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THE UNITED REPUBLIC OF TANZANIA

ACCELERATED FOOD SECURITY PROJECT (AFSP)

Integrated Nutrient Management Plan (INMP)

Final

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AFSP- Integrated Nutrient Management Plan (INMP)

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Summary

1. The Environmental and Social Management Framework (EMSF) provides the overall safeguard framework for scaling-up the NAIVS activities under the AFSP assisted by the World Bank. In complement of the ESMF, the Integrated Nutrient Management Plan (INMP) addresses specific environmental safeguard issues related to the handling and use of fertilizer nutrients financed under the Accelerated Food Security Project (AFSP). The overall objective of the INMP for the AFSP/National Agricultural Input Voucher Scheme (NAIVS) is to predict potential positive and negative impacts of increased fertilizer use and to suggest appropriate protective/ mitigation/enhancement measures at different levels of the fertilizer chain including health and safety conditions during storage and handling of fertilizer.

2. To ensure sustainability and minimum adverse impacts to the environment, appropriate mitigation measures are being incorporated, using integrated management approaches which are mainstreamed more broadly and nationally across the sector in compliance with the World Bank's Operational Policy OP4.09 on Pest Management and the Government own requirements on sustainable Integrated Pest Management Plan (IPMP) and the Integrated use of Plant Nutrition Strategies (IPNS).

3. Following a short background (chapter 1), legal and regulatory framework (chapter 2) the INMP proposes a short description of fertilizers and their use in agriculture (chapter 3) and the principles and practices of integrated soil nutrient management, including conservation farming practices (chapter 4). The expected overall environmental impacts of NAIVS, including enhanced carbon sequestration (Chapter 5) are followed by an analysis of the potential environmental and social impact of fertilizer use, along the fertilizer chain (chap 6). Chapter 7 analyses potential impacts their cause and risk level. Proposed mitigation measures which are summarized (Chapter 8) in the proposed Integrated Soil Nutrient Management Plan (INMP), followed by key conclusions and recommendations (chapter 9).

4. Key mitigation actions of potential safety and environmental impacts of increased fertilizer use are mainstreamed into AFSP implementation, including in the supplementary financing to the Agricultural Sector Program (ASDP), with regard to specific agricultural research and extension activities. Monitoring of mitigation indicators are already integrated into the project MIS and impact studies.

1. Background

Introduction

1. The Government of Tanzania has agreed to prepare an Integrated Nutrient Management Plan (INMP) to manage the use of fertilizer nutrients and seed financed by the AFSP Project. In complement of the ESMF, the overall objective of the INMP for the NAIVS is to predict potential positive and negative impacts of increased fertilizer use and to suggest appropriate avoidance/mitigation/enhancement measures at different levels of the fertilizer chain including storage condition at central and local levels, health and safety conditions during storage and handling of fertilizer. The INMP will address institutional, regulatory and budgetary issues to ensure that approved substances are procured, transported, stored, handled, and used and that any remnants are discarded appropriately. The INMP[1] will also ensure that the use of these substances is monitored effectively and that a responsive change management process is in place if any changes in their use are required.

2. Note that the Integrated Pest Management Plan – (IPMP see section C) also includes training and capacity building to support sustainable use of these nutrients. The implementation of the INMP will be financed by the Project. Because the Project is processed under OP/BP 8.0, the INMP will be completed after the approval of AFSP by IDA's Board of Executive Directors, but within three months of the date of effectiveness.

Environmental and Social Management Framework (ESMF)

3. The ESMF provides the overall safeguard framework for scaling-up the National Agricultural Input Voucher Scheme (NAIVS) activities taking place in Tanzania under the Accelerated Food Security Project (AFSP) assisted by the World Bank. To ensure sustainability and minimum adverse impacts to the environment, appropriate mitigation measures are being incorporated, using integrated management approaches which are mainstreamed more broadly and nationally across the sector in compliance with the World Bank's Operational Policy OP4.09 on Pest Management and the Government own requirements on sustainable Integrated Pest Management Plan (IPMP) and the integrated use of Plant Nutrition Strategies (IPNS).

4. The overall goal of the NAIVS is to scale-up small-scale farmers' access to productivity enhancing technologies (fertilizers and improved seed varieties), as a strategy to ensure sustainable agricultural growth and food security. Large subsidies of fertilizers especially to small scale farmers will improve their input access and is expected to raise agricultural production. The fundamental assumption is that plant nutrition management will contribute to food security and to the sustainable production of agricultural goods without harm to the environment. The protection of the environment demands that nutrients be added in quantities and by methods that maximize crop productivity and recovery of the added nutrients and managed in an environmentally sustainable way.

5. The expectation of the NAIVS activity will eventually lead to an increase use of chemical (inorganic) fertilizers, improved seed and development of irrigation facilities, mainly for seed production. Such an increase use of these inputs, are likely to cause also an increase in pest pressure (new pests and the upsurge of historically minor pests) and diseases within the sector. The concern of the Government is thus, to ensure that such activities are managed in an environmentally sound manner with little or no impact on the environment and the society at large.

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[1] The completed INMP will be disclosed in Tanzania and at the World Bank INFOSHOP

6. Where fertilizer use is low[2], increased application will help to improve crop production and benefit the environment by limiting soil mining and reducing land degradation. This is achieved through an integrated approach of nutrient management. This approach integrates the use of variety of soil and water management technologies and practices, including soil nutrient supply, that boosts up plant nutrient sources in the soil and making nutrient uptake more efficient (including decreased losses) within sustainable cropping systems.

7. The ESMF provides guidelines for assessing possible environmental and social impacts in the course of implementing the National Agricultural Inputs Voucher Scheme (NAIVS). These guidelines indicate the responsible bodies involved in ensuring that the sector compiles to sound agricultural practices without harm to the environment, the expected negative and positive impacts of NAIVS in relations to the environment, what mitigation interventions to be taken in addressing these impacts. The present INMP complements the ESMF with specific safeguard elements specifically related to fertilizer handling and integrated soil nutrient management. It does not present a detailed theoretical analysis of fertilizer use nor does it provide guidance on the amounts of fertilizer that farmers should apply in specific locations to particular crops.

