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Managing Africa's Soils No. 25

Exploring new pathways for innovative soil fertility management in Kenya

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About the authors

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About NUTNET

NUTNET is a network that aims to improve the management of soil fertility in Africa. It is a partnership of fifteen organisations from six African and two European countries: INERA, Burkina Faso; SOS Sahel, Ethiopia; KARI, KIOF & ETC East Africa, Kenya; IER, Mali; Environment Alert & University of Makerere, Uganda; IES, Zimbabwe; IIED & IDS, United Kingdom; and AB/DLO, LEI/DLO, SC/DLO, ETC & KIT, The Netherlands. NUTNET is funded by DGIS, the Ministry of Foreign Affairs in The Netherlands.

About *Enhancing soil fertility in Africa: from field to policy-maker*

This project builds on the work done by the NUTNET network, which has been extended to include the Swedish University of Agricultural Sciences (SLU), the Universidad Complutense de Madrid (UCM) and the National Agricultural Research Foundation (NAGREF) from Greece. It is funded by the International Co-operation for Development (INCO) programme of the European Union, which links ongoing research projects on soil fertility management in sub-Saharan Africa, focusing on the implications of diverse social, economic and environmental settings, and the differing perceptions held by stakeholders of research and policy design.

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Summary

This working paper discusses the impact of a multi-institutional research programme in low potential areas of Kenya. The programme elaborated nutrient balances, combined with economic analysis, to better understand causes and effects of soil fertility decline. Alongside, better soil fertility management practices were developed using a participatory technology approach. This paper assesses to what extent farmers changed their practices, if the program has influenced way of working with extension and research, or has led to better informed policies.

The use of a participatory approach to research, including regular discussion of results with farmers, has led to lasting changes at farm level. After participating in the research process, farmers started managing their crop residues more efficiently, using more diverse forms of organic inputs, producing better quality compost, improving their soil conservation practices and experimenting with agro-forestry, planting densities and different doses of compost.

At institutional level, the agencies involved in the process started using various participatory methodologies. The partnerships that developed between institutions and farmers enhanced the learning process, enabling them to target and prioritise soil fertility management options more effectively; while the experience, resources and interest of each participating institute helped improve working relations with farmers, provided opportunities for capacity building with research staff and widened the scope for using the results of the research.

In particular the results of the nutrient balance studies have been used to inform policy makers and raise awareness on declining soil fertility. However, although stakeholders participated in policy level discussions, it was not possible to initiate effective policy processes within the project time frame, as policy makers were not involved at a sufficiently early stage of the programme. Furthermore, the development of appropriate communication tools at the policy level requires urgent attention.

Effective change in the management of soil fertility requires the involvement of relevant stakeholders at all levels, from farmers to policy makers. Appropriate tools are needed to facilitate their full participation in decision making processes, and to ensure that all parties can communicate with each other, and that provision is made for capacity building, setting up the necessary infrastructure and establishing a favourable policy environment for implementing these options.

French summary

Résumé

Ce document relate l'impact d'un programme de recherche multi-institutionnelle dans des régions à faible potentiel du Kenya. Ce programme élaborait les bilans d'éléments nutritifs, combinés avec des analyses économiques, pour mieux comprendre les causes et les effets du déclin de la fertilité des sols. Dans le même temps, des pratiques améliorées de gestion de la fertilité des sols étaient développées à partir d'une approche de technologie participative. Le présent document évalue à quel point les agriculteurs ont changé leurs méthodes, si le programme a influencé la façon de travailler dans le domaine de la recherche ou a abouti à des politiques mieux informées.

L'utilisation d'une approche participative à la recherche, y compris des discussions régulières avec les agriculteurs sur les résultats, a conduit à des changements durables au niveau des exploitations agricoles. Les paysans engagés ont amélioré la gestion des résidus agricoles, utilisé plus de types d'apports organiques et en plus grandes quantités, appliqué des stratégies pour améliorer la qualité des composts et réparé les terrasses endommagées bien plus rapidement qu'auparavant. Les paysans font aussi des expériences avec l'agroforesterie, et les différents taux d'utilisation de compost.

Au niveau institutionnel, le partenariat établi pendant le processus de recherche s'est avéré utile pour élargir les dimensions pédagogiques et pour mieux donner la priorité et cibler les options d'une gestion améliorée de la fertilité des sols. Le fait d'avoir travaillé avec différentes institutions a également augmenté la gamme d'expériences, de ressources et d'intérêts disponibles et a multiplié les occasions de renforcer les capacités et d'élargir la possibilité d'utiliser les résultats produits par les recherches. A l'issue du programme, les institutions participantes ont adopté l'utilisation des méthodologies participatives à des degrés divers.

