum, cowpea	pigs added	intercropping, rotation, manure and fertiliser	?
South Nyanza, Kenya	more sugar cane			?
Mid Machakos, Kenya	more maize, more cotton, fruit	pasture development, less stock	oxen traction, manure, terracing	not known
Lower Sokoto valley, Nigeria	less rice, more sorghum, millet and cash crops	oxen	oxen traction, fertiliser, irrigation pumps	not known
Upper Embu, Kenya	more coffee, trees planted	dairy cattle	terracing, dairy cattle stall fed	not known
Upper Machakos, Kenya	more fruit, vegetables, trees planted	dairy cattle	some terracing, dairy cattle stall fed	increased

FIGURE 1. Theoretical Stages in the Ecological Soundness of Farming Systems

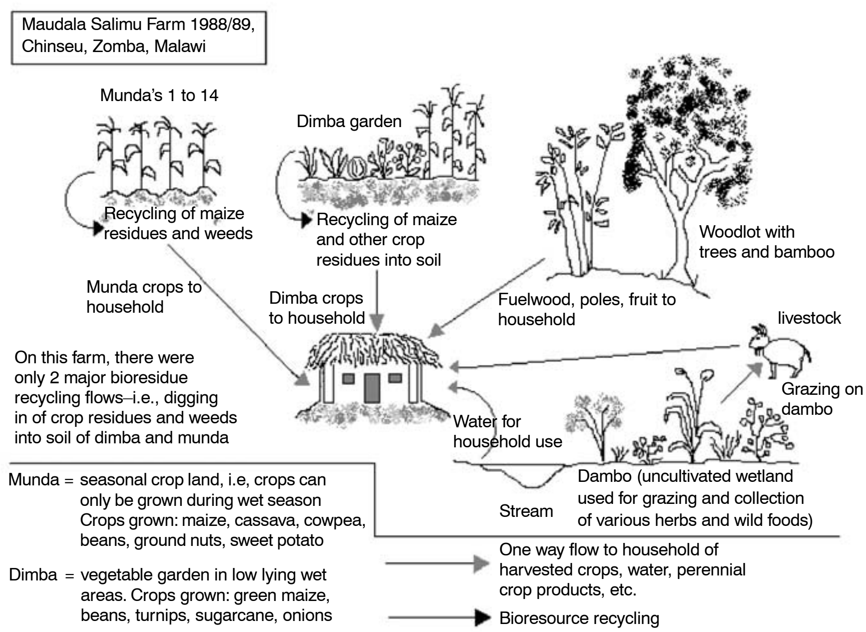
	→ Sustainability →			
	low	medium		high
				
Farming system	monocrops	Multiple cropping	mixed farming	integrated farming
Natural resource type	single	few	multiple	multiple
Enterprise assemblage examples	rice or corn	rice-wheat or corn-cassava cereal-legume	cattle, poultry, vegetables, cereals, legumes, fruit trees	livestock, poultry, fish, vegetables, cereals, legumes, aquatic plants, fruit trees, multipurpose trees
Species diversity	low	low	medium	high
Bioresource recycling	low	low	medium	high
Natural resource capacity	low	medium	high	high

of crop and livestock species are present and discuss what new ones could be integrated into the system. Everyone can see what biological resources are available and discuss how they might increase farm efficiency by recycling some of them between enterprises. Everyone can discuss which niches are degraded and how one might rehabilitate soil and water resources. This learning exercise based on drawings helps farmers pinpoint where money might be saved. For example, possible new internal flows such as recycling of manure and compost could be indicated on diagrams. These new flows can then be discussed as potential substitutions for external inputs like inorganic fertilizer. Often, in the discussions over farm models, farmers challenge researchers to tell them how a particular piece of land or water resource could be rehabilitated. Researchers are asked for their ideas on what new species could be cultivated for food and/or market. The new ideas, in combination with local knowledge, can be superimposed on the current drawing of the farming system. This enables the farmer to produce a vision of a future based on more ecologically sound farming (Lightfoot and Noble, 1993; Lightfoot, Dalsgaard, Bimbao and Fermin, 1993; Noble, 1996a).

Illustration from Malawi

Figures 2a and 2b illustrate an example of the transformation that occurred to one family farm in Malawi over a period of six years. The figures are abbreviated drawings from the detailed pictures drawn by the Salimu family. They used these drawing as a mechanism for learning, discussion and envisioning the future of their farm system and also recording the evolutionary transformations that took place (Noble, 1996b).

