TECHNICAL ADVISORY NOTE (TAN)

DEVELOPMENT AND DISSEMINATION OF SUSTAINABLE INTEGRATED SOIL FERTILITY MANAGEMENT STRATEGIES FOR SMALLHOLDER FARMS IN SUB-SAHARAN AFRICA

Abstract

The abstract should provide the following information:
the project title, the main research outcomes/impacts, the replicability perspectives (scaling-up/out) and the overall context in which the research has been conducted (geographical, political, socio-cultural and economic dimensions).

Many sub-Saharan African soils are weathered, fragile and of low inherent fertility: increased exploitation by growing human and animal populations has often depressed their already low productive potential. In most African countries, off-take of major plant nutrients regularly exceeds replenishment, the organic matter content of soils has declined and increasing population pressure has made traditional fertility restoration by bush-fallowing (shifting cultivation) increasingly ineffective. This has both lowered the efficiency of the mineral fertilizers and contributed to degeneration of the soil structure and, in turn, increased drought-susceptibility - due to the soil's diminished capacity to capture and retain water.

The research programme No. 535 *"Development and dissemination of sustainable integrated soil fertility management strategies for smallholder farms in sub-Saharan Africa"* contributed to sustainable increases in agricultural productivity and farmer incomes through the development and dissemination of improved Integrated Soil Fertility Management (ISFM). ISFM refers to making the best use of inherent soil nutrient stocks, locally available soil amendments and mineral fertilizers in order to increase land productivity while maintaining or enhancing soil fertility. In this context, soil fertility management has been the entry point to interventions aiming at improving agricultural productivity. To this effect, the research programme has embedded the ISFM in a framework including aspects such as weather, the presence of weeds, pests, and diseases, crop management, and, beyond that, socioeconomic aspects such as input and output prices, labour availability and the farmer's production objectives.

The overall contexts in which the research and the technological options (in a number of two to three options per site) have been tested and implemented referred to the following three farming systems: the agro-pastoral millet/sorghum system, the maize-mixed system and the irrigated rice-based system. The research project has been implemented in 11 countries of West and Southern Africa and provided a source of knowledge and advice for investment projects in the whole region.

At the process level, the project generated improved understanding of interactions between organic inputs and mineral fertilizers and their impact on soil organic matter build-up and nutrient supply. At the action research level, the key challenge has been to combine local knowledge of socio-economic and biophysical determinants of yield and soil quality with scientific knowledge of agro-ecological principles to develop practical and feasible technologies with a potential to boost farm production and at least maintain or improve soil fertility.

Main successful technical components of the research programme:

1. Prototype, and/or demonstrated and/or validated, sustainable ISFM practices for dissemination directly to farmers and via technical reports and technical advisory notes/knowledge management notes;
2. Proven methodologies to facilitate further refinement, dissemination and adoption of such practices;
3. Trained personnel capable of successfully applying the above methodologies;
4. Improved awareness among key stakeholders of actions needed to remove socio-economic constraints to adoption of ISFM practices;
5. Economic data on the public goods benefits of selected ISFM practices.

***SECTION ONE*: THE INSTITUTIONAL CONTEXT**

The project within the IFAD context, relevance to/linkages with other IFAD programmes/initiatives, implementing partners and main activities carried out.

• Existing linkages with other IFAD initiatives:	
- Grants:	- Grant No. 444 -IFDC, *"Participatory Evaluation, Adaptation and Adoption of Environmentally Friendly Nutrient Management Technologies for Resource-Poor Farmer"*; - Grant No. 322 -IFDC, *"Networks on soil fertility restoration and management in resource poor areas of sub-saharan Africa"*.
- Loans:	- Village Organization and Development Project (PODV), Togo; - Smallholder Floodplain Development Project, Malawi; - South East Dry Areas Project, Zimbabwe; - Smallholder Dry Areas Resources Management Project, Zimbabwe; - Southern Province Food Security Project, Zambia.
• Target regions and	- West Africa (Benin, Burkina Faso, Mali, Niger, Nigeria, Togo and Ghana) and Southern Africa regions (Malawi, Zambia, and Zimbabwe).
implementing partners:	- IFDC and TSBF-CIAT as coordinators, local NGOs (CREMA, RAFIA, C2D, AMEDD, IFAD ONG, APGR, AGIR and OIC), NARS (IER, INRAN, ITRA, LSSEE, SARI, ARI and ABU/IAR), Farmer-Based Organizations (ACVR/GAIP, UGV-Afangnah, Groupements GIFS Togo/Benin and FEPAB) and Rural Finance Institutions (CMEC, CREP, UCEC/Z).