Regulatory Framework Governing the NAIVS and AFSP

8. The Environmental Management and Coordination Act, 1999 and the Environmental Management Act, 2004 provides for the establishment of a legal and institutional framework for the management of the environment in Tanzania. Part VI sections 81 to 103 and its subsequent elements in the Environmental Impact Assessment and Audit Regulations (G.N. No.349 of 2005, regulations 12 to 43) provide guidelines on Environmental Impact Assessment (EIA). Tanzania also published its National Environmental Policy (NEP) in December 1997 and the National Conservation Strategy for Sustainable Development, the National Environmental Action Plan (NEAP) and specific sectoral policies such as those on land, mining, energy, water, agriculture, population and fisheries. The NEP recognizes the EIA process as a means of ensuring that natural resources are soundly managed, and of avoiding exploitation in ways that would cause irreparable damage and social costs.

9. Based on World Bank OP 4.01, NAIVS is rated as Environment Assessment Category B project. Project activities do not require a full EIA. Approval of the ESMF by NEMC and periodic supervision on ESMF implementation by NEMC and other stakeholders is considered sufficient to meet existing regulatory requirements and World Bank safeguard policies.

10. Roles and Responsibilities of the National Environmental Management Council (NEMC). The National Environmental Management Council (NEMC) is under the division of environment in the office of the Vice President. The council has an advisory role on all environmental related issues including impacts of NAIVS activities and is responsible for enforcing pollution control at the same time performs technical arbitration role in the undertaking of environmental Impact Assessment.

11. NEMC has prepared a comprehensive EIA procedures and guidelines dated March 2002 that is linked at the levels of the sector and district environmental units. The procedures are legally binding ensuring clear lines of command which facilitate its effective implementation. At the sector and district levels the environmental units will be in partnership and will collaborate in the implementation of the EIA process with NEMC. Thus, the role and responsibilities of these units include the following:

- ***At sectoral Level***, the units, with assistance from NEMC, has to develop sectoral guidelines within the framework of the national EIA guidelines whose responsibilities will be to issues EIA registration forms to operators and provide relevant information on policies and other administrative requirements and assist the general EIA process administration at sectoral level.

[2] Average fertilizer use in Tanzania is below 10kg/ha, and even far lower in the food crop sub-sector.

- ***At District level,*** the unit[3] role and responsibilities are to: (i) issue EIA registration forms to operators and provide relevant information on policy, legal and other administrative requirements at the district level; and (ii) coordinate EIA process at district level

12. The EIA process is presented in the General Environmental Impact assessment Guidelines and Procedures prepared by NEMC revised in March 2002 containing five volumes. The procedure for conducting EIA involves: (i) registration of the project; (ii) screening of the project to classify it according to its respective category; (iii) conducting an EIA; (iv) reviewing he EIA; (v) issuing the relevant permits; (vi) decision-making; (vii) monitoring project implementation; (viii) auditing the completed project; and (ix) decommissioning the project upon its completion.

13. The National Environmental Management Act 2004 is the main legislation that governs how the Environment is managed. Currently, the National Environment Policy (NEP) has identified the following as critical environmental problems: (i) Land degradation; (ii) Lack of accessible good quality water for both urban and rural inhabitants; (iii) Environmental pollution (e.g. water contamination); (iv) Loss of biodiversity, habitat and wetlands; (v) Deterioration of Aquatic systems; and (vi) Deforestation.

2. Legal and regulatory framework

Fertilizer Act[4] 2009.

14. The object of this Bill[5] is to make provisions for new fertilizer legislation for the purpose of effective regulation of the fertilizer industry. It intends to create conducive environments for the private sector participation in the fertilizer industry and ensuring quality standard for all agricultural fertilizer and fertilizer supplements manufactured, imported and sold to farmers in the country.

15. The Bill is divided into Nine Parts:

i. Part I deals with the preliminary matters which include the interpretation of various terms as used in the proposed Act.
ii. Part II provides for the institutional framework for the administration of the Act. It proposes establishment of the National Fertilizer Committee stipulates the management and functions of the Committee and elaborates the composition of members of the Committee and the proceedings thereof. The establishment District Fertilizer Committees and Tanzania Fertilizer Regulatory Authority as a regulatory organ to deal with fertilizer registration and regulation are proposed under this part.
iii. Part III provides for the registration of fertilizers brands and grades which shall be allowed for use in Tanzania and licensing of fertilizer dealers. It restricts any person from dealing with fertilizer business without being licensed under the Act.
iv. Part IV deals with manufacturing, importation and distribution or fertilizer. It gives the Director the power for providing permits to persons dealing with manufacturing, importation and distribution of fertilizers or fertilizer supplements. Cancellation or suspension of permits and conditions for such cancellation or suspension are matters covered under this Part.
v. Part V deals with fertilizer inspection, sampling and analysis. This part provides for the appointment of Inspectors, Analysts, their powers and procedures for fertilizer analysis.

[3] The composition of the District Environment Unit (see ESMF)
[4] See Annex 1. Bill gazetted on 21 Nov 2008 and passed on 23 April 2009.
[5] To repeal the Fertilizers and Animal Food stuffs Act, Cap. 378

vi. Part VI covers appeal procedures against the decision of the Director of the Fertilizer institute (?), Inspectors and Analysts.
vii. Part VII deals with the financial provisions of the Tanzania Fertilizer Regulatory Authority.
viii. Part VIII deals with general offences and penalties.
ix. Part IX deals with miscellaneous issues including the power of the Minister to make regulations for the better carrying out the provisions of the Act. It also provides for the transitional provisions and repeal of the Fertilizer and Animal Foodstuffs Act, Cap. 378.

16. Specific regulations related to fertilizer production, import, distribution and use are currently under preparation and discussed among key public and private stakeholders. Main application regulations and directives are expected for early 2011.