En particulier, les résultats des études portant sur les bilans des éléments nutritifs ont été utilisés pour informer les décideurs politiques. Bien que des discussions communes aient été tenues avec différents décideurs politiques, cela n'a pas entraîné d'initiatives politiques avant la fin du projet, surtout à cause de l'engagement tardif des décideurs politiques. De surcroît, il faudrait s'occuper d'urgence du développement d'outils de communication appropriés au niveau politique.

Initier les processus de changement dans la gestion de la fertilité des sols, dépendra de l'engagement de toutes les parties prenantes dans les processus de prise de décision. Cela nécessite l'emploi d'instruments appropriés pour combler le manque de communications et permettre une exploration efficace des solutions qui correspondent aux demandes des paysans. De telles initiatives doivent s'accompagner du renforcement des capacités à tous les niveaux, de l'apport de l'infrastructure nécessaire et d'un environnement politique favorable.

1 Introduction

Agricultural production in low potential areas of Kenya is constrained by declining soil fertility, unpredictable and erratic rainfall. Farmers are further hampered by inefficient input supply systems and markets for produce, and have limited opportunities to earn off-farm income. Other factors which affect agriculture are insufficient credit schemes and cash for investment, inadequate extension services, insecure land tenure and poor infrastructure. However, while it may be easy to list the problems that need to be overcome, there are no simple formulae for addressing these constraints and improving food security and rural livelihoods (Jager, 1999; Kinyanjui et al., 2000).

One of the challenges faced by those involved in rural development is improving soil fertility management in low potential areas. This working paper discusses the impact of a multi-institutional research programme in low potential areas of Kenya called LEINUTS[1]. The programme elaborated nutrient balances, combined with economic analysis, to better understand causes and effects of soil fertility decline. Alongside, better soil fertility management practices were developed using a participatory technology approach. This paper assesses to what extent farmers changed their practices, if the program has influenced way of working with extension and research, or has led to better informed policies. It starts with a brief description of the study area, before going on to outline the participatory approach used in the LEINUTS programme and its implications for learning at various levels – from the farm, through extension and research and up to policy level.

The LEINUTS approach

The LEINUTS programme was based on the Nutrient Monitoring framework (NUTMON), which uses a multi-disciplinary approach to identify and improve soil fertility management practices[2]. With a focus on building networks between stakeholders, the programme involved seven institutions from Kenya, Uganda and Europe, ranging from NGOs and national research institutes to universities. Farmers and research personnel

[1] The full name of LEINUTS is "Potentials of low external input and sustainable agriculture to attain productive and sustainable land use in Kenya and Uganda" and it was co-ordinated by LEI/DLO, The Netherlands.
[2] See Jager et al. (1998) for a detailed description of the methodology.

from several disciplines participated in the learning process, which began by identifying local concerns, opinions and knowledge, and then used them to develop and assess new technologies for improving soil fertility management strategies.

LEINUTS initiated debates with stakeholders at three different levels: farm level, the services aimed at supporting farmers (extension, research and other farmer support institutions) and policy level. Specific tools were used at different stages of the research process to facilitate dialogue with farmers and stimulate changes in soil fertility management.

The study area

The study was conducted in the Kalama Division of Machakos District, which is located in the Eastern Province of Kenya. With a population of 915,000 people (CBS, 2000), Machakos District covers an area of about 616,300 hectares, 85% of which is classified as semi-arid to arid. In the centre of the district, hills of up to 1800-2100 metres above sea level (masl) are surrounded by an extensive plateau that slopes from 1700 to 700 masl. Rainfall is bi-modal, with an annual average of between 500-1500mm, depending on location and altitude. The research site has two growing seasons per year, lasting from 90-119 days.

The main soils are ferralo-haplic Acrisols with Luvisols and Ferralsols. They are shallow and well drained, and many places have topsoil of loamy sand to sandy loam which is deficient in nitrogen, phosphorus and organic matter (Jaetzold and Schmidt, 1982; Kassam et al., 1991). These fragile soils are protected by extensive soil and water conservation measures, such as cut-off drains, stone lines, trash lines and terraces, particularly bench terraces on steep slopes (Tiffen et al., 1994). Farmyard manure, crop residues, mulch and cover crops are also used to fertilise and protect soils.

Agricultural land in the study area is held under freehold tenure. Farmers grow maize, pigeon peas, sorghum, beans and fruit trees, and raise indigenous breeds of cattle, goats, sheep and poultry. The main problems in the district include declining soil fertility, a reduction in the amount of arable land available per capita, unpredictable and unreliable rainfall, unproductive livestock and limited use of agricultural inputs (DAO, 1996).

