

The African Network for Soil Biology and Fertility: New Challenges and Opportunities

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Abstract

Soil fertility degradation has been described as the single most important constraint to food security in sub-Saharan Africa (SSA). Soil fertility decline is not just a problem of nutrient deficiency but also of 1) Inappropriate germplasm and cropping system design, 2) Interactions with pests and diseases, 3) The linkage between poverty and land degradation, 4) Often perverse

national and global policies with respect to incentives, and 5) Institutional failures. Tackling soil fertility issues thus requires a long-term perspective and a holistic approach. The African Network for Soil Biology and Fertility (AfNet) of Tropical Soil Biology and Fertility institute of CIAT whose ultimate goal is to strengthen and sustain stakeholder capacity to generate, share and apply soil fertility management knowledge and skills to contribute to the welfare of farming communities is devoted to overcoming this challenge. This African-wide network has over 200 members from National Agricultural Research and Extension Services (NARES) and universities from various disciplines mainly soil science, social science and technology exchange. This paper is an highlight of AfNet's main activities which include: Network field research activities, information and documentation, training and capacity building.

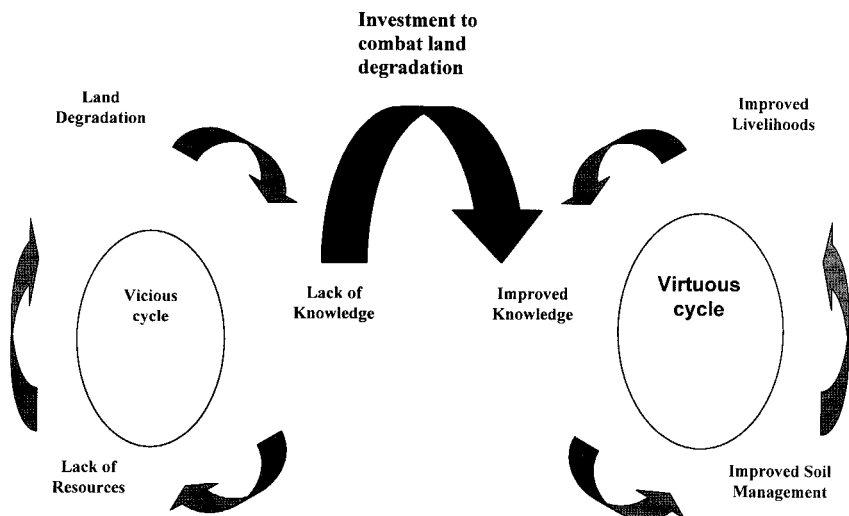
Introduction

Africa has 340 million people, over a half of its population living on less than USD 1 per day, a mortality rate of children under 5 years of age of 140 per 1000 and life expectancy of only 54 years. The latest figures show that some 200 million people, or 28% of Africa population are chronically hungry. The average African consumes only about 87% of the calories needed for a healthy and productive life. At present, over USD 18 billion is spent annually on food imports and in the year 2000, Africa received 2.8 million tons of food aid, a quarter of the world's total. Over half of the African population is rural, and directly dependent on locally grown crops or foods harvested from the immediate environment. Macro-policy changes imposed externally in the last decade, such as structural adjustment and the removal of fertilizer subsidies, were executed without any clear understanding of the likely consequences at a micro-level and hidden effect on continued erosion of the natural resource base. Structural adjustment policies resulted in the reduction of the use of external inputs, extensification of agriculture through the opening of new lands and the reduction of the farmers' potential for investment in soil fertility restoration. Technological, environmental, socio-cultural, economic, institutional and policy constraints have been identified to hamper agricultural development in Africa. These constraints are: (i) low soil fertility (ii) fragile ecosystems (iii) over dependence on rainfall (iv) aging rural population and thus limited physical energies for production (v) underdeveloped and degraded rural infrastructure (vi) insufficient research due to lack of motivation and inadequate facilities (vii) inadequate training and extension services (viii) high post harvest losses (ix) insufficient market (x) lack of credit

and insufficient agri-input delivery systems (xi) limited farmers' education and know-how (xii) continental brain-drain of African intellectuals (xiii) policy instability (xiv) inconsistent agricultural policies and efficient land tenure. This led to the New Partnership for Africa's Development (NEPAD) to recognize that agriculture-led development is fundamental to cutting hunger, reducing poverty, generating economic growth, reducing burden of food imports and opening the way to an expansion of exports. Per capita food production in Africa has been declining over the past two decades, contrary to the global trend. The result is widespread malnutrition, a recurrent need for emergency food and an increasing dependence on food grown outside the region. The average annual increase of cereal yield in Africa is about 10 kg/ha, the rate known as the one for extensive agriculture neglecting external inputs like improved seeds and plant nutrients. The growth rate for cereal grain yield is about 1% while population growth will be about 3%. During the last 35 years, cereals production per capita has decreased from 150 to 130 kg/person, whereas in Asia and Latin America an increase from about 200 to 250 kg/person have been observed. Both labor and land productivity are among the lowest of the world. The Forum for Agricultural Research in Africa (FARA) with its member sub-regional organizations (SRO) has developed a vision for African Agricultural Research, which calls for 6% annual growth in agricultural productivity.

