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The African Network for Soil Biology and Fertility (AfNet)

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Abstract

Soil fertility degradation has been described as the single most important biophysical 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 is devoted to overcoming this challenge. AfNet's ultimate goal is to strengthen and sustain stakeholder capacity to generate, share and apply soil fertility management knowledge and skills to contribute towards improved livelihoods of farming communities. 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 transfer. This paper highlights AfNet's main activities which include: Network field research activities, information and documentation, training and capacity building.

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Introduction

The African Network for Soil Biology and Fertility (AfNet) of the Tropical Soil Biology and Fertility Institute of CIAT was established to overcome the challenge of soil fertility degradation in the African continent.

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 in the African continent. 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.

With a total number of 10 researchers in 1989, AfNet has now a total number of over 220 scientists in 2003 (**Figure 1**). It is an African-wide network with 111 members from East and Central Africa, 70 from Southern Africa and 39 from West Africa. The data in **Figure 2** gives the AfNet participating countries.

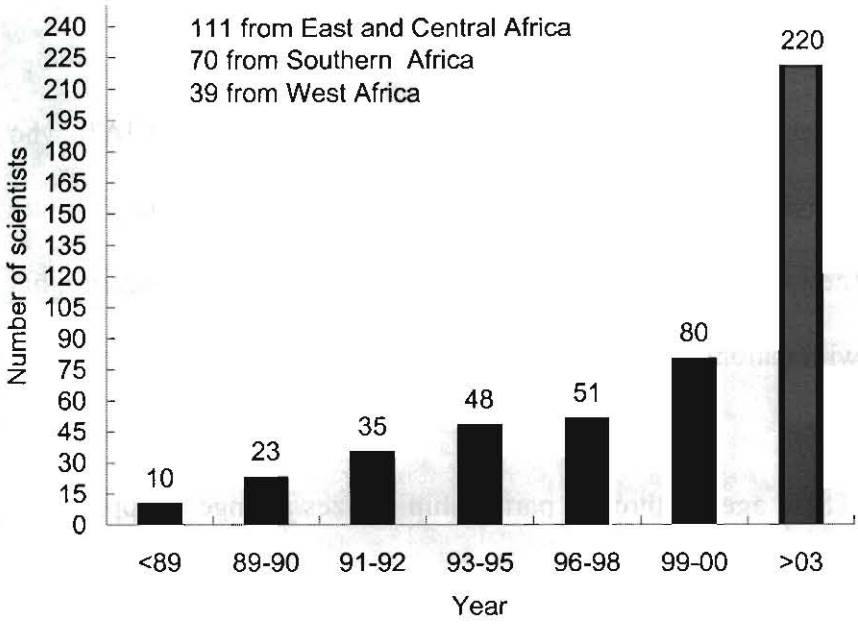

Figure 1: AfNet member registrations since inception

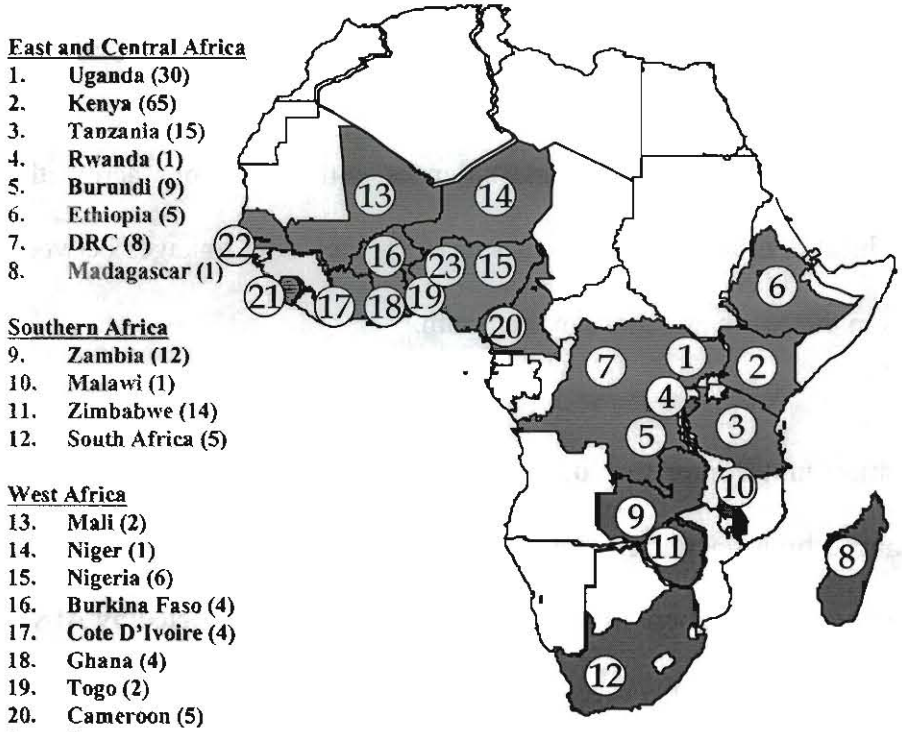

Figure 2: AfNet participating countries, 2003: Number in parenthesis represent the number of AfNet participants in the particular country