Dialogue with farmers

Selecting farmers

Two groups of farmers were selected for the study. Those in the first group were trained in LEIA methods, and had to have used at least three LEIA technologies on over half of their cultivated land for a minimum of three consecutive years. The second group of 'conventional' farmers was made up of representatives from more traditional farming systems, who had similar productive resources to the LEIA group, but did not use any LEIA technologies.

Participants were selected after the programme objectives had been explained and discussed at community meetings, which were aimed at making farmers feel that they had a stake in the project. Farmers helped identify the criteria for participation, which included willingness to take part in the programme; access to certain productive resources, such as a minimum amount of land, labour and livestock; and market orientation. Experience with the LEIA methods used in the programme was also taken into account, to ensure that the LEIA farmers were competent in these techniques.

Table 1. Main characteristics of farms studied

Characteristics	*Conventional farms (n=10)*	*LEIA farms (n=8)*
Human resources		
Consumer units (aeu)	4	3.0
Labour units (aeu)	4	3
Primary education (%)[1]	92	94
Secondary education (%)[1]	42	42
Land		
Total cultivated area (ha)	2.4	2.4
Average slope (%)	17	17
Capital		
TLU	3.3	3.7
Value of livestock (US$)[2]	570	540
Value of land (US$)	2318	2012
Value of equipment (US$)	85	62
Ratios		
Land/labour (ha/aeu)	0.85	0.95
Land/consumer (ha/aeu)	0.85	1.03
Consumer/labour (aeu/aeu)	1.02*	0.93*

[1] Percentage of household members over 15 years old, with primary, secondary or further education.
[2] 1 US$ = Ksh 60 (at time of study)
* Significant difference (P=0.1)

A total of eighteen farmers participated in the study, of which ten farmed conventionally and eight used LEIA methods[3]. LEIA farmers were selected in collaboration with the NGO Kenya Institute of Organic Farming (KIOF), a partner in the LEINUTS programme that had been involved in training farmers in LEIA practices on study sites. The government extension agency helped select conventional farmers, focusing on candidates that were representative of the area. They chose farms that were fairly similar to each other, to ensure that variations between the groups were more likely to be caused by the test technologies rather than inherent differences. Before the selection was finalised, all chosen farmers were visited to check that they met the criteria, understood the objectives and implications of the research, and were motivated to see the process through to the end. Table 1 shows that the two groups were comparable in terms of labour and livestock resources, and the area and topography of their arable holdings.

Participatory assessment of soil types

LEINUTS used a three-phased approach at farm level: diagnosing problems, then testing and disseminating various technologies. In the diagnostic phase, participatory tools were used to assess natural resources. Farmers classified different soil types according to local criteria, and then used participatory soil mapping and transect walks to identify the constraints and potential of each type of soil. The researchers took samples of each soil type identified by farmers, sent them to a laboratory for analysis and presented the results at a feedback session in the village. Bar diagrams and illustrations of the symptoms of nutrient deficiency were used to compare the results of the analysis with farmers' assessments (Onduru et al., 1998). After discussions of the results, participants drew up a list of options for improving soil fertility management.

Nutrient balance studies

Researchers then helped farmers identify nutrient flows within their current management system, using resource flow maps to determine the net effects of the various flows. This exercise was based on the NUTMON model, which identifies three types of flow: inflows, internal flows and external flows at plot, household and farm levels[4]. The resource flow maps drawn by farmers mainly showed qualitative flows, which were quantified over the next three years through a combination of semi-structured interviews and monthly measurements at farm level. Data on the economic performance of the farming systems were also collected, and analysed with NUTMON software. The results were shared with farmers in joint analysis workshops, presented in the local language and with many visual tools. Again, the symptoms of nutrient deficiency were used to help farmers understand the results of nutrient balances and encourage them to discuss the constraints to soil fertility and possibilities for improving it.

[3] The initial selection included more farms, but some dropped out of the process.

[4] The importance of nutrient balances as a tool for understanding nutrient gains and losses and enabling farmers to manipulate flows has been demonstrated by Bosch et al. (1998).

Participatory Technology Development (PTD)

The results of the diagnostic phase provided the basis for the next stage of the programme, Participatory Technology Development. This is a joint learning process for farmers, extension workers and researchers, who work together identifying problems, selecting test technologies, listing the criteria and indicators used by farmers to evaluate the test technologies, implementing on-farm trials, and monitoring and evaluating the results of the trials (Reijntjes et al., 1992). After discussing proposals put forward by all those involved in the programme (see Table 2), participants selected some technologies for on-farm trials.