***SECTION TWO* : THE PROGRAMME IMPLEMENTATION**

The research programme:

Description of the technology/participatory methodology/approach developed, costs of the inputs used to implement the research programme, rural areas and context where the research has been implemented (specifying environmental conditions)

The research programme has been implemented in three farming systems each one characterized by specific socio-economic and environmental conditions:

1. Agro-pastoral millet/sorghum systems (millet, sorghum, livestock, remittances): classified as having a high potential for poverty reduction and a low/moderate potential for agricultural growth;
2. Maize-mixed systems (maize, cassava, cattle remittances): classified as having a high potential for poverty reduction and a moderate/high potential for agricultural growth;
3. Irrigated systems (rice, vegetables, and livestock): with fairly good potential for poverty reduction and a high potential for agricultural growth.

The diversity of the above contexts implied that experimented solutions were site-specific: it required much emphasis on farmer experimentation, participatory learning and building of partnerships between soil fertility management stakeholders (farmers, credit providers, input dealers, research and extension agencies, government) at village, regional, and national levels. To face the diversity and complexity of farming realities, the project used a combination of market-driven participatory approaches and systems thinking.

Over the timeframe of the project, an innovative and flexible methodology

to sustainable agricultural intensification has been developed: the Competitive Agricultural Systems and Enterprises Approach (CASE). CASE has been based on the agri-business system at the regional level: it combined participatory methods in order to develop and extend ISFM strategies with support to institutional changes facilitating effective linkages between farmers and the market through two iterative and partly overlapping participatory learning approaches.

Concerning the Decision Support Tools (DSTs) developed and tested in the research programme, a set of 8 mechanisms has been used and adapted on the basis of the farming systems, the site specificity and the complexity of the tool itself (see Table No. 1).

Table No.1: DSTs used in the project classified on the basis of: level of complexity, site and farming system in which they have been used.

Decision Support Tool	Type/Complexity	Site	Farming System
Soil maps	Data base/Simple	Togo	Maize-mixed
Cropping calendars	Simple	Togo, Bagré, Burkina Faso	Maize-mixed; irrigated rice
Dichotomy keys	Simple	Burkina Faso	Sorghum/millet agro-pastoral systems
Resource Flow Map (RFM)	Nutrient flow diagram/Simple	Benin, Togo, Mali, Zambia, Zimbabwe	Maize-mixed
Manure guide	Simple	Zimbabwe, Zambia	Maize-mixed
QUEFTS	Optimal fertilizer doses/ Medium	Bagré, Togo, Burkina Faso	Maize-mixed
NUTMON	Quantification of nutrient flows/Medium	Benin, Togo	Maize-mixed
RIDEV	Dynamic rice model/ Medium	Bagré, Burkina Faso	Irrigated rice

During the research programme, the following five key activities have been implemented:

1. Improvement of zaï technology – traditional practice which involved making small pits in crusted soils that were abandoned as useless and using some limited external inputs to rehabilitate 'wasteland' in agro-pastoral millet systems (in Africa's semi-arid regions);
2. Soil and water conservation (SWC) measures, such as stone lining or grass strips in the Sahel and Sudan savanna zones of sub-Saharan Africa considered crucial to reduce runoff and soil loss and to improve soil moisture content;
3. Combined use of minimum tillage with organic and inorganic fertilizer inputs in order to have yields gains for sorghum and millet cultivation;
4. Use of short mucuna fallow in mixed maize and cassava systems;
5. Plantation of the fast-growing, N-fixing Acacia auriculiformis tree, in maize-based farming systems (in costal savannah of West Africa).

Target group and impact:

Description of the target group, the beneficiaries and the benefits and the main research outcomes/impacts (vulnerable groups, project impacts and effects on the human, social and natural capital).

- *Impacts on the human capital:*
- *Impacts on the social capital:*
- *Impacts on the natural capital:*

Project target group :
Rural communities in West and Southern Africa.

Impacts on the human capital:
- Increased knowledge in water management, combined use of organic inputs and judicious use of mineral fertilizers, rice systems, maize-cassava systems;
- Improved understanding of ISFM interactions;
- Improved awareness among key stakeholders of actions needed to remove socio-economic constraints to adoption of ISFM practices;
- Trained personnel capable of successfully applying the tested methodologies.

Impacts on the social capital:
- Stronger networking among NARS, local NGOs, rural finance institutions and farmers based organizations (FBOs);
- Substantial financial gains from wood sales and from enhanced maize yields;
- Enhanced capacity of local institutions for demonstrating and extending research results.