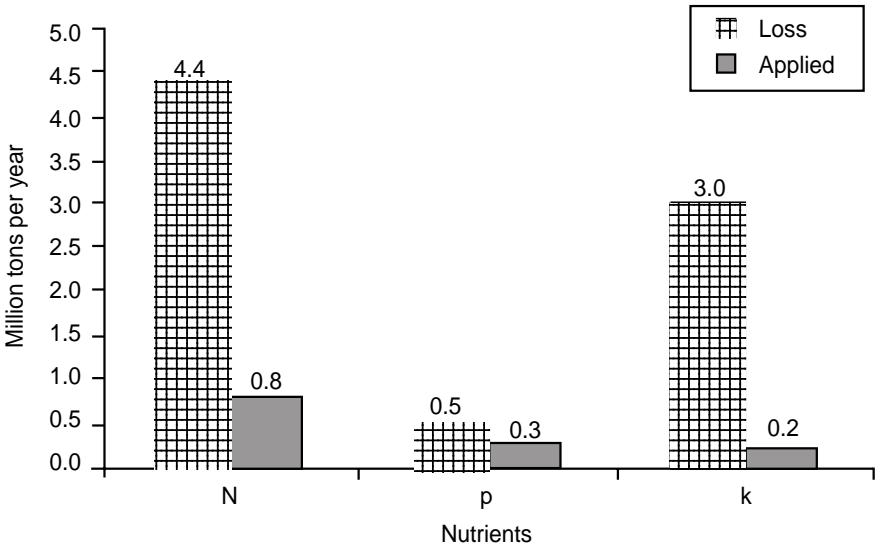
Land degradation is one of the most serious threats to food production in the continent. The population is thus trapped in a vicious poverty cycle between land degradation, and the lack of resources or knowledge to generate adequate income and opportunities to overcome the degradation and it is urgent to invest to combat land degradation to revert this vicious circle (Figure 1.1).

Figure 1.1: Combating land degradation to improve rural livelihoods



Scientists have reported that soil loss through erosion is about 10 times greater than the rate of natural formation, while the rate of deforestation is 30 times higher than that of planned reforestation. Although large areas of forests, wetlands, river valley bottoms and grassland savanna have been put under food crops, the food gap (requirements minus production) keeps widening. Soil nutrient depletion is a major bottleneck to increased productivity in Africa and has largely contributed to poverty and food insecurity. Soil nutrient depletion occurs when nutrient inflows are less than outflows. Nutrient balances for many cropping systems are negative indicating that farmers are mining their soil. The data in Figure 1.2 clearly illustrate the level of nutrient mining in African agro-ecosystems. For nitrogen as an example, whereas 4.4 million tons is lost per year, only 0.8 million tons is applied.

Figure 1.2: Macronutrient application versus loss in Africa



Source: Sanchez et al. (1997)

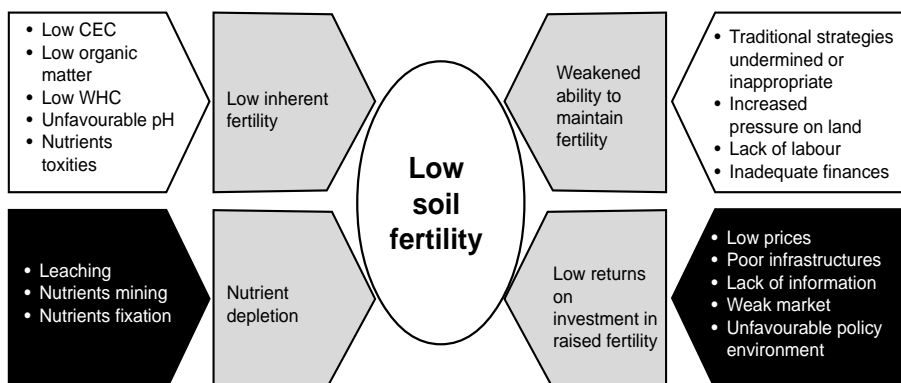
The different biophysical, chemical and socio-economic factors contributing to low soil fertility and poor productivity are reported in Figure 1.3.

At present, fertilizer use in Africa is about 9 kg ha⁻¹ as compared to 87 kg ha⁻¹ for the developed countries (Table 1.1). With 9% of the world's population, SSA account for less than 1.8% of global fertilizer use and less than 0.1% of global fertilizer production.

Table 1.1: Population, cropped land and fertilizer use (1961-97) in some African countries as compared to some developed ones

	1961			1997		
	Pop. (Million)	Crop land (Million ha)	Fertilizer use (Kg ha ⁻¹)	Pop. (Million)	Crop land (Million ha)	Fertilizer use (Kg ha ⁻¹)
World	3136	1352.0	23.0	5823	1501.0	90
Dev. countries	987	654	42	1294	640.0	87
S.S Africa	219	120	0.15	578	154	9
D.R. Congo	16	7.0	0.04	48	7.9	0.8
Kenya	9	28.8	2.8	28	4.5	29
Nigeria	38	0.6	0.5	104	30.7	4.5
Egypt	29	2.6	93	65	3.2	313
France	46	21.4	113	58	19.5	260
India	452	160.9	21	966	169.8	95
USA	189	182.5	41	272	177.0	114

Source: FAO 1999

Figure 1.3: Biophysical, chemical and socio-economic factors contributing to low soil fertility and poor productivity in Sub-Saharan Africa

Source: Murwira, 2003

The gradual degradation of the land is a menace to rural communities, in terms of food security and a continued exploitation of the fragile resource base depleted from many plant nutrients. There is, therefore, a critical need to develop and implement management options that both mitigate soil degradation, deforestation and biological resources losses and enhance local economies while protecting the natural resource base.