Tanzania Fertilizer Regulatory Authority

17. The Fertilizer act establishes an authority to be known as the Tanzania Fertilizer Regulatory Authority or in its acronym "TFRA" (headed by a Board). The Authority shall be the regulatory body in the fertilizers industry and shall in particular:

i. regulate all matters relating to quality of fertilizers, fertilizer supplements and sterilizing plants;
ii. register all fertilizer and fertilizer supplements dealers and their premises;
iii. license fertilizer dealers; issue permits for importation and exportation of fertilizer and fertilizers supplements;
iv. maintain a register of fertilizers, fertilizer supplements and sterilizing plants;
v. maintain and publish periodically a register of fertilizer dealers; implement ratified international conventions relating to fertilizers;
vi. regulate and control the import, production, transportation, dealing, storage, and disposal of fertilizer or fertilizer supplements;
vii. collect, maintain and publish information related to fertilizers and fertilizer supplement;
viii. make guidelines on the sound management and effective control of fertilizers and fertilizer supplements;
ix. in collaboration with Local Authorities, conduct public educational campaigns on the sound application and management of fertilizers and fertilizer supplements;
x. conduct regular training of stakeholders on fertilizer matters;
xi. register inspectors and analysts;
xii. inspect or cause to be inspected fertilizer or fertilizer supplements for quality assurance;
xiii. implement policies, strategies and programs relating to fertilizer industry development;
xiv. provide technical advice to the government and other institutions on all matters relating to the fertilizer and fertilizer supplements management and control;
xv. conduct or cause to be conducted research relating to fertilizers and fertilizer supplements;
xvi. foster co-operation between the institute and other institutions or organizations and stakeholders;
xvii. collaborate with the national and international organizations on all matters relating to the fertilizer and fertilizer supplement;
xviii. implement specific and general directives of the Authority;
xix. regulate fertilizer price based on the appropriate methods as shall be set out in the regulations;
xx. carry out any other functions as may be conferred upon it in the performance of its functions under this Act; and Cap.191
xxi. ensure that it adheres with the Environmental Management Act.

Regulations. Fertilizer and Animal Foodstuffs

18. Ordinance (Cap 467) of 1962 is the founding regulatory document for the fertilizer industry. The ordinance was meant to regulate importation, manufacture, and sale of fertilizer and animal foodstuffs, but enforcement was difficult due to the disparate nature of these two product lines. For example, the custodian of this law is the director of veterinary services within the Ministry of Livestock Development, while fertilizer is housed within the Ministry of Agriculture. The government has begun the process of repealing the Fertilizer and Animal Foodstuffs Act to facilitate the development of a regulatory framework for fertilizer. The functional law impacting fertilizer is the 1975 Standards Act, which established the Tanzania Bureau of Standards. The bureau is mandated to standardize imported and locally produced commodity specifications, including mineral fertilizer. It is not an overall fertilizer regulatory body, and it rarely acts beyond setting and controlling the standards at the port of entry. This lack of quality control and regulatory mechanisms has allowed sales of low-quality fertilizer products on the market[6].

19. In 2009 a parliament act also revised the Standard Act and established a new Board for standards. Application measures are under preparation. Current standards for main fertilizer formulas used under AFSP are shown in Annex 2.

[6] Source: Fertilizer Supply and Costs in Africa. IFDC, 2007

3. Fertilizers and their use

Organic and mineral fertilizers

20. The present initiative of NAIVS is to increase access of agricultural inputs (fertilizers and improved seeds) by small-scale farmers. In order to achieve growth and increase agricultural production there is a need to increase the use of fertilizer which provides the key nutrients needed by the crops. Without proper management, continuous crop production reduces nutrient reserves in the soil, decreases crop yields and leads to soil degradation.

21. A fertilizer is any substance, when added to the soil, will supplement the soil with those elements required for plant nutrition: fertilizers could be of organic (compost, manure, etc.) and/or inorganic[7] nature. Further to enhancing crop growth, fertilizer (organic/inorganic) will also increase the overall biomass of crop residues, which can in turn be reincorporated into the soil as a green manure to improve the structure and the organic matter level of the soil. Nutrient application from organic and inorganic sources should thus be at the absolute and relative level required for optimal crop growth and yield, taking into account crop needs, soil nutrient balances, agro-climatic considerations and improving soil characteristics while minimizing negative externalities.

22. **Inorganic fertilizers** may also be classified according to the number of key elements they contain. According to their specific content in major plant nutrients (Nitrogen, Phosphate and Potassium) fertilizers may be:

i. Single fertilizers or materials containing only one major nutrient element;
ii. Incomplete fertilizers those that contain two major nutrient elements;
iii. Compound fertilizers materials that contain the three major elements (N, P and K);
iv. Mixed fertilizers contain two or more major nutrient elements that are supplied by two or more fertilizer materials.

23. Inorganic fertilizers are most effective when application coincides with specific growth stages and nutrition requirements of the plants.

24. **Organic fertilizers** (organic matter, compost, etc.) also play an important role in the improvement of soil structure and of the soil Cation Exchange Capacity (CEC), especially in many highly weathered tropical soils were the inherent CEC is often low. Soil organic matter plays a key role in enhancing the soil buffer capacity for water and nutrients. They are also often a good source of the secondary and micro-nutrients necessary for plant growth, and contribute a modest quantity of the primary nutrients (N, P, and K) requirements. Biological nitrogen-fixation by leguminous plants and soil micro-organisms is another example of organic fertilization, whereby bacteria-nodules on the roots of the plants synthesize nitrogen for the plant and soil (when the root system decays).

Fertilizer grades/formulas.

25. Major plant nutrients could be supplied by different fertilizers types and their efficiency varies with soil type and crops. Main fertilizer types are:

[7] Also commonly called mineral or chemical fertilizers.

Table 1: Major nutrients and fertilizer types

Major Nutrient	Fertilizer type	
N /a	Urea, ammonium sulphate, ammonium nitrate, CAN	
P_2O_5	DAP, TSP, SSP, MRP	
K_2O	Potassium Chloride, Potassium sulphate	
S	All Sulphates	
Ca	Calcium carbonate and sulphate	
A range of NPK grades; 20:10:10, 25:5:, 6:20:18,:10:18:24, 4:17:15, etc		
Several brands of foliar fertilizer are also available in the market e.g. Borax		
Other micro-elements		

/a Standards for Urea, DAP and MRP are shown in Annex 2.

26. In most cases, efficient use of inorganic fertilizers requires high concentration (high grade) of the desired product in order to decrease significantly transport costs.