Impacts on the natural capital:
- Reduction of environmental degradation (i.e. efficient use of scarce organic inputs, less risk of crop failure, reduced erosion);
- Increased yields (i.e. in low-input systems, most technologies have been based on combined adoption of organic inputs and judicious use of mineral fertilizers; as a results yields were increased from 0.4 to 0.7 t ha^{-1} to 2 to 2.7 for sorghum and from 0.8 t ha^{-1} to 3 to 4 t ha^{-1} for maize);
- Improved water storage;
- Enriched biodiversity.

The gender dimension:

Women's role in the research programme, impacts on the gender equity and women's empowerment.

The research programme has been very successful in addressing gender roles in the various pilot villages. Women played an important role in the ISFM project activities and related decision making; they were on average well represented in the ISFM farmer groups.
Sometimes, gender roles have been discussed at the village level to stimulate female and male farmers to work together. However, access to resources often differed among household members and women had only limited access to certain resources.

Accessibility:

Identification of the physical availability of the research outputs in different time and places as well as their affordability by the rural poor.

All activities at all sites have been carried out in partnership with multi-stakeholder platforms and village-level farmer organizations to give them ownership of the results and to facilitate their final affordability. By giving farmers the lead in the research, they have become owners of the results facilitating the adoption of the research outputs.

Concerning the affordability of the five key tested technologies, the overall research has been based on a combination of locally available organic resources and the correct use of mineral fertilizers in order to facilitate their adoptability.

More precisely:

- The adoption of Zaï technologies usually needs to be supported by investments: farmers who do not own the land they cultivate might be reluctant to invest in these technologies and hence to adopt the proposed solutions;
- The introduction of stone lining and grass strips has been based on indigenous technologies developed in Burkina Faso and Niger: the accessibility and affordability by the rural poor is guaranteed;
- The Minimum tillage through plowing has been based on an indigenous technology practiced all over sub-Saharan Africa: farmers already knew the basic principles and it ensured a broader use of the research outputs;
- The use of short Mucuna fallow might be not spread as rural poor who do not own the land have been generally reluctant to invest in soil fertility improvements;
- The adoption of the fast-growing, N-fixing Acacia auriculiformis tree usually requires high start-up costs (i.e. buying plants) and farmers who do not own their land are not allowed to plant trees on the land. As a consequence, the technologies might be adopted only by a limited number of farmers.

Constraints faced during the programme implementation:

Difficulties faced during the implementation of the research programme, specifying the internal (limited infrastructure, lack of inputs etc) and the external (socio-political and environmental aspects) constraints.

Constraints related to:

- *Internal conditions:*
- *External conditions:*

Constraints related to the internal conditions:

- Unavailability of suitable organic materials in large quantities;
- Limited farmers financial resource (e.g. for minimum tillage combined with ISFM money is required for charts, wheel barrows and picks).
- Lack of a fertilizer supply chain.

Constraints related to the external conditions:

- Price distortion;
- Inadequate infrastructure to access to the market;
- Difficulties in accessing mineral fertilizer for food crops especially by small-scale farmers.

Institutional sustainability and degree of farmers' involvement in the research programme:

Underlying the degree of farmers' meaningful involvement in the definition and implementation of the main research steps/research process - which determines also the level of social and psychological acceptability- and explanation of the measures taken to support the institutional, organizational and professional changes at all levels.

- The research project has been based on researcher-farmer dialogue and mutual learning. It provided technical backstopping and participatory training in order to stimulate a bottom-up participatory research process on technological options and institutional arrangement.
- Researchers and farmers have worked together with the aim of developing answers to site-specific problems and making the best use of locally available resources, knowledge and skills. Social learning has been promoted through "learning plots" characterized by working together on some specific common fields managed by the ISFM farmer groups. At each pilot site, farmer learning groups and local facilitators exchanged experiences around learning plots. An important aspect of this strategy has been that objectives, activities and training modules were decided by the farmer group and the facilitators together, with a strong accent on sharing experiences and development of tools. Learning plots have often allowed comparison by many farmers (most of the time above ten) of one or two alternative technological options compared with common farmer practices.
- The options that were tested during the research programme have been directly identified by farmers and also the testing and the validation have been conducted by the farmers themselves with the support of researchers in order to promote learning by doing and to allow farmers to adapt the technology to their particular circumstances.
- Participatory diagnosis of constraints and opportunities has also been developed during all the phases of the research programme.

Dissemination pathways:

Description of the ways through which the project results are made available at the village level and at the national/international level (workshops, reports, seminars etc).

- *The communication strategies at the village level:*
- *The communication strategies at the national and international level:*

The communication strategies at the village level:

- Exchange visits and study tours;
- Farmer-to-farmer dissemination and demonstration plots;
- Technical Advisory Notes and leaflets;
- Posters.