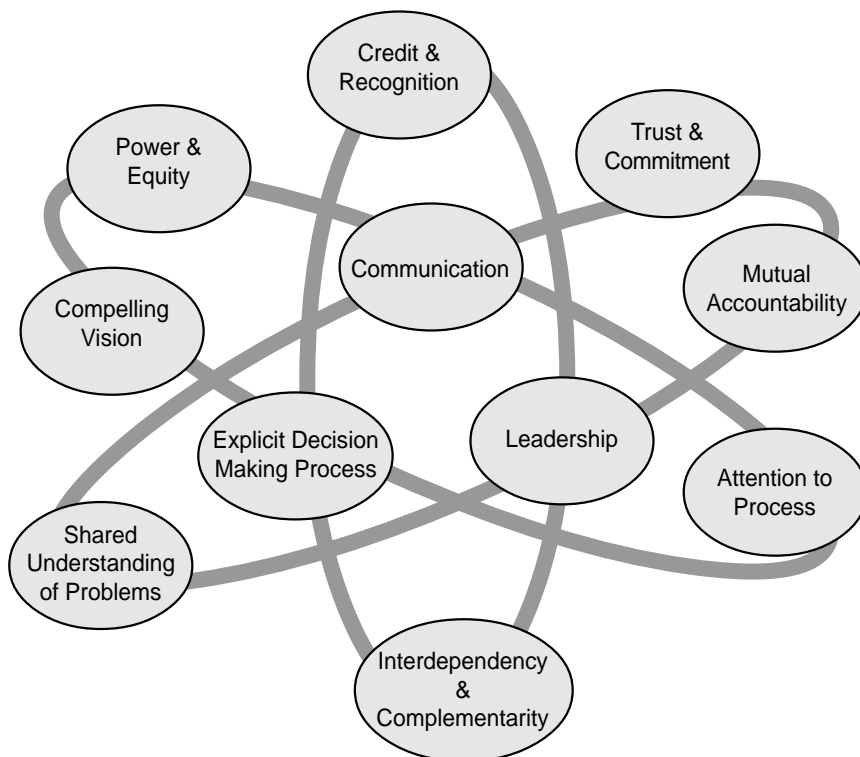
Transforming African Agriculture and expanding its production capacity are prerequisites for alleviating rural poverty, household food deficits and environmental exploitation in the continent. Because opportunities for expanding the cultivated area are rapidly being exhausted, as much as four-fifths of future production increases must come from higher yields. The use of effective strategies to combat land degradation is one of the key components of the higher productivity. The African Network for soil biology and fertility (AfNet) of the Tropical Soil Biology and Fertility Institute of CIAT is established to overcome the challenge of soil fertility degradation in the African continent. In this paper, after a brief presentation of AfNet objective and management, we will present the new challenges and opportunities of this network in field research activities, information and documentation, training and capacity building.

AfNet Objectives and Management

Networking may be defined as a strategy by stakeholders in a given area of interest to work together to achieve a common objective. The building blocks of a network are the participating individuals or institutions. These stakeholders collaborate on the hypothesis that working together is more beneficial and effective than working independently, and that there is a need to go outside the organization in order to accomplish their goals. Through networking, participants (a) build-up their knowledge base, (b) understand the processes through which they can promote values and (c) translate their understanding into action. Several achievements are possible in research through networking. The collaborating institutions or individuals are in a position to exchange information and combine collective experience of professionalism in the same field as partners. Figure 1.4 gives the different elements of partnerships and these elements are considered by AfNet in order to increase the network effectiveness and efficiency.

The advantages of networking include:

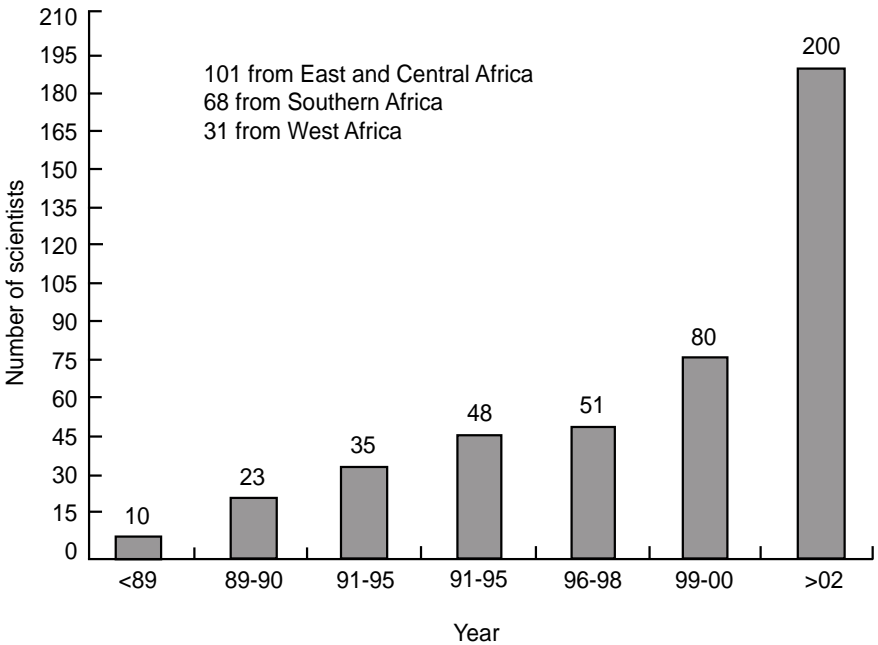
- i) To achieve economies of scale and efficiency in research by concentrating scarce human, financial and other resources on key national and regional problems;

Figure 1.4: Elements of Partnerships

- ii) To provide increased bargaining power with external partners;
- iii) To minimize duplication;
- iv) To exchange information and combine collective experience of professionals in the same field;
- v) To carry out collaborative research through network experiments;
- vi) To undertake joint capacity building;
- vii) To capture research spill-over/ spill-in effects;
- viii) To rationalize human resource development;
- ix) To mobilize research efforts on trans-national problems that require collaboration between countries;
- x) To exploit a larger market for agricultural research technologies through regional collaboration;
- xi) To demonstrate impact despite the declining investment in agricultural research through regional cooperation;
- xii) To achieve lower transaction costs;
- xiii) To facilitate better and more access by all stakeholders of available technologies at regional and international levels.