27. **Minjingu rock phosphate** (MRP), is exploited in the Manyara Region and appears in most soils as effective and profitable as imported triple super phosphate (TSP). A new formulation (Minjingu mazau = MRP + urea) will be marketed and its use is similar to DAP although its concentration in P is twice lower. Farmers are applying 125-250 kg MRP/ha as a capital investment, and could expect a five-year residual effect. Considering its lower solubility, when compared to DAP, MRP may be indicated for soils with low pH. A particular important environmental consideration in the case of Minjingu rock phosphate is dust (this issue was solved by the granular form) and the presence of heavy metals and radio nuclides[8]. Of the metals contained in MRP, Cadmium (Cd) represents the greatest concern because of the potential human risks via transfers in the food chain. However the Cadmium level in MRP is considered as low (9 mg/kg) and within the same range as those reported from other RP mines. Despite this, there is a need to monitor the Cadmium levels in soils as phosphate fertilizers are continuously being applied to soils.

Fertilizer Standards and Other Control measures

28. The only law in function but loosely implemented is the 1975 Standards Act.No.3 which established the Tanzania Bureau of Standards (TBS). TBS is entrusted with setting of standards of all commodities imported or locally produced including mineral fertilizer and ensure quality. However, the TBS rarely acts beyond setting the standards and controlling quality mainly at port of entry. The 1975 Standard Act has been replaced by a new Standards Act in January 2009 (annex x)

29. The Standards encompasses: (i) scope; (ii) chemical requirement; (iii) physical appearance; (iv) packaging and packaging volumes; (v) labeling; (vi) levels of heavy metal contamination; and (vii) levels of moisture content.

30. Currently there are 8 Fertilizer Standards in Tanzania: (see standards for details). For the time been there are no standards for foliar or bio-fertilizer

Rate of fertilizer application.

31. **Fertilizer rate** may be expressed in kilograms nitrogen (N), phosphoric anhydride (P_2O_5) and potash (K_2O) per hectare, or in number of bags of specific fertilizer materials/formulation per hectare. The choice of the fertilizer dependent on adequate supply of each required nutrient

[8] MRP like most other Rock Phosphate (RP) mines contains heavy metals

according to specific crop needs. To determine fertilizer needs it is essential to know which nutrients are required for the desired target yield to avoid inefficient utilization of nutrients by plants. Precaution should be taken when unfavorable soil physical and chemical conditions reduce fertilizer use efficiency (FUE), especially during drought periods when fertilizer application will not de efficient, due to lack of moisture.

32. Main technical optimal nutrient requirements for specific crops have been determined for main soil types in Tanzania[9]. These recommendations are continuously updated by the agricultural research services as new research results become available. Besides technical optimal nutrient supply, research is also determining the economic optimum for fertilizer application aiming at optimizing farmers return on investment rather than reaching the technical optimal productivity level.

33. Through implementation process by the NAIVS scheme, extension agents will be facilitated to translate the language of the scientists into terms that farmers understand. Fertilizer materials available in the market do not occur as N, P or K. So the recommendations of the extension agents must be made in terms of these available materials. In this way the extension agent will be able to give farmers more practical fertilizer recommendations. If one knows how to compute the amount of fertilizer materials, he will be able to apply the recommended amount and also choose the cheapest source of adapted fertilizer sources.

Timing and methods of fertilizer application.

34. One of the most important aspects of fertilizer use is to know when and how fertilizers should be applied. It depends primarily on the type of crop grown and the soil characteristics determining the mobility of the particular nutrient. With nutrients that are stored efficiently in soil (i.e. P, K, S), fertilizers can be broadcast annually at or before planting, or banded below the seed. P is immobile in the soil and it should therefore be incorporated into the root zone (e.g. during sowing). N applications should be timed to coincide with periods of peak demand and rates adjusted according to rainfall received during the season via split applications (particularly in sandy soils) to reduce leaching losses. Application of nitrogen shall be split to at least two (heavy textured soils) or three (sandy soils) doses during the cropping season. Furthermore N applications should be covered with soil to avoid major losses by evaporation.

35. Further to the adapted rates of application, the efficiency of fertilizer use (and reduced losses) is also determined by several important factors such as the placement location in the soil. According to the fertilizer type, soil conditions and crop grown, main placement techniques are described as follows:

i. *Plough - Sole placement*[10]. In this method, the fertilizer is placed in a continuous band on the bottom of the furrow during the process of ploughing. Each band is covered as the next furrow is turned. This method has been recommended in areas where the soil becomes quite dry, up to a few inches below the soil surface during the growing season, and especially with soils having a heavy clay pan. By this method, fertilizer is placed in moist soil where it can become available to growing plants during dry seasons.

ii. *Deep placement of N and P fertilizers*. This method of application of nitrogenous and phosphatic fertilizers is adopted in paddy fields. In this method, ammonical nitrogenous fertilizer (e.g. ammonium sulphate) or ammonium forming nitrogenous fertilizers (e.g. urea), is placed in the reduction zone, where it remains in ammonia form and is available to the crop

[9] See: Revised Fertilizer Recommendations in Tanzania. Mlingano Agricultural Research Institute. Ministry of Agriculture Food Security and Co-Operatives. P.O Box. 5088, Tanga

[10] Any tool or implement inserted or drilled at desired depth below the soil surface to supply plant nutrients to crop before sowing or to a standing crop is called placement. Thus, fertilizers are placed in the soil irrespective of the position of seeds, seedlings or growing plants.

during the active vegetative period. Deep or sub-surface placement of these fertilizers also ensures better distribution in the root zone and prevents any loss by surface drain-off. Deep placement is done in different ways, depending upon the local cultivation practices. In irrigated tracts, the fertilizer is applied under the plough furrow in the dry soil before flooding the land and making it ready for transplanting. In areas where water in the field remains limited, fertilizers are broadcasted before paddling which moves the fertilizer deep into the root zone.

iii. *Sub-soil placement*. Fertilizers are placed in the sub-soil with the help of heavy power machinery. This method is recommended in humid and sub-humid regions where soils are strongly acidic and the levels of available plant nutrients are extremely low. Under these conditions, fertilizers, especially phosphatic and potassic are placed in the sub-soil for better root development.

iv. *Localized soil placement*. This involves the application of fertilizers into the soil close to the seed or plant. Localized placement is generally used when relatively small quantities of fertilizers are to be applied. Localized placement reduces the 'fixation' mainly of phosphorus but also potassium in specific soils.

v. *Foliar Application*. This refers to the spraying suitable fertilizer solutions on leaves of growing plants. These solutions may be prepared in a low concentration to supply anyone plant nutrient or a combination of nutrients. These nutrients are absorbed through the leaves of plants. Best results occur when visual symptoms of nutrient deficiencies observed during early stages of deficiency.