The communication strategies at the national and international level:

- Publication of 40 scientific papers, 4 Ph. D. theses and 15 M.S. theses;
- Technical Advisory Notes, Knowledge Management Notes and newsletters (i.e. AISSA newsletters);
- Manuals on: agro-ecological ISFM principles, facilitators' approaches, inland valley rice systems;
- International training courses in English and French on the technological and institutional aspects of ISFM;
- Distance learning courses via the Internet.

Further research needs:

Identification of the new areas considered to be relevant and needed to be taken into account since they influence the adoption and/or the relevance of the research results (new problems or links not investigated by the research).

- Need to promote plowing with manure (especially in north Sudan zones) as it had the most significant impact on yield and little effect on soil carbon;
- Need to combine different kinds of expertise and to work in partnership with other rural development and research organizations;
- Need to strengthen institutional platforms and networks;
- Need to address the diversity and dynamics of farmer specific realities;
- Efforts should be made to avoid the dry mucuna mulch being burnt (mainly due to the risk of fire).

SECTION THREE: USEFUL INFORMATION

Vocabulary:

ISFM: Integrated fertilization based on the combination of organic and inorganic fertilizers, the investment in soil amendment, the use of soil and water conservation methods, and other appropriate farming practices.

Keywords:

Soil fertility, learning plots, ISFM, yield, fertilizer, agro-pastoral millet/sorghum systems, maize-mixed systems, irrigated systems, legumes, maize-macuna-cassava, soil carbon, crop, CASE approach, DSTs.

Useful links:

AISSA: www.aissa.org – documents
IFDC: www.ifdc.org/New_Design/Programs/Soil_Fertility/index.html
IFAD: www.ifad.org/grants/tags/535.htm
Distance learning course: www.aglearn.net/isfmHome.html

References:

IFDC publications, Techincal Advisory Notes, Manuals, Reports, Ph.D. and M.S. Theses - available at IFDC and IFAD upon request.

Year of Publication:

March 2007

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Acronyms:

- *NGOs*

CREMA: Centre de Recherche et d'Essai des Modèles d'Autopromotion/Togo
RAFIA: Recherche, Appui et Formation aux Initiatives d'Auto développement/Togo
C2D (PODV):Croisade pour le Développement Durable/Togo
AMEDD: Association Malienne d'Eveil au Développement Durable/Mali
IFAD ONG: Institut de Formation et Action pour le Développement des Initiatives Communautaires Durables/Benin
APGR: Action pour la Promotion des Groupements Ruraux)/Burkina Faso
AGIR: Association pour l'appui aux Groupes d'Initiatives en milieu Rural/Burkina Faso

- *NARS:*

IER: Institut d'Economie Rurale/Mali
INRAN: Institut National de Recherche Agronomique du Niger/Niger
ITRA: Institut Togolais de Recherche Agricole
LSSEE: Laboratoire des Sciences du Soil, Eaux et Environnement)/Benin
SARI: Savannah Agricultural Research Institute/Ghana
ARI: Animal Research Institute/Ghana
ABU/IAR: Amadou Bello University/Institute for Agriculture Research/Nigeria
DARTS: Department of Agricultural Research and Technical Services/Malawi
AREX: Department of Agricultural Research and Extension/Zimbabwe

- *Extension*

ICAT-RC:Institut de Conseil et d'Appui Technique- Région Central/Togo-central
ICAT-RM: Institut de Conseil et d'Appui Technique- Région Maritime/Togo-maritime
DDDA: Direction Départementale de Développement Agricol/Niger
DPAHRH/Z: Direction Provinciale de l'Agriculture, de l'Hydraulique et des Ressources Halieutiques/Zoundweogo/Burkina Faso
DPAHRH/K: Direction Provinciale de l'Agriculture, de l'Hydraulique et des Ressources Halieutiques /Kadiogo Burkina Faso
DRAEP/RC: Direction Régionale de l'agriculture, de l'Elevage et de la Pêche/Région Centrale/ Togo

- *Farmer-Based Organizations (FBOs) :*

ACVR/GAIP: Association des Communautés Villageoises Responsables/Groupe d'Action pour l'Intensification de la Production et la commercialisation des produits agricoles/Togo
UGV-Afangnah: Union des Greniers Villageois/Togo
FEPAB: Fédération des Producteurs Agricoles de Burkina/Burkina Faso

- *Rural Finance Institutions*

CMEC: Caisse de la Mutuelle d'Epargne et Crédit/Togo
CREP Feminine-Ifangni/Benin: Caisses Rurales d'Epargne et de Prêts
UCEC/Z: Union des Caisses d'Epargne et Crédit de Zoundweogo/Burkina