AfNet is coordinated by 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. It is managed by a scientific committee composed of the director of TSBF, the AfNet coordinator and five members from the national programmes elected by AfNet members during AfNet general assembly meeting.

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

After a brief overview of the Africa's soil fertility problem, this paper presents and discusses AfNet objectives and management, new challenges and opportunities for the network in field research activities, information and documentation, training and capacity building.

Overview of soil fertility problem in Africa

Over a half of Africa's population is 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 deterioration 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 rainfed agriculture (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 markets (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) political instability (xiv) inconsistent agricultural policies and inefficient land tenure. 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 supply 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 is 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. This led to the New

Partnership for Africa's Development (NEPAD) to recognize that agriculture-led development is fundamental to cutting off hunger, reducing poverty, generating economic growth, reducing burden of food imports and opening the way to an expansion of exports.

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 and knowledge to generate adequate income and opportunities to overcome the degradation and it is urgent to invest to combat land degradation to reverse this vicious circle (**Figure 3**).

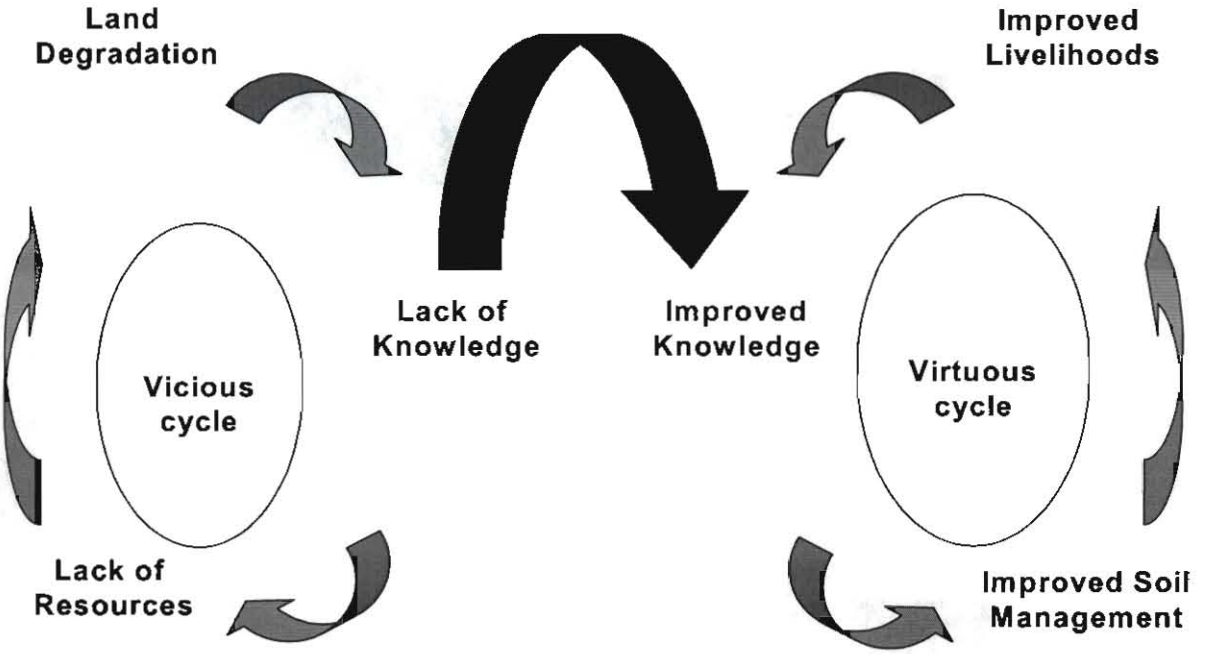

Figure 3: Combating land degradation to improve rural livelihoods.