Table 2. Suggested technology options

LEIA farmers	*Conventional farmers*	*Extension workers and researchers*
• Compost • Liquid manure • Green manure • Different types of terrace	• Farmyard manure • Mineral fertilisers • Different types of terrace	• Rock phosphate • Mixing additives to compost (bone meal, rock phosphate etc.) • Green and liquid manures, "Bio fix" • Crop rotation • Soil and water conservation

The methods suggested by LEIA farmers focused on using locally available resources and organic inputs, while most of the options put forward by researchers were new to participating farmers. Compost and liquid manure were the technologies jointly selected by both groups of farmers and researchers for participatory on-farm research. The first treatment is what farmers normally apply which is on average 16 t/ha compost in the case of LEISA farms and a combined application of 16 t/ha "Boma" Manure and 57 kg/ha DAP in conventional farms. The second treatment involves a doubling of LEISA farmers' current compost application rate while the third treatment is a combined application of T_2 with 7 t/ha of liquid manure. Farmers and researchers wanted to compare the impacts of these technologies on maize with respect to soil nutrient balances and the agro-economic performance (Onduru et al., 1999).

A wide variety of tools and events were used to improve communication between stakeholders involved in the joint learning process and development of appropriate technologies. These included exchange visits to expose farmers to a broad range of soil fertility management practices; training research staff in PTD concepts, participatory resource flow mapping and joint evaluation of trials; and workshops with farmers, researchers and extension workers to develop the experimental design. Tools used included icebreakers, sub-group discussions, plenary presentations, visual aids, scoring and ranking exercises and brainstorming sessions. These were used to facilitate the

selection of technologies, joint design of treatments and agreement on procedures for implementation, data collection and evaluation, which were summarised in an action plan.

A specially trained community-based enumerator collected data from the target area on a monthly basis, while more frequent records were kept by researchers and farmers, the latter logging data in pictorial form. Researchers and extension staff visited farmers every month, and conducted a participatory evaluation of the trials to assess farmers' opinions and suggestions about the test technologies and their suitability for dissemination. The first evaluation was conducted during a field day, when the crops were still growing, and the second took place at the end of the trial. At the end-of-season meeting, farmers were asked for their opinions on an individual and group basis, and visual tools were used to share the results of the PTD process and open a debate on the processes of change.

Developing pathways of change with policy makers

In the third year of the research programme, the proposals put forward by farmers, extension agents and researchers were used to develop a list of possible options for improving soil fertility management. A workshop was held to present the results of the diagnostic phase, PTD trials and nutrient balance studies, discuss pathways for change at district level and formulate an action plan for improving soil fertility management. The workshop was attended by fifty-two participants, including agricultural extension staff, researchers, test farmers, farmers' representatives, provincial administration staff, input suppliers, co-operative societies involved in supplying inputs, NGOs and church development agencies. It gave participants an insight into the influences and historic trends in agriculture at district level, as well as the current farming situation, declining soil fertility and the organic farming options offered by LEIA technologies. A subsequent workshop organised by the NUTNET project[5] identified specific policies influencing soil fertility management, which needed further study to improve understanding of the processes involved in formulating and implementing policies. Stakeholders were invited to deliberate on the way forward at a separate feedback session.

[5] NUTNET – *Improving Soil Fertility in Africa: Nutrient Networks & Stakeholder Perceptions* is an umbrella project aimed at creating better links between research teams working on soil fertility management in sub-Saharan Africa.

2 Results and discussions

Learning at farm level

Identifying soil types and assessing their nutrient status

The team used discussions with farmers during the diagnostic stage of the programme to draw up an inventory of options for addressing the constraints to effective soil fertility management. These were then investigated with a combination of indigenous and scientific knowledge, using both participatory tools, such as soil mapping and transect walks, and more formal quantitative assessments, such as soil sampling and analysis. The results showed that there are significant correlations between the perceptions and indicators of soil fertility used by farmers and researchers, and that farmers use their knowledge of soil types and differences in soil nutrient status to tailor their soil fertility management practices to different situations (Onduru et al., 1998).[6] Diagnostic tools are therefore an important means of facilitating dialogue between farmers, extension workers and researchers, improving stakeholders' understanding and awareness of soil fertility and enabling them to identify appropriate options to improve the situation.