FIGURE 2a. Bio-Resource Flow Model of Farming System BEFORE Transformation, Zomba District, Malawi

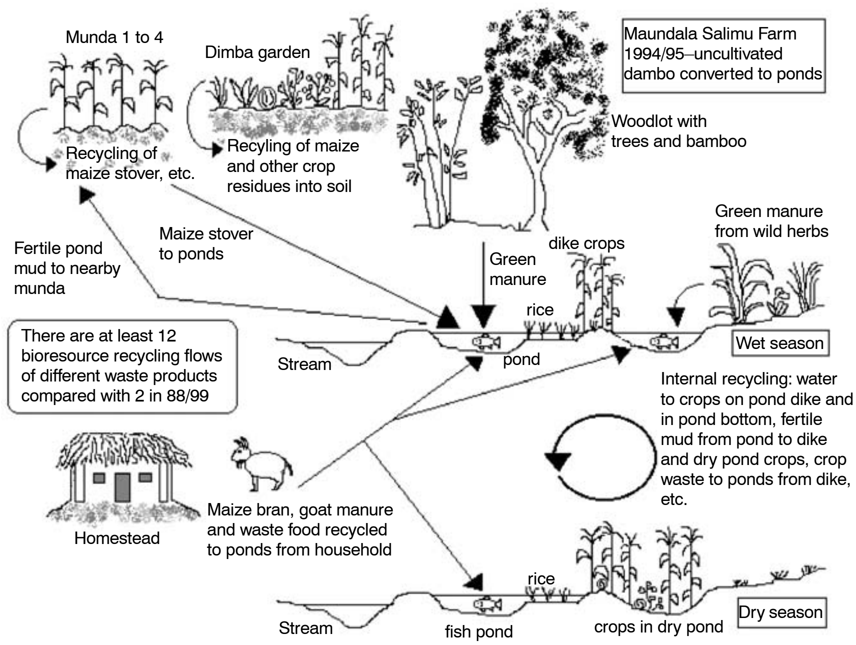


Average annual net income per 100 m^2
munda = approx. US$2.8 (total annual net income of approx. US$840 from 3 ha)
Dimba = approx. US$1.0 (total annual net income of approx. US$40 from 0.4 ha)
dambo = US$0.00
Total net income = US$880 (includes cash and non-cash income)

Annual crop production (kg/ha)
Munda = 3400
Dimba = 1000
Dambo = 0

Note: 1988/89 was an *average* year as regards rainfall

FIGURE 2b. Bio-Resource Flow Model of Farming System AFTER Transformation, Zomba District, Malawi



Average annual net income per 100 m^2
munda = approx. US$0.9 (total annual net income = approx. US$300 from 3.4 ha)
Dimba = approx. US$1.0 (total annual net income = approx. US$400 from 0.4 ha)
dambo = approx. US$18.5 (total annual net income = approx. US$390 from .21 ha)
Total net income = US$1090 (includes cash and non-cash income)

Annual crop production (kg/ha)
Munda = 1600
Dimba = 600
Dambo = equivalent of over 5000

Note: 1994/95 was a *drought* year as regards rainfall

Before transformation, the household was very dependent on the seasonal cropland (munda) to provide food and cash income. This was fine as long as rains were good and predictable. However, during the early 1990s, rains became erratic and drought years were common. Fortunately, the Salimu family had already started to utilise the uncultivated wetlands (dambo) area, harness water and manage it for rice-fish production. They started with a couple of small ponds and expanded to six with eventually crops on the dikes. The whole pond system acted as a focus for internal recycling of bioresidues on the farm. The ponds generated rich mud, which was utilised for fertilising dike crops and to some extent nearby cropland. The water captured in ponds was used for livestock and household use as well as watering nearby crops. In the severe drought of 1994/95, some ponds were allowed to dry up and crops were grown in the rich mud of the pond bottoms to augment cash income and food for the family. Thus, the transformation of the dambo increased the resilience of the farm system to the drought. This is illustrated by the increase in annual net income (US$1090) to the household in 1994/95 drought year above that of a normal rainfall year in 1988/89. Had the Salimu family been solely reliant on seasonal cropland and dimba during the drought, then their annual income likely would have declined to US$700 or less (Noble, 1996b; Brummett and Noble, 1995).