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 in-flows are less than outflows. Nutrient balances for many cropping systems are negative indicating that farmers are mining their soil. The data in **Figure 4** 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 are applied. Similar trends are also observed for phosphorus (P) and potassium (K).

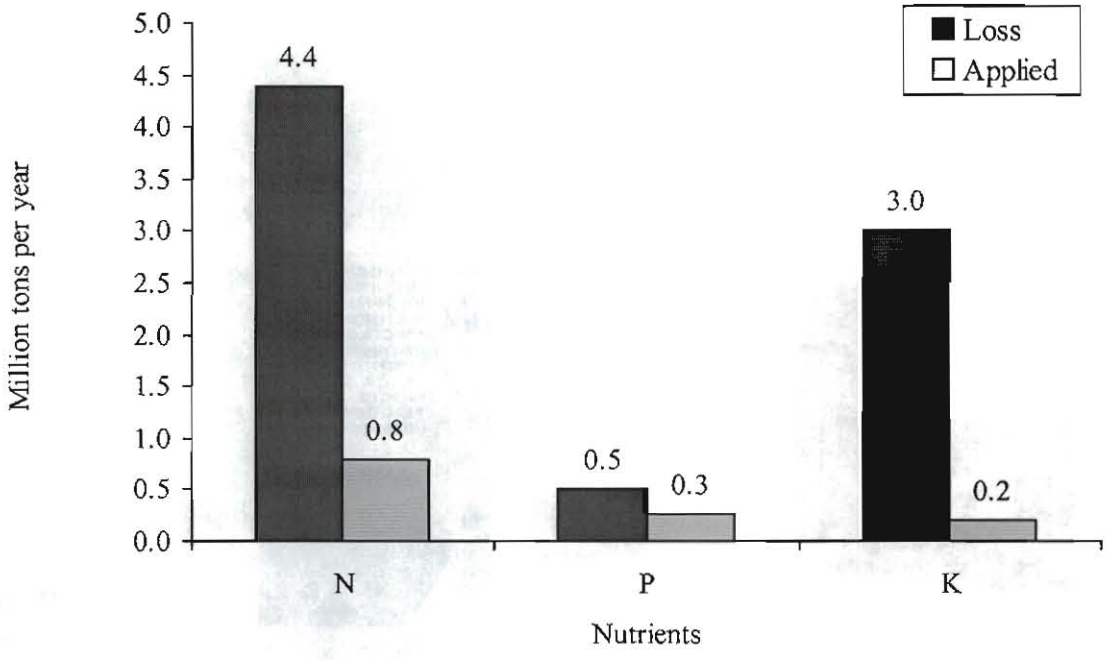

Figure 4: Macronutrient application versus loss in Africa

The different biophysical, chemical and socio-economic factors contributing to low soil fertility and poor productivity in sub-Saharan Africa are reported in **Figure 5**. This low productivity of agriculture is related to the low quality of the soil resource base which on one hand has been due to inherent or induced deficiencies of major nutrients N, P, and K or low nutrient holding capacities, high acidity and low organic matter. On the other hand low soil fertility is driven by socio-economic factors which include macro-economic policies, unfavorable exchange rates, poor producer prices, high inflation, poor infrastructure and lack of markets. These multiple causes of low soil fertility are strongly inter-related including the interaction between biophysical and socio economic factors

and hence need for a holistic approach in ameliorating the soil fertility constraints in sub-Saharan Africa (Murwira, 2003).

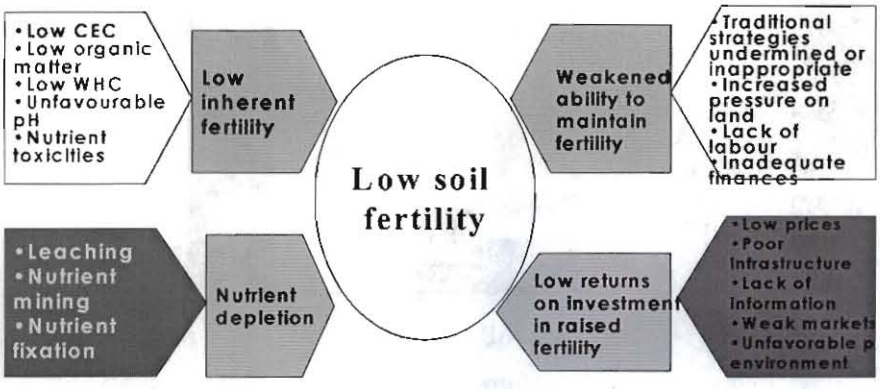

Figure 5: Biophysical, chemical and socio-economic factors contributing to low soil fertility and poor productivity in Sub-Saharan Africa