Nutrient balances

In order to understand the farming systems and nature and causes of declining soil fertility in Kenya, a number of studies were conducted on soil nutrient budgets and the economic performance of farms (Jager et al., 1998). They revealed that nitrogen outputs exceeded inputs at a rate of 21 – 25 kg/ha/year, representing an annual depletion of 0.4 – 0.5% across the farming systems studied (Table 3). Despite growing pressure for agricultural produce, few inputs are used and nutrients are lost from the system through processes such as erosion and leaching, as well as through harvests (Nandwa et al., 2000).

Some of the 'conventional' farmers were keen to start using LEIA techniques while the research into nutrient flows was still under way. It is possible that interest was further stimulated by contact with NGOs working on LEIA technologies, and by the project focus on assessing the impact of LEIA practices on integrated nutrient management.

[6] Similar findings were reported by Corbeels et al. (2000) in the semi-arid highlands of Tigray, Ethiopia, and by Kanté and Defoer (1994) in southern Mali.

Table 3. Nutrient stocks and flows in low potential areas of Machakos, Kenya (1997-1998)

	Conventional systems	*LEIA systems*
N-stock (kg/ha)	3900	6400
N-flow (kg ha^{-1},yr^{-1})	-21	-25
N-flow (% of stock, yr^{-1} x 10^{-1})	-0.5	-0.4
P-stock (kg/ha)	2000	1700
P-flow (kg ha^{-1},yr^{-1})	2	1
P-flow (% of stock, yr^{-1} x 10^{-1})	1	1
K-stock (kg/ha)	7800	10200
K-flow (kg ha^{-1},yr^{-1})	-9	2
K-flow (% of stock, yr^{-1} x 10^{-1})	-1	0

While the project team had hoped that the PTD process would encourage them to review their methods, they had to ensure that both groups maintained their normal practices until the end of the exercise.

The results of the analysis of nutrient balances in the area were shared during meetings with farmers. Visual aids were used as discussion points, and to explore the possible options for preventing further decline in soil fertility. Summarised in Table 4, they include combining inputs from various sources, reducing losses from erosion and leaching by increasing the organic matter content of soils, mulching, planting deep-rooted leguminous plants, and reducing gaseous losses by handling compost, farmyard manure and liquid manure more carefully. Possible constraints to using the proposed technologies are lack of materials for making compost, shortage of labour for building terraces along contours, and lack of cash for purchasing inputs.

Table 4. Suggestions for improving soil fertility

LEIA farmers	*Conventional farmers*
• Increasing the quantity of manure and compost • Using additives to improve the quality of compost • Avoiding the use of compost or manure that is not fully decomposed • Incorporating compost into the soil as soon as possible to minimise gaseous losses • Covering compost heaps • Installing more soil and water conservation structures. • Planting leguminous crops	• Covering manure or compost to reduce gaseous losses • Using additives when preparing compost • Incorporating crop residues into the soil • Planting leguminous plants, e.g. cowpea • Applying liquid manure • Applying the correct dose of fertiliser • Rotating crops • Taking measures to reduce soil erosion

The bar diagrams used to display the economic performance of farms showed that between 25-30% of net farm income was based upon 'nutrient mining'. There were no clear differences in economic performance between LEIA and conventional management systems, although further analysis revealed that LEIA management required more labour and produced slightly higher gross margins per acre of crop than the conventional systems. The results of the study indicated that LEIA technologies may not be the sole means of improving soil fertility management, and that the way forward may lie in combining the best uses of locally available inputs with external sources of nutrients.

During discussions about the economic performance of their farms, participants said that financial returns were not their primary concern as they relied on off-farm activities to supplement the household income, and viewed farming as a means of guaranteeing food security. They made the following suggestions for increasing farm income:

- Trying out cash crops, such as tomatoes;
- Producing more manure and compost to increase crop yields;
- Keeping dairy cattle in a zero grazing system to increase manure production and raise farm income. However, this option was limited by the capital required to set it up, and the fact that unreliable rainfall would affect the production of fodder.

Identifying technology options and PTD

The participatory tools used during the PTD process enabled stakeholders to discuss the potential of various technology options as they collaborated on the design and selection of trials, drawing planning maps, developing ranking methods and visual aids, ensuring that farmers knew how to fill out their record sheets, and organising field days. The results of the PTD shows that high doses of compost and liquid manure were more effective in increasing grain yields than single applications of compost, as they had a more beneficial effect on the soil nitrogen balance (Onduru et al., 1999).

The PTD process increased farmers' capacity to experiment and improved their confidence in their own ability to find solutions to different problems. At the end of trial period they were experimenting independently, trying out *tithornia* as a green manure, testing different doses of compost on various crops, conducting trials with plant density and spacing, and adapting techniques tried out during the PTD phase. After experimenting with compost on maize during the trials, half of participating farmers began testing its effects on vegetables once the trials had finished. They are also working on improving the quality of their compost and manure, and using liquid manure on their kitchen gardens. Other farmers in the area have also started trying out the technologies tested during the PTD process. The estimated take-up rate was 1:2 for each experimenting farmer.