Illustration from Ghana

The Ghana case study is one of a mixed farming system similar to that in Malawi. Livestock, trees, vegetables, cereals and root crops are all grown for both home consumption and sale. Recycling is limited to the collection of various forages, crop residues and leaves for the livestock. Over a period of a little more than a year the farm transformed dramatically. Water resources were rehabilitated, vegetable plots were established, fish and ducks were integrated into the farming system, and much more recycling occurred. A previously neglected wetland area of the farm was rehabilitated through improving water flow and impounding in a small pond. This provided sufficient water to stock fish and irrigate a newly established vegetable plot. Manure from all the animals was recycled to the pond and vegetable plot as were cocoyam and leuceana leaves. Pond mud was recycled to the vegetable plots to substitute for chemical fertilizer. With savings on external inputs, more products going to market, more meat and vegetables being marketed, and more internal recycling of nutrients, the farm outlook was reversed (Prein, Lightfoot and Ofori, 1996).

INDICATORS FOR EVALUATING 'SUSTAINABILITY'

Learning about ecological soundness of farming systems builds on the theoretical framework described in Figure 1. Using this framework to pose four general questions, farmers can design simple indicators to track what is happening to their agroecosystem when they implement new management strategies. Below is an example of such indicators:

How much more profit does the farm make for every dollar invested? (economic indicator)

How much more productive is the farm? (natural resource capacity indicator, e.g., $kg/m^{-2}/yr^{-1}$)[1]

How much more diverse is the farm? (possible indicator of ecological soundness)

How much recycling is going on? (possible indicator of ecological soundness)

In this example, economic performance is indicated through changes in profit-cost ratios. Likewise, productivity performance is indicated through changes in weight of biomass produced from all enterprises. Ecological performance is indicated through changes in number of recycling flows and diversity of species cultivated. Benchmark values are estimated for the current farming system. Recall is used to assess past farming systems, and potential values are estimated for future farming systems. With the passage of time, changes in existing farming systems are tracked (Lightfoot, Bimbao, Dalsgaard and Pullin, 1993). Changes in these indicators before and after transformation are easily seen in a four-way graph or kite plot as shown in Figure 3. Each indicator is arranged on an increasing scale of improvement so that the larger the kite formed, the more sustainable the farming system. The farmers together with researchers determine the scales for the plots based on the initial and on-going measurements they make for the indicators over a period of two growing seasons. While these plots allow researchers and development workers to communicate with each other, farmers sometimes find them difficult to follow. This problem can be avoided by allowing farmers to design their own units for the graphs and symbols for the indicators on their drawings of their farms. Such an exercise builds farmers' skills in monitoring and evaluating what is happening to their farm.

Illustration from Ghana

The above indicators were used to track change in the whole farming system. Estimates were made of the current farming system before transformation and compared with estimates after just over a year in the transformation process. All indicators improved. Results shown in Fig-

FIGURE 3a. Changes in Indicators for Ecological Soundness Before and After Transformation, Mampong-Nkwanta, Ghana

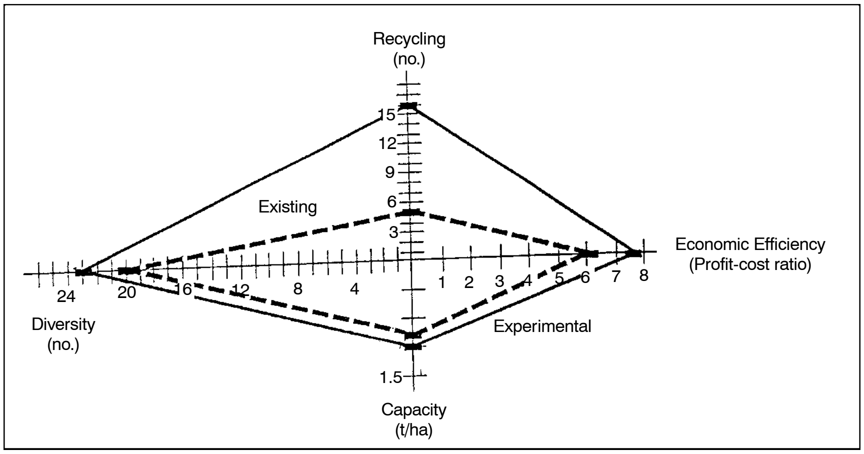
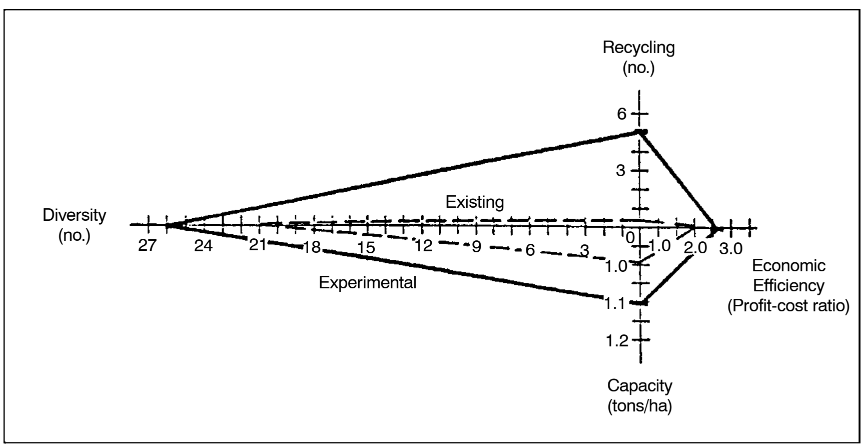