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**). 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: Population, cropped land and fertilizer use (1961-97)

	1961			1997		
	Pop. (million)	Crop land (million ha)	Fertilizer use (kg/ha)	Pop. (million)	Crop land (million ha)	Fertilizer use (kg/ha)
World	3136	1352.0	23.0	5823	1501.0	90
Dev countr.	978	654	42	1294	640.0	87
S.S Africa	219	120	0.15	578	154	9
DR 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

The gradual degradation of the land is a threat to rural communities, in terms of food insecurity and a continued exploitation of the fragile resource base depleted from many plant nutrients. There is, therefore, a critical need to develop and implement sound management options that can 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 being exhausted rapidly, 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 was established to overcome the challenge of soil fertility degradation in the African continent.

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 individual 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 (c) translate their understanding into action and d) create synergy with partners to achieve more output. Several achievements are possible in research through networking. The collaborating institutions or individuals are in a position to exchange information thus combining collective experience of professionalism in the same field as partners. **Figure 6** gives the different elements of partnerships and these elements are considered by AfNet in order to increase the network effectiveness and efficiency.

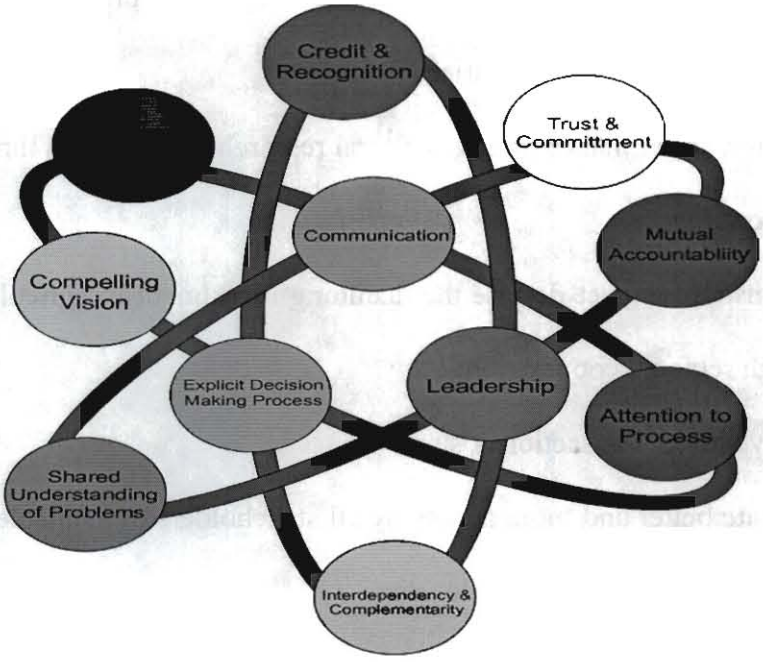

Figure 6: Elements of Partnerships

The advantages of networking include to:

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

ii) Provide increased bargaining power with external partners;

iii) Minimize duplication;

iv) Exchange information and combine collective experience of professionals in the same field;

v) Carry out collaborative research through network experiments;

vi) Undertake joint capacity building;

vii) Capture research spill-over/ spill-in effects;

viii) Rationalize human resource development;

ix) Immobilize research efforts on trans-national problems that require collaboration between countries;

x) Exploit a larger market for agricultural research technologies through regional collaboration;

xi) Demonstrate impact despite the declining investment in agricultural research through regional cooperation;

xii) Achieve lower transaction costs;

xiii) Facilitate better and more access by all stakeholders of available technologies at regional and international levels.

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 accelerated 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.

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 External Input Sustainable Agriculture (LEISA) 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.

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.

In recent years, the need has been recognized to integrate socio-economic and policy research with technical or biophysical research. To this end, Soil fertility can no longer be regarded as a simple mechanism addressed 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 innovative, knowledge- intensive process and participatory research and development focus rather than a purely technical focus (Gichuru et al., 2003). Recently, AfNet has shifted its focus from thematic research into farmer participatory research whereby the main focus will be to carry out an impact oriented research to benefit the African farmer.

AfNet field research activities addresses the same research outputs of the TSBF institute of CIAT (**Figure 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.