Farmers were exposed to a whole range of new soil fertility management options through their dialogue with researchers and extension agents, and many have changed their management practices since participating in the research process. Crop residues are better managed, as they are incorporated into the soil soon after harvest, and as farmers are more aware about soil and water conservation practices in general, they are quicker to repair broken terraces and stabilise terrace embankments. Manure and compost are now recognised as important soil amendments, and all eighteen participating farmers are producing more compost and using various additives to improve its quality, such as *Tithornia sp*. and wood ash. Manure and compost heaps are no longer left in the open for long periods, but are now shaded with various locally available materials, and only taken to the field just before being incorporated into the soil. As they cannot produce enough compost and manure to fertilise whole fields over a single cropping season, farmers apply these inputs on a rotational basis. They have started using mulches in their kitchen gardens and planted agro-forestry tree species, such as *Sesbania sp*, in scattered stands in fields or along hedges. However, many have been put off using rock phosphates and other mineral fertilisers because of the cost involved.

Building a network at local level

A year after the active phase of the study ended, participating farmers continued to meet regularly, sharing their knowledge, experiences and resources, and taking turns working on each other's farms to compensate for labour shortages. They also contribute financially to local projects, demonstrating that the approach has succeeded in strengthening existing local institutions and establishing horizontal links between various groups. When the team and community members were selecting test farms, representatives from LEIA farmer groups set up before the programme began were included in the core research group, which subsequently acted as spokesperson for the communities where LEINUTS was working. By the end of the study period, it had an elected board consisting of a chairman, secretary and treasurer, and had facilitated various collective activities. This type of network and platform provides important opportunities for farmers to learn about and share their experiences with integrated soil fertility management, as has been noted elsewhere (Deugd et al., 1998; Defoer et al., 2000).

With greater interaction between farmers and extension, visits of the latter to the research site have continued even though the programme has finished. The research process has helped bridge the gap between extension services and farmers and the agency now uses the 'research group' as its point of contact with farmers. The usefullness of the service has improved since refocusing a number of its activities.

Lessons learned at the level of research, extension, and farmer support institutions

The research process provided an opportunity for farmers to learn about better soil fertility management practices, while enabling researchers to improve their understanding of indigenous technologies that could be used to manage soil fertility. Recognition of the rationales behind local farming systems and the value of local expertise in overcoming the constraints to soil fertility led researchers to change their attitudes. The resulting collaboration produced experimental designs that took account of farmers' needs and integrated their evaluation criteria in the monitoring process.

Much of the success of the programme depended on establishing good working relationships between research staff and local farmers. This was achieved by frequent visits from the researchers, and by using community-based enumerators to collect data. The fact that they lived locally meant that they were on hand to collect data during major farm operations. Once they had been trained to take a more proactive role, the enumerators were able to advise and motivate farmers, rather than simply observing and recording their activities.

Collaborative working methods and the creation of platforms for exchange between farmers, extension staff and universities enabled stakeholders to share their experiences and discuss the performance of technologies previously developed by research institutes. A range of specially designed communication tools enabled researchers to engage in more structured dialogue with farmers and work in close partnership with them, developing, evaluating and disseminating improved technologies. The multi-institutional and multi-disciplinary approach adopted by LEINUTS revealed much about the biophysical and socio-economic farming environment, helping researchers understand farm management and target and prioritise different techniques for managing soil fertility.

The approach also created broader institutional learning opportunities, as it involved people from a range of organisations with a variety of resources, links and interests. The research process gave them the opportunity to work as a team, improving communication between the different agencies and providing the basis for joint initiatives in soil fertility management. A collaborative approach to working and learning encouraged participants to recognise the value of different types of knowledge, enabling them to work successfully with farmers and other stakeholders in soil fertility management. NGOs also played an important role in the process, as they had already established working relationships with communities in the study site.

The partnerships established during the research process not only produced better results, but also strengthened relationships between stakeholders, linking national and international scientists and creating new partnerships between farmers, development

workers, researchers and extension agents. This is a promising development for the future of further joint initiatives to improve soil fertility management.