FIGURE 3b. Changes in Indicators for Ecological Soundness Before and After Transformation, Zomba District, Malawi



ure 3a from assessing before and after farming systems transformation are compared in a four-way plot or kite of the indicators. Resource rehabilitation and increases in recycling from 5 flows to 16 and species diversity from 20 to 23 brought modest increases in biomass production and more impressive increases in economic efficiency. Interestingly, economic efficiency was not sacrificed to ecological soundness (Lightfoot, Prein and Ofori, 1996).

Illustration from Malawi

Similar, though less impressive, results were reported from a different case study farm (Figure 3b) to that of Salimu household (Figures 2a, 2b) in Malawi. Again, in a little over a year, improvements were seen in all indicators. Recycling flows increased from zero to five and species diversity from 21 to 26. The rehabilitation of water resources for culturing fish and growing vegetables in 'dambo' lands resulted in modest rises in economic efficiency and biomass production. A severe drought occurred so it is surprising to see any increases at all. Again, economic efficiency goes hand in hand with ecological soundness (Lightfoot and Noble, 1993).

CONCLUSIONS

Ecological Soundness Can Pay

The impact of multiple simultaneous interventions–the adding of new species, new recycling flows and rehabilitation of land and water resources–on economic performance is assessed at two levels: the agroecological niche and the whole farming system. The main questions raised by farmers for impact assessment are:

- How much more income can be earned from rehabilitated agroecological niches?
- How much does it cost to rehabilitate agroecological niches and ensure sustainable production?

Data from the two case study farms from Ghana and Malawi (Table 2) serve to illustrate this assessment. Income increases from rehabilitating water resources in lowlands and wetlands varied from as little as US$32.00 (farm featured in Figure 3b) up to US$390.00 (farm, Figure 2b) in Malawi, while the Ghanaian income increase was US$202.00. While some Malawian farms appear to perform poorly this was not the case from the farmers point of view. Both Malawi examples illustrate conditions for different drought years in Malawi and to make any

TABLE 2. Economic Impacts of Farming System Transformation in Zomba District, Malawi and Eastern Region, Ghana

GHANA	BEFORE				AFTER			
	Gross Income	Total Cost	Net Income	Net Cash Income	Gross Income	Total Cost	Net Income	Net Cash Income
Lowland	921	27	894	600	1481	63	1418	889
Upland	566	200	366	430	819	135	684	638
Homestead	167	12	155	132	22	47	−25	9
Fishpond	0	0	0	0	202	36	166	192
River	32	0	32	0	0	0	0	0
Farm	**1686**	**239**	**1447**	**1135**	**2524**	**281**	**2243**	**1728**
% Change					50%	18%	55%	52%

MALAWI	BEFORE				AFTER			
	Gross Income	Total Cost	Net Income	Net Cash Income	Gross Income	Total Cost	Net Income	Net Cash Income
Homestead	142	14	128	78	108	18	90	20
Dimba	271	106	165	112	296	26	270	173
Munda	205	96	109	−15	205	97	108	−34
Dambo	0	0	0	0	32	38	−6	23
Farm	**618**	**216**	**402**	**175**	**641**	**179**	**462**	**182**
% Change					4%	−17%	15%	4%

money at all in such years is a considerable achievement (Lightfoot and Pullin, 1995; Noble, 1996a).

Taking the Malawi example illustrated in Table 2, rehabilitation costs, which comprised mainly labor for clearing watercourses, diverting watercourses, and impounding water or digging ponds, were low at more or less US$37.00. This, however, did mean that in the first year the farmer in Malawi made a loss. The balance of all the interventions made in this Malawi case provided a modest gain of 4% on gross income and 15% on net income. This was because pond mud and compost substituted for chemical fertilizer in the wetland ‘dimba’ vegetable gardens; so considerable savings, US$80.00, were made. Much more dramatic increases in gross and net incomes where realized from all the changes made in the Ghana case where gross income rose by 50%, from US$1,686.00 to US$2,524.00.