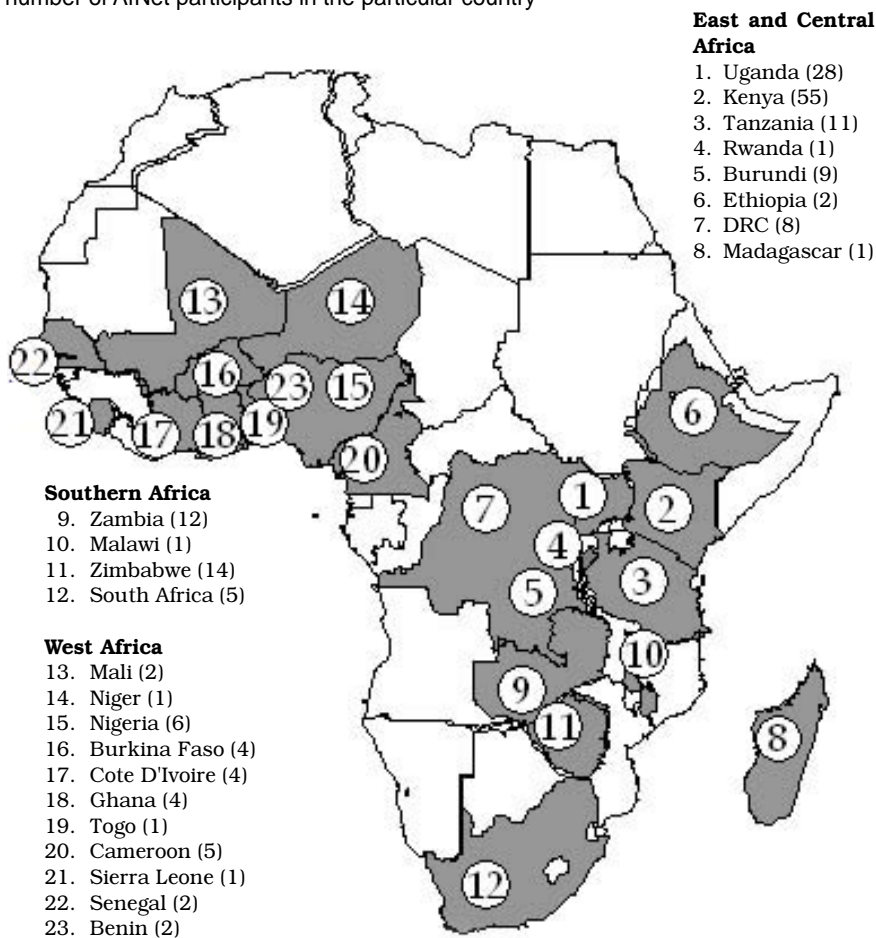
The African Network for Soil Biology and Fertility (AfNet) was established in 1988 and is the single most important implementing agency of TSBF in Africa. Its main goal is to strengthen and sustain stakeholder capacity to generate, share and apply soil fertility and biology management knowledge and skills to contribute to the welfare of farming communities. It is a mechanism to facilitate and promote collaboration in research and development among scientists in Africa for the purpose of developing innovative and practical resource management interventions for sustainable food production. AfNet has membership from National Agricultural Research and Extension services (NARES) and Universities from various disciplines mainly soil science, social science, agronomy and technology exchange.

Figure 1.5: AfNet member registrations since inception



With a total number of 10 researchers in 1989, AfNet has now a total number of over 200 persons in 2003. It is an African-wide network with 101 members from East and Central Africa, 68 from Southern Africa and 31 from West Africa (Figure 1.5). The data in Figure 1.6 gives the AfNet participating countries.

Figure 1.6: AfNet participating countries, 2003: Number in parenthesis represent the number of AfNet participants in the particular country



AfNet is under the auspices of the Tropical Soil Biology and Fertility Institute of CIAT, who implement most of its activities in Africa through AfNet. The AfNet members share TSBF goals and approaches. TSBF conduct research in a variety of tropical countries, but always in collaboration with national scientists. This implementation of TSBF agenda through partnership utilizes a range of approaches with particular emphasis on the following:

- i) **Catalysis:** Ensuring that AfNet members are kept at the forefront of conceptual and methodological advances by conducting and promoting review, synthesis and dissemination of knowledge and information. This is done through workshops, training and sabbatical and short exchange visits.
- ii) **Facilitation:** Co-ordinating actions by members to achieve progress

and success in research. This is done by providing backstopping support in the preparation, submission, implementation and publication of research results.

- iii) Collaboration: Developing appropriate alliances with institutions across the research, educational and development spectrum, including linkages between institutions in the North and those in the South.

AfNet has a coordination unit comprising of a secretariat, research assistants and the coordinator. AfNet is managed by a scientific committee comprising of the director of TSBF, the AfNet coordinator and five members from the national programmes elected during general assemblies by AfNet members.

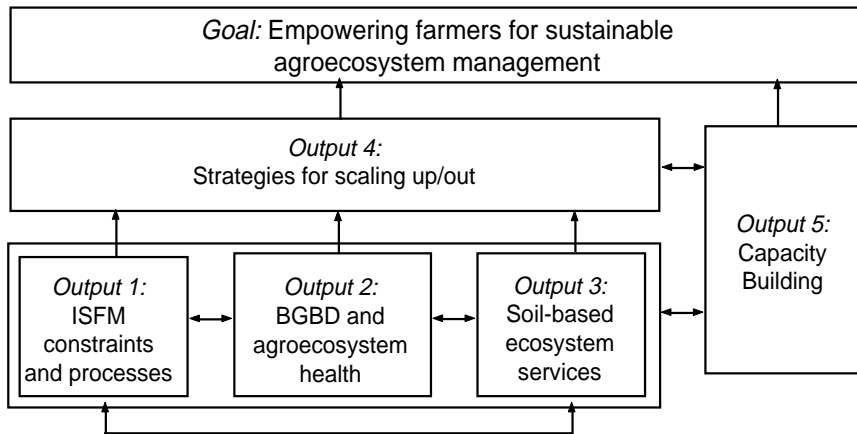
AfNet is dedicated to work more closely with other networks, system-wide ecoregional initiative such as AHI, SoilFertiNet, ANAFE, DMP, SWMNet, ECABREN, MIS and is planning to have an active role in the various challenge programmes of the CGIAR.

Network field activities

Predictive interdisciplinary research across environments, using standard methods and experimental designs, reinforces results, enables the drawing and extrapolation of generalized conclusions and enhances modeling capacity, all leading to accelerate progress in essential research areas. AfNet works with partners to identify key research themes or problems of regional or international importance and then develops appropriate experimental methods and protocols for addressing those topics. There will be a special focus on the use of decision support systems, GIS and modeling for the extrapolation of research results to other recommendation domains.