Institutionalising and scaling up

The participatory approach discussed here contrasts sharply with the "top-down technology transfer" model, and challenges the view that indigenous knowledge counts for little in the development of appropriate technologies. However, the encouraging results achieved are tempered by the fact that ours was only a pilot project, and while it may have succeeded in closing the gap between farmers and researchers, the general trend seems to be that the distance between them is increasing. Hall and Nahdy (1999) reported that participatory research with farmers is largely shaped by previous scientific research practices, institutional politics, the quality of human resources, individual personalities and professional aspirations, and country-specific cultural norms. Hilhorst and Toulmin (2000) argue that this type of research will only flourish if institutions undergo fundamental internal reforms, adding that researchers should also be judged on the basis of successful collaboration with farmers.

Because it involves both research institutes and NGOs, the multi-disciplinary approach is better suited to institutionalisation and scaling up than more limited initiatives. In their review of community involvement in research, Alsop and Farrington (1998) noted that individual institutions often operate on a very localised basis. Lawrence et al. (1999) reported that though NGOs have more experience with on-farm participatory research, they operate on a much more limited scale and mandate than state institutions.

Senior management and policy makers at KIOF, KARI and other participating institutions attended further feedback sessions to consider the adoption and institutionalisation of the methodologies used in the research process. At KIOF this has helped raise awareness of the importance of nutrient balances and the potential of this approach, which is now increasingly used within the institution and during the annual training sessions it organises for participants from all over eastern Africa. In the past, most KARI researchers concentrated on in-house commodity research programmes, as there was little incentive to work with farmers, given that the internal reward systems virtually ignored such initiatives on the basis that they were not sufficiently scientific. KARI has also started taking a more pro-active role in participatory research, encouraged by capacity building initiatives and various other experience with this type of approach (Sutherland and Mundy, 1999).

Impact of the research process and lessons learned at policy level

A district-level workshop on policies gave stakeholders further insights into nutrient balances and soil fertility management in general, which ended with the elaboration of an action plan for overcoming various constraints (see Box 1 below).

Box 1. Actions suggested at a district-level workshop on policy in Machakos

Soil fertility management

- Use locally available resources to improve soil organic matter content;
- Step up water harvesting initiatives;
- Conduct more training to raise awareness of the range of soil fertility management techniques;
- Increase research into alternative technologies.

Access to inputs

- Promote co-operative management strategies to enable farmers to pool their resources;
- Reduce dependency on government subsidies by promoting the use of local resources.

Improving rural development

- Provide artificial insemination services at village level.
- Use local processing to add value to farm products.
- Mobilise the community to take action on various agricultural development issues
- Facilitate the acquisition of title deeds to encourage investment in short- and long-term soil fertility management strategies.
- Credit provision
- Facilitate marketing to improve output-input price ratios
- Improve rural infrastructure

During the courses of the workshop, it became clear that while community initiatives are a fundamental requirement for change, better targeting and timely implementation of agricultural policies are also needed to facilitate the processes of change. Policies should be designed to encourage farmers to invest in soil fertility. Central government, however, is still seen as the dominant force shaping policies, largely excluding community and civil society groups from the policy process. Most participants agreed that policies are mostly formulated and implemented from the top down, and that extension agents and researchers have little opportunity to express their concerns at district or national level.

The gap between policy makers and research was underlined by the fact that district level policy makers only became aware of the project as it entered its final phase. Although they could participate in discussions about the results achieved, they were involved too late to feel part of the project, or to have their suggestions implemented before it ended. Any future initiatives of this sort should take note, and ensure that policy makers are involved as early as possible, in order to achieve some kind of synergy between policy design and the development and promotion of appropriate technologies. Having said this, it is worth pointing out that the feedback and exchange sessions did help raise awareness of nutrient balances and low external input technologies in general[7], and led to one local Member of Parliament raising a question on the matter in parliament.

Although a considerable amount of energy has been invested in developing tools to facilitate dialogue, reflection, analysis and experimentation with farmers and extension workers, little has been done to improve communication between stakeholders and policy makers. Initiatives to involve policy makers in the debate about soil fertility management need to be followed through, by developing tools and approaches that take account of the different actors operating at various levels of the policy process (Jager et al., 1999). Another issue requiring more attention is the presentation of scientific findings in a form that can be understood by lay people, from farmers to politicians (Ebanyat and Bekunda, 2001).

[7] In Uganda, the chairman of Kabale district council proposed that the proceedings of the workshops should be written in simpler language and copied to him, so that he can develop proposals for by-laws to improve the management of soils in his district. This is one example of research raising awareness of the problems faced by farmers; the challenge now is to translate findings on nutrient balances into policy (Ebanyat and Bekunda, 2001).