36. Fertilizers could be applied by single type (or formulation) or by bulk blending. It is the process of mixing two or more different fertilizers varying in physical and chemical composition without any adverse effects. For this formulation certain additional materials called 'fillers' and 'conditioners' are used to improve the physical condition of the mixed fertilizer, mainly applied as top dressing.

4. Integrated Soil Nutrient Management (ISM).

Introduction

37. In many cases, soil nutrient imbalances can be corrected through the application of appropriate inorganic and organic fertilizers. Correcting nutrient imbalances not only leads to sustainable high crop yields, but it reduces also the need to cultivate unsustainable marginal lands, hence reduces overall soil and land degradation. Restoring soil nutrient balance does not necessarily require heavy inorganic fertilizer applications: planting practices such as terracing, alley cropping, and low-till farming prevent also nutrient loss. Other practices, including use of cover crops, intercropping with legumes and the application of organic manure, also improve soil nutrient reserves (especially nitrogen) and its overall structure. The rotation of cereals and leguminous plants has been shown to reduce the need for chemical fertilizer use by up to 30 percent, as cereals absorb the nitrates released from the decaying roots and nodules of leguminous plants.

38. Techniques such as integrated soil nutrient management[11] include the application of organic and inorganic fertilizers and help in maintaining and increasing the soil nutrient reserves. Such an approach aims at achieving the balance between the nutrient requirements of plants and the nutrient reserves in the soils, thus maintaining high yields over the longer term and preventing soil degradation and environmental contamination.

39. Different strategies for increasing agricultural productivity have been developed which focus on using available nutrient resources more efficiently than in the past. The integrated plant nutrition management approach (IPNM) will be used to target both, the increase in agricultural production and safeguarding the environment for future generations. The success of IPNM will depend upon the combined efforts of farmers, researchers and extension agents, as well as nongovernmental organizations (NGOs) active in the rural sector.

Integrated Plant Nutrient Management (IPNM)[12]

40. The soils ability to supply adequate nutrients decreases with cropping intensification and increasing demand for food. The task ahead is to maintain and where possible increase sustainable crop productivity to meet demands for food and raw material and to enhance the quality of land/soils and water resources. Integrated plant nutrient management (IPNM) is an important component of sustainable agricultural intensification: this approach complements integrated nutrient management in combination with the use of ‘best cropping practices. IPNM canters on the management of soils in their capacity to be a storehouse of plant nutrients that are essential for vegetative growth. The goal of IPNM is to integrate in an optimal way the use of all natural and man-made sources (organic and mineral) of plant nutrients, so as to increase crop productivity in an efficient and environmentally friendly manner, while maintaining the capacity of the soil to be productive for present and future generations.

41. IPNM incorporates many technologies and practices, including conservation agriculture, nitrogen fixation, and organic and inorganic fertilizer application. Soil conservation practices enhance more efficient crop use of available nutrients and prevent unnecessary losses of soil nutrients by wind and water erosion and leaching.

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[11] See also guidelines provided by FAO/COAG in 1997 (summary in Annex 3) and technical guidelines in Annex 4.

[12] The approach has many similarities with the IPM (Integrated pest management approach – see further explanations in ESMF) in terms of overall approach and strategies, although covering two different technical areas.

42. The strategy optimizes all aspects of nutrient cycling – supply, uptake, and loss to the environment in order to optimize food production. At farm level, IPNM aims to optimize the productivity of nutrient flows within the farming system, integrating crop and livestock production systems. This includes the applications of external plant nutrients and amendments, efficient processing and recycling of crop residues and other organic wastes, to optimize plant nutrient supplies. In the process, IPNS empower farmers by increasing their technical know-how and decision-making capacity, and promote changes in land use among crop, livestock and forestry systems in support of agricultural intensification.

43. The concept of IPNS involves increasing agricultural production by improving plant nutrition and other production factors management. This also results in a higher production of crop residues and organic wastes, as well as increased soil carbon levels. Agricultural intensification requires increased flows of plant nutrients from soils to crops, higher nutrient uptake levels and higher stocks of plant nutrients in soils. The major aspects put forward for consideration are:

i. assessment of plant nutrient requirements to meet crop production targets;
ii. choice of nutrient sources and methods of supply;
iii. price levels and the issue of subsidies for plant nutrients/fertilizers;
iv. legislative aspects; and
v. Support for extension and research.

44. At the level of the local farming communities, IPNS take into account plant nutrient sources outside the cropping areas, including plant nutrients in irrigation water and flood sediments, manure produced by grazing livestock, forests and permanent pastures, forest litter and organic material that is physically transferred from forest or pastures to cropped areas. Although IPNS require financial and labor investments, they generate additional income and promote increased rates of return from all inputs. IPNS involve risk management and enhance the synergy among crop, water and plant nutrition management. IPNS also promote the rationalization in the transfer of organic matter and plant nutrients from non-cropped to cropped areas, and the mobilization of unused nutrient resources or the saving of valuable nutrient sources diverted as domestic fuel, raw materials for building or for industrial purposes.

Sustainable Agricultural Land and Water Management – Better Land husbandry.

45. The critical natural resource inputs into the production of food and commercial crops are land and water. However, these resources are not sustainably managed resulting in land degradation, soil erosion, deforestation, diminishing water resources and declining biodiversity. Sustainable land and water management is key for sustained agricultural production for ensuring food security and agricultural incomes for the present and future generations.

46. **Better management of land resources** mainly targets higher efficiency of soil nutrients (mainly nitrogen and P) and available rain water use efficiency, to maintain and increase crops and fodder productivity. This in turn would allow for sustainable ‘commercial’ cropping and food diversification. Actions under sustainable land management should therefore emphasize better land husbandry (see Box below) at farm level, including integrated soil nutrient management relying on both organic and inorganic technologies. Adapted conservation agriculture practices will increase the soil water and nutrient buffer capacity to ensure higher productivity of rain-fed crops and mitigate the effects of weather variability and climate change. This approach would also reduce loss of agricultural land, especially in more fragile areas, and protect vulnerable areas.