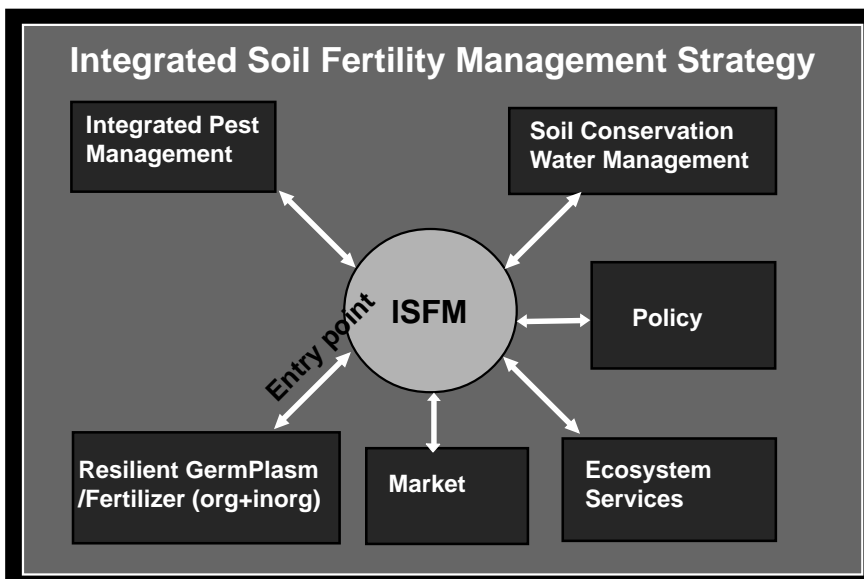
AfNet field research activities addresses the same research outputs of the TSBF institute of CIAT (Figure 1.7) with the overall goal of empowering farmers for sustainable agro ecosystem management. Output 1 on Integrated Soil Fertility Management (ISFM), output 2 on belowground biodiversity and agro-ecosystem health and output 3 on soil-based ecosystem services are the technical outputs for the development of alternative options. In Africa all research institutions are confronted with the challenge of extending their research findings for successful impact on farm. The fourth output on strategies for scaling up/ out will focus on evaluation of management options, on pathways of knowledge interchange and on policies for sustainable soil management by using the technical options developed by the other outputs.

Figure 1.7: The Tropical Soil Biology and Fertility Institute of CIAT research outputs



During the past three decades, the paradigms underlying soil fertility management research and development efforts in SSA have undergone substantial change. From the nutrient replacement paradigm to Low Input Sustainable Agriculture (LISA) AfNet adopted the Integrated Soil Fertility Management (ISFM) paradigm that forms an integral part of the Integrated Natural Resource Management (INRM) research approach with a focus on appropriate management of the soil resource (Figure 1.8).

Figure 1.8: Integrated Soil Fertility Management strategies with wider natural management concerns



In essence, ISFM is the adoption of a holistic approach to research on soil fertility that embraces the full range of driving factors and consequences- biological, physical, chemical, social, economic and political.

The need has been recognized for integration of socio-economic and policy research besides technical research. Soil fertility can no longer be regarded as a simple squared by the issue of organic and inorganic nutrient sources. The holistic approach encompasses nutrient deficiencies, inappropriate germplasm and cropping systems, pest and disease interaction with soil fertility, linkage between land degradation and poverty and global policies, incentives as well as institutional failures. Such long-term soil fertility management strategy requires an evolutionary and knowledge intensive process and participatory research and development focus rather than a purely technical focus.

AfNet will focus in the years to come on the following research topics and projects for the implementation of its field research activities.

Nutrient budgets of agroecosystems

Past research focuses on N, P, and K, there is need to target other macronutrient besides nitrogen, phosphorus and potassium and micronutrients and soil carbon. There will be need to focus more on methodologies for extrapolation of results in the time and space scales. The validation of transfer functions leading to better estimates of leaching losses, gaseous and erosion losses and the need to link nutrient balances data to other soil productivity indicators, total or available nutrient stocks, fertilizer needs and response functions and nutrient budgets to farmers' perception and knowledge systems.

Economic, policy and dissemination issues

In most of the research projects, economic policy and dissemination issues are incorporated with focus of economic analysis of soil fertility technologies with special emphasis on the trade-offs of alternative strategies of soil fertility management (eg food, feed, soil fertility management, social functions), the need to incorporate economic and bio-physical modeling to capture long-term sustainability and risk perspectives.

On adoption and impact assessment, special attention is put on the assessment of socio-economic and agronomic factors affecting farmers' adoption of best bet technologies, the measurement, the understanding of the potential and constraints and the economics of different dissemination channels. Research on ways to increase farmers' access

to external input through the establishment of appropriate credit and saving schemes. Policy research and advocacy to create an enabling environment to accelerate adoption of best bet technologies and establishment of policy briefs and studies on economic of different dissemination channels will be emphasized.

Long-term soil fertility management trials

AfNet is contributing with NARS to maintain long-term soil fertility management trials in the sub-humid highlands of Kenya at Kabete (established since 1976), the sub-humid zone of Burkina Faso at Farakoba (established since 1990), the dry savannah of Burkina Faso at Saria (established since 1960) and at Fada (established since 1990) and the Sahelian zone of Niger at Sadore (established since 1982). The overall goal is to access sustainability indicators from the different inputs (organic and inorganic) and cropping systems.

Combining organic and inorganic nutrient sources for increased soil quality

The overall goal of the work on organic-inorganic interactions is to (i) empower farmers (Including extension workers and stakeholders) to use organic and inorganic resources with optimal efficiency; (ii) understand the long-term effects on nutrient recovery efficiencies and (iii) better understand the non-N effects of organic amendments (weed suppression eg striga, other nutrients (Ca, Mg, K, S, P etc...), moisture retention and use).