3 Conclusions

Using a participatory research approach

The participatory approach used in this research demonstrated the potential synergy and complementarity of the knowledge held by farmers, extension agents and researchers. Working through an inclusive process of dialogue, observation, diagnosis, experimentation and exposure to different types of knowledge, participants generated a range of options for improving soil fertility management. These covered soil and water conservation measures, as well as the use of compost and manure, agro-forestry tree species, mulching, rock phosphates, bone meal, etc. However, farmers are only likely to adopt sound soil fertility management practices if they think they will get a return on their investment, and it is therefore important to address the broader issues affecting rural livelihoods, and consider value-adding strategies as a means of facilitating change in soil fertility management.

Participatory research methods have made it possible to develop more appropriate technologies that take account of the perceptions and socio-economic situation of farmers. However, while various national research institutions and NGOs in Kenya recognise the value of such approaches, their viability largely depends on the institutional and social context within which they are promoted, the degree and manner in which major actors are involved in the research process, and the value attached to their work. The new approaches to addressing soil fertility issues should be institutionalised, and matched by measures to equip extension agents with the skills required for integrated soil fertility management. Training institutions need to develop tools for assessing the constraints to agricultural production, teach more practical approaches to solving the many problems related to soils, and help students consolidate their knowledge and adapt to different sociological settings through a system of mandatory internships (Ebanyat and Bekunda, 2001).

Nutrient budgets

There is now much greater awareness of the trends in declining soil fertility, which constitutes an important first step in defining pathways for changing management practices. Such awareness is largely due to studies of nutrient budgets, but their

usefulness depends on how the results are shared with stakeholders, from farmers and extension staff to researchers and policy makers. Nutrient budgets can provide valuable insights into nutrient flows and other factors affecting soil fertility management. However, it should be remembered that they are only snapshots of a particular point in a long-term process, and with this in mind, researchers need to be careful about extrapolating limited, locally specific data to regional or national levels (Scoones and Toulmin, 1998). The processes used to collect data for these nutrient budget studies need to be simplified. To obtain reliable results, farmers have to note every detail and quantity in a laborious and time-consuming process (Jager et al., 1998). New tools are required to speed up data collection and make it more accurate, as there is a fairly wide margin for error in the current system of asking farmers to estimate 'invisible' flows (Ebanyat and Bekunda, 2001).

Partnerships

No single institution can meet all the challenges involved in improving soil fertility management, which can only be overcome by building partnerships between, farmers, extension agents, private sector, researchers and policy makers. By working together, these institutions can create new avenues for learning and have a positive impact on the pace and progress of change, provided that they focus on developing technologies through farmer-centred approaches aimed at solving problems identified by farmers, and ensure that information is shared and disseminated effectively. Coming from a range of institutional backgrounds, the multi-disciplinary research teams working on the programme benefited from the diverse skills and resources of their colleagues, as well as gaining insight into participatory methodologies, the dynamics of smallholder farming systems, and targeting and prioritising soil fertility management options.

At farm level, the research process helped establish new partnerships between extension agents, researchers and farmers. It raised farmers awareness of declining soil fertility, encouraging them to adopt and adapt new methods of addressing the problem. Farmers' willingness to change their practices revealed a flexibility and ability to tailor management strategies to changing circumstances and experiences, in contrast to the received wisdom that they simply tend to follow tradition.

Engaging with policy makers

Although we are now seeing debates on policy and the impact of research processes, they will have little effect unless the links between research and extension are strengthened, and the system for informing policy makers is improved. The absence of proper platforms for exchange, however, may prevent the dissemination of information about new technologies, limiting the potential for research results to influence change.

Genuine communication between stakeholders is needed to facilitate positive changes in soil fertility management at all levels, which will also require their involvement in a range of decision making processes, from selecting test technologies to targeting capacity building initiatives, improving the infrastructure and designing and implementing policies. Although considerable effort has been invested in improving communication between stakeholders, much still needs to be done to ensure that the results of research are presented in an understandable and accessible manner to policy makers. In particular the results of the nutrient balance studies have been used to inform policy makers and raise awareness on declining soil fertility. However, it was not possible to initiate effective policy processes within the project time frame, as policy makers were not involved at a sufficiently early stage of the programme. Furthermore, the development of appropriate communication tools at the policy level requires urgent attention.

Most people in the field now accept that the development of sound soil fertility management practices and technologies can be furthered by integrating participatory research methods into existing institutional and social frameworks. However, the dialogue and collaboration integral to such developments should not be restricted to the short lifecycle of most projects. Development is an ongoing continuum, and it is essential that programmes are implemented at a pace commensurate with national development imperatives, within a time frame and funding cycle that allows for the processes of change.

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