Box: Basic Elements for Better Land Husbandry Components

Promotion of an integrated and synergistic resource management approach embracing locally appropriate combinations of the following technical options:

- build-up of soil organic matter and related biological activity to optimum sustainable levels (for improved moisture and nutrient supply and soil structure) through the use of compost, farmyard manure, green manures, surface mulch, enriched fallows, agro-forestry, cover crops and better crop residue management;
- integrated plant nutrition management with locally appropriate, and cost effective, combinations of organic/inorganic and on/off-farm sources of plant nutrients;
- better crop management with improved seeds of appropriate varieties, improved crop establishment at the beginning of the rains, weed management and integrated pest management;
- better rainwater management to increase infiltration and reduce runoff (erosion) so as to improve soil moisture conditions within the rooting zone, thereby lessening the risk of moisture stress during dry spells, e.g. box ridges)
- improvement of soil rooting depth and permeability through breaking of a cultivation, induced compacted soil layer (hoe/plough pan) through conservation tillage practices (sub-soiling, chisel ploughing)
- reclamation, where appropriate (i.e. if technically feasible and cost effective), of arable land that has been severely degraded by such processes as gullying.
- for irrigated crop production systems, also improving water use efficiency: improved water distribution to minimise channel seepage losses, and mulching to reduce evaporation losses, and minimising the risk of salinization by following good irrigation and drainage practices; and
- for livestock production systems, better integration of crop and livestock production in both the cereal based farming and agro-pastoral systems.

- ***Adoption of people-centred self-learning and investigating approaches***
- ***Community-based participatory approaches*** to planning and technology development
- ***Better land husbandry that offers farmers tangible economic, social and environmental benefits.***

Source: Strategic Investment Programme for Sustainable Land Management in Sub-Saharan Africa (FAO, 2007)[13]

47. Although much investment in conservation agriculture has already been made in Tanzania, uptake has been modest. However, the overall thrust of key agricultural support programmes is to support the widespread introduction of profitable farming options to the poor. The evidence is clear that, as farmers rise out of poverty, so they diversify and are able to take the longer term decisions to protect their environment. Thus as the AFSP contributes to create a profitable basis for food and agricultural production in Tanzania, complementary efforts are also promoting sustainable farming approaches (see complementary financing of ASDP). The involvement of community-based organisations will be encouraged to provide additional capacity to drive this change.

48. **Management of water resources**. Tanzania agriculture is largely dependent of rain which is currently not reliable because of the climate change. In the context of increased weather variability and climatic change, increasing water use efficiency and strengthening irrigation potentials will contribute to increased revenues to farmers. Outside of irrigation development, simple water-harvest technologies may enhance efficient water use and crop productivity.

49. **Climate Change Issues.** Tanzania relies on rain-fed agriculture and the current droughts have resulted in poor crop yields or total crop failure, leading to serious food shortages, hunger and malnutrition. In other areas flooding has also severely disrupted food production in several districts of the country. The most vulnerable groups are rural communities, especially women, children, female-headed households and the elderly. The possible interventions to mitigate the effects of climate change are many and have been included in the focus areas of the AFSP, among others: a) promotion of drought tolerant maize varieties; b) improved crop management practices (timing of

[13] See also different studies related to Soil fertility initiative.

planting, plant spacing, varieties); c) improvement in land and water management practices for efficient fertilizer use, soil and water management and conservation farming practices; d) control of soil erosion and protection of fragile lands (hills, wetlands, water catchment areas); e) management and control of disease and pests; and of community based storage systems for both food and seed.

Conservation Agriculture (CA) / Conservation farming

50. CA is a concept for resource-saving agricultural crop production that strives to achieve acceptable profits together with high and sustained production levels while concurrently conserving the environment. CA is based on enhancing natural biological processes above and below the ground. Interventions such as mechanical soil tillage are reduced to an absolute minimum, and the use of external inputs such as agrochemicals and nutrients of mineral or organic origin are applied at an optimum level and in a way and quantity that does not interfere with, or disrupt, the biological processes. CA is characterized by three principles which are linked to each other, namely:

- Continuous minimum mechanical soil disturbance.
- Permanent organic soil cover.
- Diversified crop rotations in the case of annual crops or plant associations in case of perennial crops.

51. Conservation "arable" agriculture is normally based on soil tillage as the main operation. The most widely known tool for this operation is the plough, which has become a symbol of agriculture. Soil tillage has in the past been associated with increased fertility, which originated from the mineralization of soil nutrients as a consequence of soil tillage. This process leads in the long term to a reduction of soil organic matter. Soil organic matter not only provides nutrients for the crop, but it is also, above all else, a crucial element for the stabilization of soil structure. Therefore, most soils degrade under prolonged intensive arable agriculture. This structural degradation of the soils results in the formation of crusts and compaction and leads in the end to soil erosion. The process is dramatic under tropical climatic situations but can be noticed all over the world. Mechanization of soil tillage, allowing higher working depths and speeds and the use of certain implements like ploughs, disk harrows and rotary cultivators have particularly detrimental effects on soil structure. Excessive tillage of agricultural soils may result in short term increases in fertility, but will degrade soils in the medium term. Structural degradation, loss of organic matter, erosion and falling biodiversity are all to be expected. (T. Friedrich, FAO).

52. Soil erosion resulting from soil tillage has forced us to look for alternatives and to reverse the process of soil degradation. The logical approach to this has been to reduce tillage. This led finally to movements promoting conservation tillage, and especially zero-tillage, particularly in southern Brazil, North America, New Zealand and Australia. Over the last two decades the technologies have been improved and adapted for nearly all farm sizes; soils; crop types; and climatic zones. Experience is still being gained with this new approach to agriculture and FAO(Food and Agriculture Organization) has supported the process for many years.