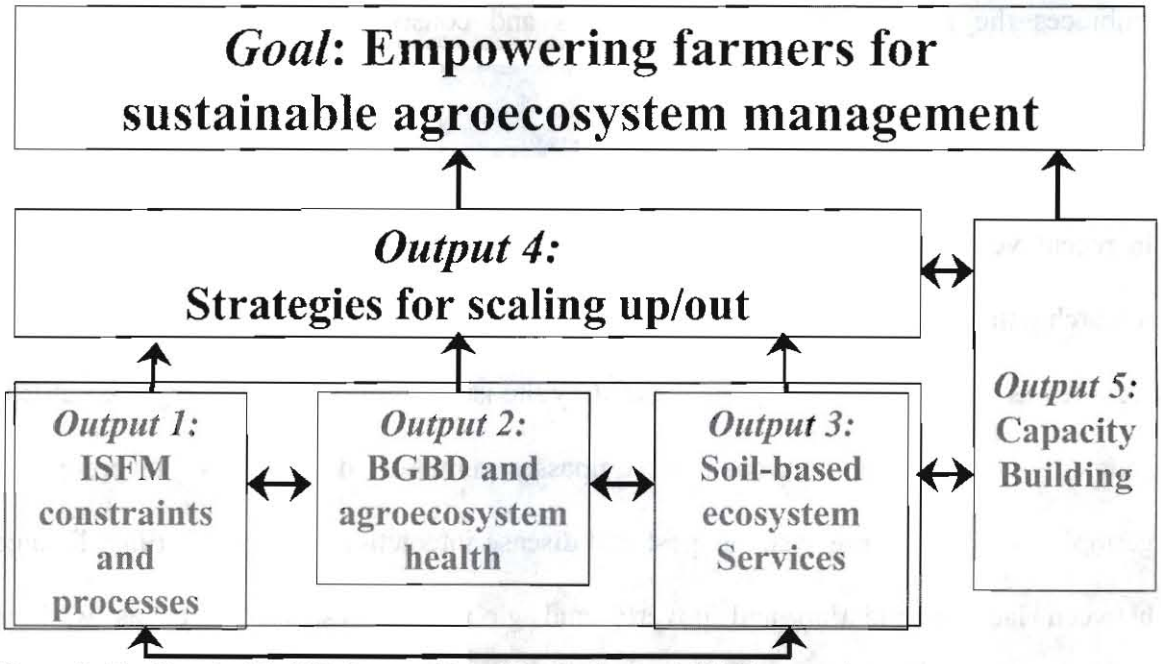

Figure 7: The Tropical Soil Biology and Fertility Institute of CIAT research outputs

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.

In a meeting bringing together key institutions involved in soils research in East and Southern Africa to discuss current soil research and plan for future collaborative efforts a background of future AfNet research was defined (Palm et al., 2001).

AfNet will focus in the years to come on the following research topics and projects for the implementation of its field research activities a) Nutrient budgets of agroecosystems; b) Socio-economic, policy and dissemination issues; c) Long-term soil fertility management trial; d) Combining organic and inorganic nutrient sources for increased soil quality; e) The role of legumes in soil fertility restoration; f) Livestock and soil fertility issues g) Use of rock phosphate as capital investment to replenish soil fertility h) Nutrient and water interaction; i) Land tenure; j) Conservation tillage; k) Belowground biodiversity l) Low quality organic resource management.

At present, AfNet is implementing field research in about 50 representative benchmark sites in Africa. **Figure 8** gives some selected benchmark sites where experiments were carried out in 2002/3. 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 Integrated Soil Fertility Management (ISFM).