The role of legumes in soil fertility restoration

The general objective for this network study is to foster strategic research on issues that increase efficiency of legume cover crops (LCCs) for enhancement and sustaining soil fertility and hence crop yields in smallholder farms in the Sub-Saharan Africa. The derived specific objectives are: 1) Review and document current information on the use of LCCs for soil fertility improvement in the Africa region 2) Determine the contribution of above and below ground biomass from LCC on the subsequent food crops 3) Determine the relationship between source and quantity of N from cover crops and its recovery in the subsequent crop 4) Evaluate tradeoffs in gains and losses in food production, land availability, labour constraints and capital that may affect the adoption of LCCs 5) Develop a decision support guide for dissemination of LCC technologies.

Livestock and soil fertility issues

For this research theme we will emphasize on the assessment of manure production, livestock rangeland ratios for sustainable production. Strategies that minimize competition between crops and livestock. The overall objective for the improvement of manure management aims at reviewing past manure work in the individual countries and identifying technologies that could be disseminated without doing basic research; testing and validating, various composting/storage techniques on crop yield, soil fertility maintenance and economics with farmers' participation; and the contribution of manure use to soil organic matter.

Use of rock phosphate as capital investment to replenish soil fertility

The use of fertilizers is a possible option to reverse the soil fertility decline trend but their high costs constitute an handicap mainly to resource poor farmers. There is therefore a need for alternative, affordable P sources. Rock phosphates which are found in most parts of Africa have low reactivity. They, however offer a cheaper source of P for resource poor farmers. For this issue, there is need to extend the agronomic evaluation of suitability of PR to perennial crops and other crops than the traditional cereals and to investigate on the interaction between soil, climate and water conservation on PR effectiveness. The screening of plant species and association with Vascular Arbuscular Mycorrhizae (VAM) for efficient use of PR need more attention. The economics of compacted products with PR and development of decision support systems (DSS) need to be emphasized. Solubility of these phosphate rocks can be improved by using combination of the rock and organic/green manures. Besides their solubilization effects, the organic materials influence soil P availability by altering some processes governing soil P pools such as microbial activities and P sorption. Different organic inputs are likely to impart different effects on rock phosphate dissolution and soil P availability depending on their composition, rate of application, and type of soil and agro-ecological zone. This network research theme therefore is to do on-farm testing of Phosphate rocks P dissolution as influenced by different types and rates of organic materials and the subsequent crop yield. Specifically, the research is intended to identify, characterize and evaluate locally available organic materials for their potential to enhance phosphate rock solubilization under farmer's conditions. Also establish the effect of local organic materials on PR dissolution and its relative agronomic effectiveness. In addition the research will assess the effects of organic and inorganic P sources on soil P dynamics and fractions.

Nutrient and water interaction

African dry lands soils have low inherent fertility, and this combined with high inter-annual variability and erratic rainfall distribution in space result in water limiting conditions and poor crop yields. The use of effective strategies to control nutrient mining and improve water and nutrient use efficiency in dry land Africa is one of the key components for higher productivity. In light of large initial investment in material machinery and labor for water harvesting, there is need to focus research to increase the profitability in the farming systems. Although water and nutrient interaction research is essential for increasing and stabilizing crop production, and for maximizing the returns from investments on fertilizer and water harvesting techniques, far less studies on these interactions have been carried out in the dry lands of Africa, compared to studies on nutrients or those of water separately. A win win situation will occur when water and nutrients are combined as this will increase the efficiency of these inputs and therefore improve their profitability to the small-scale farmer.

Land tenure

Land tenure has a critical impact on market values and thus on economic decision making as to the uses to which land should be put and how to utilize the natural resource. Nature of land rights affects use; duration of right affects nature of long-term investment. World Bank estimates suggest that the capital value of land and natural resources constitutes half to three quarters of a nation's wealth: the less domestic capital and the less developed the economy, the higher this proportion. What is true for the nation is also typically true for the family and individual. Land and natural resources are therefore likely to be by far the largest class of asset in most economies. Its efficient use and management must be one of the keys to successful economic development. Secure land rights will move the key economic resource of land towards the highest and economically most efficient use.

Lack of secure land tenure is associated with overexploitation of resources. In turn, overexploitation of land and natural resources critically affects the economic welfare and food security. With insecure land tenure, farmers have no incentive to commit long-term investments for sustainable farming and livelihood.

The main goal of this research theme is to contribute to poverty reduction through increased land productivity to improve food security, while conserving the natural resource base for sustainable production. The purpose is to provide farming communities, policy-makers and other stakeholders with land tenure policy options that will improve adoption

of land management and conservation technologies. The research agenda seek to achieve the following specific objectives: (1) Review and compile existing land and natural resource use and investment policies that has direct implication to smallholder farmers' decision-making process, (2) Identify categories of tenure that play major role in adopting available technologies for integrated land management and natural resource use, (3) Estimate socioeconomic gains associated with secure land tenure through bio-economic modeling/simulation, (4) Suggest policy instruments that would encourage secure land tenure and maximize national goals of improving smallholder farmers' welfare.

Conservation tillage

Combination of soil fertility restoration technologies and conservation tillage practices offer opportunities to sustainable land use. However, little has been done to integrate these approaches within existing crop production systems. It is hypothesized that combining soil fertility technologies with conservation tillage practices is one of the best strategies to increase food security, sustain rural livelihoods in sub-Saharan Africa and maintain soil organic matter.

In this research theme, the following specific objectives are sought to be achieved: (i) Evaluate the productivity of different cropping systems following conservation tillage practices, (ii) Determine the effect of conservation tillage on sustainability and soil health indicators, (iii) Promote conservation tillage practices as a means to restore the productivity of degraded soils.

Belowground biodiversity

The soil biota constitutes a major fraction of global terrestrial biodiversity and is responsible for key ecosystem functions such as decomposition; nutrient acquisition, storage and cycling; soil organic matter synthesis and mineralization; soil structural modification; regulation of atmospheric composition; and the biological control of soil-borne pests and diseases. These functions remain largely under-exploited by humans for services and products in agriculture because little has been understood on the biological processes of soil unlike physical and chemical management of soil.