The impact on households of transformation towards intensive integrated farming systems goes beyond the economic and ecological indicators discussed. Farmers in Malawi listed a number of critical advantages from rehabilitating 'dambo' lands; introducing vegetables and fish; and recycling manure, household wastes, weeds, tree leaves, maize bran and stover (Lightfoot and Noble, 1993; Noble, 1996 b, c).

Household nutrition improved through more regular consumption of rice and fish. Reduced use of chemical fertilisers, by substituting them with composts and pond mud, ensured cash savings in maintaining soil fertility of vegetable plots. Most critical of all benefits was the increased availability of water for domestic use, livestock watering, and irrigating vegetables particularly in the dry season. During the 1991-92 and 1994/95 droughts these households in the two Malawi examples managed to feed themselves without loosing their savings, a considerable advantage for resource poor farmers.

Rehabilitating 'wetland' to conserve water resources has had similar impacts in other parts of Africa. In Zimbabwe's 1992 drought, households with 'dimba' gardens did not go hungry or suffer malnutrition and so maintained high labour productivity. They also held on to their capital (Kundhlande, Govereh and Muchena, 1994). Zimbabwean farmers commented that improved water management of 'dambos' and streams helped in improving food security of their households (Maseko and Bussink, 1994). Water conservation through terracing and stream diversion in Machakos, Kenya also markedly reduced crop loss where the second rains failed (Tiffen and Mortimer, 1992).

While these examples from Malawi and Ghana lack some depth and breadth they do suggest how better management of farm resources can potentially improve production and ecological health of the agroecosystem. Increased internal recycling of agricultural residues coupled with increased species diversity can synergistically improve the economics and quality of the farming environment.

Ecological Soundness Needs More Than Learning at the Farm Level

Our experiences in both Malawi and Ghana indicate that successful transformation of a farming system requires a learning process that enables farmers to easily visualise their farming options. The examples in this paper demonstrate that drawing or modelling was one way to assist farmers. Illustrations of farm resources and how they are managed helped farmers to explore different possibilities for improving the health of their farming ecosystem. New management strategies were then implemented and their impact assessed over time. Drawing diagrams of before and after was one way for the farmers to quantify and evaluate this process and learn about managing their farms in a more ecologically sound and economically viable way.

However, this learning process will only lead to short-term improvements in farms unless national government policy is favourable and actively supports such developments. Farmers do not operate in a vacuum. The wider local and national community in which they live influences the way they farm. Service providers (government, NGO and private sector) need to be sensitive and in sympathy with developing a learning process that has as its goal ecologically sound farming. For example, farmers often need new partnerships to realise their future visions for improving their farming environment. For such developments to occur, learning is not just required at the grassroots level but also at the levels of village, district, province, etc. Only concerted action by people at all levels will enable ecologically sound agriculture to have a sustained impact on the health of the environment and the communities farming them.

Recognition is also needed that environmental issues, even on individual farms, can not be solved by technological fixes alone. People and the local and national communities of which they are a part form the major influence on the local environment and so one has to address the socioeconomic causes of environmental degradation as well as its immediate biophysical aspects. For farmers attempting to rehabilitate their farming resources, dealing with these social influences will be of major import in achieving their goals. In other words, they need to learn whom they must partner with, or at least engage in discussion, in order to move forward. This involves recognition that environmental problems, even on individual farms, are the result of a wider set of social influences other than that of the individual farmer involved. It also requires that people recognise that environmental management is complex and often many 'heads' are needed to come up with potential solutions to problems. An essential part of this process should be building farmers' skills in contributing to formulation of national policy concerning agricultural development.

What are the possibilities for creating a learning process that addresses both the social and biophysical aspects of agricultural development mentioned above? One approach is to expand the learning beyond the individual farmer and the technical problems on individual farms to incorporate the community of farmers in an area. At the same time the relevant service providers and policy makers are encouraged to join in the process to form a multi-stakeholder group. Its aim should be to learn how to collaborate together to design an agreed set of goals for agricultural development.