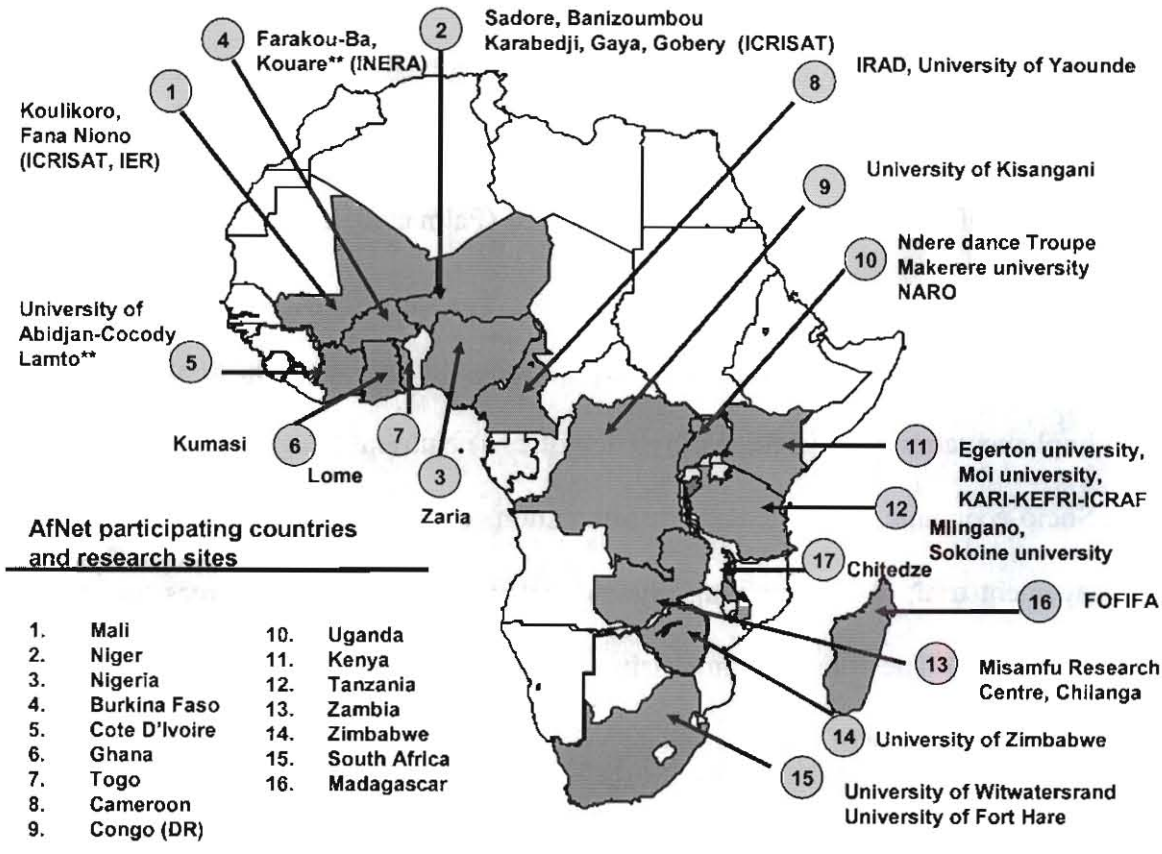

Figure 8: Selected AfNet research sites in 2002

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.

III. 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, in 2003, AfNet has published a book on "Soil Fertility Management in Africa: A Regional Perspective" and another book on "Managing Nutrient Cycles to Sustain Soil Fertility in sub-Saharan Africa" is in press. A third book on "Fighting Poverty in Sub-Saharan Africa: The Multiple Roles of Legumes in Integrated Soil Fertility Management" is in the pipeline.

IV. Training and capacity building

Access to education in rural areas is low among children, youth and adult, especially girls and women (illiteracy in rural areas is 2-3 times more than urban areas) and this is due to: 1) demographics 2) inadequate necessary inputs 3) lack of facilitating conditions (managerial, institutional, economic, social and political) 4) health and nutrition problems 5) gender factors, and 6) poverty Vandenbosch et al. (2002). Oxfarm (1999) indicated that education is the world's single most powerful weapon against poverty. It saves lives. It gives a chance to improve their lives.

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

In sub-Saharan Africa tertiary school enrolment has gone as low as 5% 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 of the limited funding of agricultural higher education (**Table 2**). 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 a 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.

Table 2: 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: Willet 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, internship and attendance at professional meetings.

Universities and other institutions of higher education 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 remains 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.

In 2003, AfNet has conducted two training courses one on "Monitoring nutrient flows and evaluating farm economic performance in tropical farming systems (NUTMON)" and the second one on "Farmer participatory research and scaling up/ out". However, in

addition to this, a short term training course is underway to 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) scientific writing; and (iv) development of research proposals.

Alliance with universities in Europe and the United States of America to have students do their thesis with TSBF officers in Africa, co-supervision of students for MSc and PhD from local universities on topics relevant to TSBF research will also strengthen the training and capacity building for AfNet.

Conclusion

Due to the increased land degradation within the African continent, the population is 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. Thus, 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 has 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 strategy of AfNet for sustainable agricultural development in Africa.

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