The strategic research in AfNet to realise this potential by:

- Developing quantitative techniques for monitoring and manipulating key functional groups of soil biota and their relationship to ecosystem service functions and plant health.

- Developing and validate management practices for key groups of beneficial soil organisms for small-scale farms.
- Linking local knowledge about biological indicators of soil quality with scientific knowledge to develop robust soil quality monitoring systems that combine precision and relevance.

This research agenda will also seek to establish the relationship between organic residue quality (resource quality), farmers' management strategies and diversity, populations and activities of biotic community (macrofauna: ecosystem engineers-earthworms, termites, ants and others) associated with biomass transfer technologies. The main aim is to come out with the best-bet approach that promote soil biotic activities, increase and sustain soil productivity and minimize pest incidence in tropical agroecosystems.

Also to sustainably increase crop yield for small-scale farmers in sub-Saharan Africa by using mycorrhiza as bio-fertilizer and build farmers' understanding on the importance of termites and other macro and meso faunal communities in African farming systems.

Low quality organic resource management

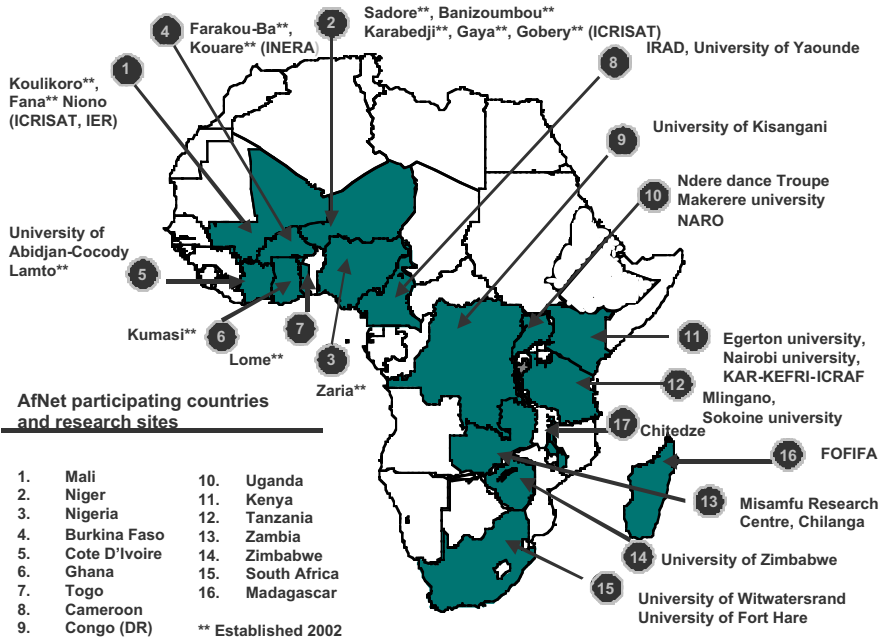
This research theme examines the functional role of low quality organic resources on soil organic matter (SOM) and the ultimate influence in sustaining crop productivity and environmental service functions in tropical agro-ecosystems as affected by management of quality and quantities of low quality organic resources available to smallholder farmers in the sub-Saharan region of Africa. The research will i) Characterize the quantity and quality of organic materials available to smallholder farmers in benchmark areas, and determine how these have influenced SOM status and dynamics under different management practices and biophysical environments; ii) determine the quantitative effects of continuous application of low quality organic inputs on SOM build up, soil nutrient supply patterns and soil physico-chemical properties; iii) quantify the differential contribution of distinct SOM functional pools (fractions) to soil properties essential for maintenance of crop productivity and environmental quality under different management systems, soils types and climatic environments in selected benchmark areas; iv) define the biophysical and socio-economic boundaries within which SOM management can be enhanced for increased soil productivity and environmental services in tropical farming systems in sub-Saharan Africa.

Site selection

The field activities are carried out on benchmark and satellite sites. The benchmark sites are selected according to several factors such as soil types, rainfall regime, farming systems, type of market, land tenure, etc...

At present, AfNet is implementing field research in about 50 representative benchmark sites in Africa. Figure 1.9 gives some selected benchmark sites where experiments were carried out in 2002. AfNet encourages multi-disciplinary approach for the implementation of its field activities but individual research projects are also supported by the network. In addition to the thematic research, focus is put now on the development of country proposals using an holistic approach to Integrate Soil Fertility Management (ISFM).

Figure 1.9: Selected AfNet research sites in 2002



Funding mechanism

The funding of network trials is on a competitive basis and the criteria used for the attribution of funds are based on: (i) the level of contribution to food security and self sufficiency (ii) equity (number of beneficiaries, poverty alleviation, gender/ age consideration) (iii) efficiency (iv) sustainability (v) effectiveness (probability of success, cost of adoption) (vi) regional collaboration.

Information and documentation

One of the main constraints to soil biological research experienced by many national scientists is limited access to current research findings. It is important not only that current research developments are accessible to members of the network but that the results of their own work are effectively disseminated. In addition, farmers in SSA are attempting to improve soils, but their efforts are constrained by limited access to useful information, low resource endowments, and lack of incentives. Wealthier households having access to information and with more options available, are more likely to manage their soils better. Poor households lack knowledge of soil management options, the capacity to invest in soils (especially in fertilizer), and have less ability to bear risk and wait for future payoffs from investment. For example, in Western Kenya, resource-poor households, with no access to information, were found to make only 5% of the farm investments, had over twice the erosion rates as compared to the wealthy farmers, and obtained only 28% of maize yields. Tragically, these resource-poor households constitute about 90% of the population. Compounding the problem are poor price incentives, land and labour constraints, and the weakness or complete lack of rural institutions for supporting information and other services. The network will collaborate with other institutions to develop information easy-to-read by farmers on transferable technologies for soil fertility restoration.

A major function of AfNet is to publish, synthesis and disseminate research results relevant to its programme goals. AfNet is publishing twice yearly the comminutor (TSBF newsletter) as a link between network members. Literature search is done as needed on specific subjects for distribution to network members. In addition to publication to refereed journals, AfNet has committed to produce three books.