What are possible practical steps to create such a process? One needs to encourage farmers to analyse not only how they manage their natural resources from a technical viewpoint. They also need to understand how such management is influenced by the social and political environment in which they live. One can start by encouraging farmers to identify the people, private-sector organisations, government and non-government institutions which have direct and indirect influence on how they farm. This paper describes how farmers used diagrams to visualise technical management options for the biophysical aspects of their farming system. A similar learning exercise can be used with farmers to determine whom they might need to collaborate with when designing new strategies for improving their farming systems. Ramirez (1997) provides an example where farmers drew diagrams or linkage maps, which identified stakeholders influencing current farming practices. Farmers then used these diagrams to identify new partnerships and linkages that might be of importance for achieving their future goals. Engel and Salomon (1994) also emphasise the need for farmers to analyse their knowledge about all aspects of their farming environment. Their approach is to develop a kit that enables people to rapidly appraise the status of their knowledge and identify where they need to improve it concerning ecologically sound development. A major part of the analysis is to learn whom one needs to collaborate with, pool knowledge and form partnerships with to design new farming strategies.

As with the biophysical aspects of the farming system, stakeholder partnerships and interactions that affect the management of farming systems need to be monitored and evaluated. The challenge is how do you do this and if you can do it, how do you use the information to improve these partnerships so that they have a positive effect on the environment?

There is no one way to approach this process except for people to realise that whether they are farmers, policy makers or service providers, they need to work and learn together. They need to negotiate and agree on a vision for the future that will lead to rehabilitation of their agricultural resources. Learning to manage farming systems in a more ecologically sound way is a continuing process because communities and the physical environments they manage are always changing and evolving. So stakeholders need not only to implement new strategies for interacting with each other and managing their natural resources but also to monitor, track and evaluate the performance of these new ways of working. This requires agreement on indicators to assess the performance of the human and technical components involved in changing agroecosystem management. Indicators probably should first address key questions regarding performance targets or expectations. Secondly, targets should be chosen such that they provide information that guide management decisions and enable stakeholders to learn and build up their capacity to organise themselves more effectively.

Indicators for monitoring stakeholder partnerships are essential and need to be negotiated between all parties concerned. These indicators provide a measure of how well stakeholders are organising themselves to plan for improved management of local farming systems. Each stakeholder linkage could be assessed using indicators such as: relevance of service provided, timeliness of service delivery, accessibility of stakeholders in the linkage, etc. Indicators for measuring the performance of relationships are used as a mechanism for stakeholder groups to learn how to organise themselves better, not to condemn each other. If indicators show that some linkages work poorly, then people have the chance to learn and adjust their roles quickly and negotiate new interactions. This is essential if local stakeholder groups are to respond effectively to rapidly changing institutional environments.

SUMMARY

To summarise, the possible steps in developing a learning process as described above are:

1. Drawing exercises to create a diagram of how land is currently managed from a technical viewpoint.
2. Drawing of linkage or stakeholder diagrams to show which people, organisations and institutions have a major influence on how farmers currently manage their land.
3. From these analyses, farmers identify whom they need to negotiate and work with in order to meet their goals.
4. Formation of a multistakeholder learning group consisting of farmers, local policy makers, service providers, etc., to develop an agreed vision for the future.
5. Negotiation on how practically to work towards this vision of agricultural development, i.e., identifying the stakeholder partnerships that will be needed to implement new options in farm management.

6. Negotiation on indicators to track changes and evaluate how effective are new management options in rehabilitating the farming environment. (The evaluation should not only involve analysis of the technical state of the agroecosystem but also ideally that of the stakeholder partnerships formed to implement new management strategies.)
7. Reflection and reassessment of the outcome based on the evaluations above.
8. Readjustment of stakeholder partnerships and management strategies and then integration of the steps above.

All of this may seem overly ambitious and, certainly, the learning approach sketched out above is meant only to demonstrate one way to approach ecologically sound farming. However, for the complex issues involved in such agricultural development, there has to be a process whereby people can become informed, build their skills and learn to work together effectively. Doing agricultural development piecemeal by emphasising technical solutions and ignoring the social factors involved is unlikely to be successful. There also has to be some mechanism by which farmers can influence local and national policy towards agricultural development. Initiating a multistakholder learning group involving policy makers is one way to address this issue.

In this paper, we illustrated how one can initiate a learning process with regard to the technical aspects of agroecosystem management. The challenge for the future is how this approach can be expanded to incorporate the social, economic and policy dimensions that will be of importance in achieving rehabilitation of degraded farming systems. The summary of the learning process in this section provides one possibility for meeting this challenge.

NOTE

1. Farmers can use whatever units they feel comfortable with to express the productivity of their farms.

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