53. Experience has shown that these techniques, summarized as conservation agriculture (CA) methods, are much more than just reducing the mechanical tillage. In a soil that is not tilled for many years, the crop residues remain on the soil surface and produce a layer of mulch. This layer protects the soil from the physical impact of rain and wind but it also stabilizes the soil moisture and temperature in the surface layers. Thus this zone becomes a habitat for a number of organisms, from larger insects down to soil borne fungi and bacteria. These organisms macerate the mulch, incorporate and mix it with the soil and decompose it so that it becomes humus and contributes to the physical stabilization of the soil structure. At the same time this soil organic matter provides a buffer function for water and nutrients. Larger components of the soil fauna, such as earthworms, provide a soil structuring effect producing very stable soil aggregates as well as uninterrupted macro-pores leading from the soil surface straight to the subsoil and allowing fast water infiltration

in case of heavy rainfall events. Keeping the soil covered and planting through the mulch will protect the soil and improve the growing environment for the crop.

54. This process carried out by the edaphon, the living component of a soil, can be called "biological tillage". However, biological tillage is not compatible with mechanical tillage and with increased mechanical tillage the biological soil structuring processes will disappear. Certain operations such as mouldboard or disc-ploughing have a stronger impact on soil life than others as for example chisel ploughs. Most tillage operations are, however, targeted at loosening the soil which inevitably increases its oxygen content leading in turn to the mineralization of the soil organic matter. This inevitably leads to a reduction of soil organic matter which is the substrate for soil life.

55. Thus agriculture with reduced, or zero, mechanical tillage is only possible when soil organisms are taking over the task of tilling the soil. This, however, leads to other implications regarding the use of chemical farm inputs. Synthetic pesticides and mineral fertilizer have to be used in a way that does not harm soil life.

56. As the main objective of agriculture is the production of crops, changes in the pest and weed management become necessary with CA. Burning plant residues and ploughing the soil is mainly considered necessary for phyto-sanitary reasons: to control pests, diseases and weeds. In a system with reduced mechanical tillage based on mulch cover and biological tillage, alternatives have to be developed to control pests and weeds. Integrated Pest Management becomes mandatory. One important element to achieve this is crop rotation, interrupting the infection chain between subsequent crops and making full use of the physical and chemical interactions between different plant species. Synthetic chemical pesticides, particularly herbicides are, in the first years, inevitable but have to be used with great care to reduce the negative impacts on soil life. To the extent that a new balance between the organisms of the farm-ecosystem, pests and beneficial organisms, crops and weeds, becomes established and the farmer learns to manage the cropping system, the use of synthetic pesticides and mineral fertilizer tends to decline to a level below that of the original "conventional" farming system. Burning crop and weed residues destroy an important source of plant nutrients and soil improvement potential. The phyto-sanitary motives for burning and ploughing can better be achieved by integrated pest management practices and crop rotations. (FAO).

57. Conservation Agriculture, understood in this way, provides a number of advantages on global, regional, local and farm level:

- It provides a truly sustainable production system, not only conserving but also enhancing the natural resources and increasing the variety of soil biota, fauna and flora (including wild life) in agricultural production systems without sacrificing yields on high production levels. As CA depends on biological processes to work, it enhances the biodiversity in an agricultural production system on a micro- as well as macro level.
- No till fields act as a sink for CO2 and conservation farming applied on a global scale could provide a major contribution to control air pollution in general and global warming in particular. Farmers applying this practice could eventually be rewarded with carbon credits.
- Soil tillage is among all farming operations the single most energy consuming and thus, in mechanized agriculture, air-polluting, operation. By not tilling the soil, farmers can save between 30 and 40% of time, labor and, in mechanized agriculture, fossil fuels as compared to conventional cropping.
- Soils under CA have very high water infiltration capacities reducing surface runoff and thus soil erosion significantly. This improves the quality of surface water reducing pollution from soil erosion, and enhances groundwater resources. In many areas it has been observed after some years of conservation farming that natural springs that had dried up many years ago, started to flow again. The potential effect of a massive adoption of conservation farming on global water balances is not yet fully recognized.

- Conservation agriculture is by no means a low output agriculture and allows yields comparable with modern intensive agriculture but in a sustainable way. Yields tend to increase over the years with yield variations decreasing.
- For the farmer, conservation farming is mostly attractive because it allows a reduction of the production costs, reduction of time and labor, particularly at times of peak demand such as land preparation and planting and in mechanized systems it reduces the costs of investment and maintenance of machinery in the long term.

58. Disadvantages in the short term might be the high initial costs of specialized planting equipment and the completely new dynamics of a conservation farming system, requiring high management skills and a learning process by the farmer. Long term experience with conservation farming all over the world has shown that conservation farming does not present more or less but different problems to a farmer, all of them capable of being resolved. Particularly in Brazil the area under conservation farming is now growing exponentially having already reached the 10 million hectare mark. Also in North America the concept is widely adopted.

59. **Main Principles of Conservation Agriculture.** Conservation agriculture systems utilize soils for the production of crops with the aim of reducing excessive mixing of the soil and maintaining crop residues on the soil surface in order to minimize damage to the environment. By doing this CA will:

- Provide and maintain an optimum environment of the root-zone to maximum possible depth. Roots are able to function effectively and without restrictions to capture high amounts of plant nutrients and water.
- Ensure that water enters the soil so that (a) plants never, or for the shortest time possible, suffer water stress that will limit the expression of their potential growth; and so that (b) residual water passes down to groundwater and stream flow, not over the surface as runoff.
- Favor beneficial biological activity in the soil in order to (a) maintain and rebuild soil architecture; (b) compete with potential in-soil pathogens; (c) contribute to soil organic matter and various grades of humus; (d) contribute to capture, retention, chelation and slow release of plant nutrients.
- Avoid physical or chemical damage to roots that disrupts their effective functioning.