- (i) Soil Fertility Management in Africa: A Regional Perspective.
- (ii) Managing Nutrient Cycles to Sustain Soil Fertility in Africa: Proceedings of the 8th Meeting of The African Network for Soil Biology and Fertility, Arusha, Tanzania.
- (iii) Fighting Poverty in sub-Saharan Africa: The Multiple Roles of Legumes in Integrated Soil Fertility Management.

Training and capacity building

The capacity for ISFM research in sub-Saharan Africa is insufficient both in terms of the numbers of professional personnel and the essential laboratory facilities. ISFM is a knowledge intensive approach to soil management. Professional staff and students alike suffer from isolation and lack of access to up-to-date educational opportunities. Networks run by sub-Regional Organisations and CGIAR Centres, such as the TSBF African Network for Soil Biology and Fertility (AfNet) provide a vehicle of opportunity to correct this situation. Priority actions include:

- Strengthen networking to engage a wide range of stakeholders and enhance the efficiency of ISFM research.
- In particular, strengthen links between research and extension (including NGOs) using a “learning by doing” approach, which includes local knowledge and builds on existing networks.
- Develop strategic partnerships in capacity building that identify and utilise the range of comparative expertise.
- Improve the dissemination of knowledge on ISFM through a wide range of methods including electronic sharing and training of trainers.
- Promote programmatic linkages with Universities and other educational institutions to strengthen curricula with appropriate and up-to-date information and teaching materials.
- Raise awareness of ISFM issues with policy and decision-makers at all levels.

Table 1.2 below showing the percentage literacy rates reveals an average (57%) literacy rate in the African continent as compared to 97% in the European continent. In some countries like Niger, the literacy rate is as low as 16%. This is a clear indication that more than half of the African population cannot read neither write hence imposing a great impairment to the implementation and dissemination of the research results.

Table 1.2: Selected education statistics for some countries in Africa and other world regions

Country	Literacy rate (%)	Tertiary school enrolment (%)
Burkina Faso	24	0.9
Kenya	83	-
Uganda	67	1.7
Niger	16	1
World	74	14
SSA	57	5
Europe	97	27

Source: ADB 1999

In sub-Saharan Africa tertiary school enrolment has gone as low as 5% as compared to the European continent, which has 27%. However, in addition to low literacy rate in the African continent, there has been a great concern that institutions of higher learning are not making a significant contribution to the national agricultural research agenda. This is due in part to the limited funding of agricultural higher education (Table 1.3). From 1987-97, World Bank global support to agricultural extension was 46.3% as compared to 2.2% for agricultural higher education. The common trend in the African continent has been decline in support for research in these institutions. This trend has to change especially with the realization that many universities in Africa have a large stock of agricultural scientists with M.Sc. and PhD degrees. For example, in 1995, there were 547 African scientists with a PhD in agriculture employed by universities and 357 in the National Agricultural Research Systems (NARSs) in Eastern and Southern Africa.

Table 1.3: World Bank Global Support for Agricultural Research, Extension and Agricultural Higher Education, 1987-97

	Million \$	Percent
Agricultural research	2,482	51.5
Agricultural extension	2,229	46.3
Agricultural higher education	108	2.2
Total	4,819	100

Source: Willett 1998

Lack of administrative, managerial and scientific capacity has been noted as the weak link in African development. Therefore, it is of great importance to launch capacity building initiatives in the African continent. The availability of personnel suitably trained in the appropriate techniques is essential for sustainable agricultural development and research. Since investment in knowledge and human resources is central to sustained development, capacity building should help to rehabilitate and strengthen research and higher education in the African region. TSBF promotes interest in soil biology and fertility among scientists by providing experience and orientation in TSBF methods through short courses, internships and attendance at professional meetings.

Universities and other institutions of higher learning represent the only sustainable option that can, in the long-term, reduce the over dependency on overseas training in the African continent. Therefore, the managers of agricultural research and extension systems in Africa should have a deep concern on improving the quality of local graduate programs because, after phasing out scholarships for overseas training,

African universities remain the primary source of human capital for agricultural research and extension agencies in the continent. The African Network for Soil Biology and Fertility (AfNet) has taken this challenge and is in the process of developing a soil biology curriculum support in African Universities. Some of the needs highlighted by 13 African Universities include: lack of critical mass, limited access to information, limited access to teaching material, poor laboratory facilities, and limited examples from African environments.

AfNet will organize short term training courses which will address the following issues: (i) TSBF Standard methods for process and applied research in Soil Biology and Fertility; (ii) data collection, statistical analysis and interpretation; (iii) methodology for on-farm research; (iv) scientific paper writing; and (v) development of research proposals. It will also liaise with universities in Europe and the United States of America to have students do their thesis with TSBF officers in Africa for co-supervision of students for MSc and PhD from local universities on topics relevant to TSBF research

Conclusion

Land degradation is one of the most serious threats to food production in the African continent. The population is thus trapped in a vicious poverty cycle between land degradation, and the lack of resources or knowledge to generate adequate income and opportunities to overcome the degradation and it is urgent to invest to combat land degradation to revert this vicious circle. Soil fertility can no longer be regarded as a simple issue squared by the issue of organic and inorganic sources of nutrients. Integrated soil fertility management embraces responses to the full range of driving factors and consequences, namely biological, physical, chemical, social, economic and political aspects. The holistic approach encompasses nutrient deficiencies, inappropriate germplasm and cropping system design, pest, disease interaction with soil fertility, linkage between land degradation and poverty and global policies, incentives as well as institutional failures. Such long-term soil fertility management strategy requires an evolutionary and knowledge intensive process and participatory research and development focus rather than a purely technical focus.

AfNet developed several research projects on Integrated Soil Fertility Management (ISFM), Belowground Biodiversity (BGBD) and agro ecosystem health, soil based ecosystem services and strategies for scaling up/ out to empower farmers for sustainable agro-ecosystems' management. Information and documentation, training and capacity building are among the main strategies of AfNet for sustainable agricultural development in Africa.

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