5. Expected environmental impacts of NAIVS

60. Current fertilizer consumption in Tanzania is estimated as follows:

Table 2: Fertilizer consumption (tons) in Tanzania

		2006	2007	2008	2009
Tobacco			30000	19000	
Sugar			8000	8000	
	DAP			15000	
	Urea			40000	
	CAN			15000	
	Amon. Sulfate			10000	
	NPK			10000	
Food/other	Other			30000	
Crops	*Sub-total*		*90000*	*120000*	
			128000	**147000**	

Source: Tanzanian Fertilizer Society

61. NAIFS/AFSP will provide beneficiaries with 2 fertilizer vouchers (one for 50 kg urea and one for 50 kg P fertilizer) which cover about 50% of the commercial price of these inputs. The potential for increased use of fertilizers by small-scale farmers would be as follows:

Table 3: NAIVS/AFSP voucher scheme in Tanzania[14]

Year	2007/08	2008/09	2009/10	2010/11	2011/12
Number of beneficiaries		0.7 million	1.5 million	2 million	1.8 million
Tons of urea (000 tons)		35	75	100	90
Tons of DAP (000 tons)		35	75	100	90

Expected scope of positive impacts of NAIVS

62. When the right type of fertilizer for a given crop is used in recommended quantities at the right time, fertilizers do generally not harm the environment. Fertilizers also have numerous positive impacts on the environment some of them direct others indirect. Positive impacts include:

i. Increased soil fertility, as nutrients removed by crops and/or soil nutrient deficits are replenished;
ii. Increased use of inorganic fertilizers will result in the production of 'healthier' crops with increased crop cover and increased biomass production (crop residues), which in turn reduces soil erosion and contributes to building-up soil organic matter levels, increasing water holding capacity and microbial activity, leading to prevention of soil degradation;
iii. Reduced area under cultivation because of higher yields as a result of fertilizer use and thus production of food needs that would be met with reduced cultivated areas at various levels from the household, community, regional and national levels;
iv. Fertilizer is a highly specialized input and its efficient use generally requires complementary inputs such as improved seed varieties and 'good agricultural practices' (e.g conservation farming) for improved use efficiency and sustainability;
v. Farmer's skills will be improved in soil fertility techniques and improved land management;
vi. Increased awareness of the environment through increased productivity and reduced pressure to expand cropped areas;
vii. Expected increase of farmers' income and improved living standards including better housing and nutrition.

Expected Scope of Negative impacts of NAIVS

63. At recommended rates (32 kg N + 23 kg P_2O_5 per acre cropped) there is no potential large scale environmental impact associated with NAIVS: expected levels of mineral nutrient use will remain on average far below research recommended levels. However, inorganic fertilizer can indeed be harmful to the environment, but only when misused in cases such as excessive applications, unbalanced applications (i.e. containing an improper ratio of nutrients for a particular soil or crop) or the application of fertilizer type that causes acidification in a given soil type.

64. Not all nutrients applied to the soil are taken-up by the growing crop and the remainder may become an environmental hazard, as unused nutrients either remain in the soil or are leached by water flows or runoff and thus end-up polluting the waterways. Some Nitrogen elements can also be volatilized into the atmosphere. Inappropriate application of fertilizer for a given location can also cause soil acidification, especially when ammonium based fertilizers are applied and in flooded soils. In addition, other negative impacts could include:

[14] Details see PAD of AFSP.

i. localized soil and water pollution by agro-chemicals and the reduction of water quality because of poor handling of agro-chemicals and/or disposal of empty containers.

ii. increased crop vulnerability to pests, due to challenges in pest management systems or introduction of new cultivars; and,

65. Major runoff of nitrates and phosphates could be of concern. In some cases, leaching of nitrates into groundwater may also be an issue. Worth noting that the above can be pragmatically addressed via one or more of the following: (i) modifying timing and rates of fertilizer applications to match crop growth stage (matching supply vs plant demand and uptake); (ii) using slow-release nutrient sources, and (iii) minimizing surface runoff and soil erosion via appropriate soil conservation measures (contour plantings, grass strips or hedgerows, rehabilitating riparian zone veg that acts as a nutrient and sediment filter). While nitrogen (nitrates) is highly mobile in the soil and water, Phosphorus (phosphates) are usually transported in sediments and are a major contributor to eutrophication (nutrient enrichment) of water bodies and the resultant algal or water weed fouling (e.g. water hyacinth on Lake Victoria). Thus scaling-up any combination of the above measures combined to good agronomic practices will reduce waste and environmental impact.

Effect on soil carbon (Ex-act tool)[15]

66. The analysis of the ex-ante carbon-balance results shows that the project according to its current design has a mitigation potential of more than five million tons of eq-CO_2 over 20 years, it therefore actively reduces anthropogenic emissions and tackles climate change. The mitigation impacts were not considered in the formulation of the project, and they should be considered as positive externalities. In a context of rising concern of governments and civil society for Global Warming, this externality should represent a further incentive to support sustainable rural development in Tanzania. This case study reflects how an intensive accelerated project that acts on food security by increasing the use of inputs can also be designed in terms of its mitigation potential. It particularly points out the fact that synergies are possible between food security and agriculture mitigation. The project gives both a short-term response by using large amounts of financed inputs and a longer-term response by progressively reducing the amounts of inputs use.

	Project Scenario (int eq-CO2)	Simulated Scenario (int eq-CO2)
Total carbon balance	-5,811,123	-1,558,440
Carbon balance/ha	-5.5	-1.5
Carbon balance/year	-290,556	-77922
Carbon balance/smallholder	-2.32445	-0.62338

[15] See Reports of this analysis at (FAO-IC, 2009) http://www.fao.org/tc/tcs/exact/ex-act-applications/on-projects/united-republic-of-tanzania/en/

6. Potential Environmental & Social impacts of Fertilizer Use

Summary

67. The overall impacts and mitigation measures of efficient use of inorganic fertilizers has been summarized as follows:

Table 4: *Impacts and mitigation measures of efficient use of inorganic fertilizers.*

Environmental and Social components	*Impacts*	*Mitigation Measures*
Physical environmental Soils Water Resources Air Quality	- Salinization of soils - Contamination of ground water - Pollution of surface water Heavy metals - Dust - Air pollution	- Conduct training on safe use and handling - Use of high grade fertilizers - Conservation farming practices increasing soil OM content and reducing leaching/losses; - Use of masks to prevent inhaling of dust - Stored and transported in closed containers - Bring the moisture content to 7-8 percent - Enforce air quality standards
Biological Environmental Fauna and Flora	- Promoting weed growth - Loss of natural plant and wildlife habitats and species - Increased pest problems	- Conducting training on safe use of fertilizers, weed control - Promoting integrated pest management (IPM) approaches
Social Environmental Aesthetic & landscape Historical/Cultural sites. Human health Human communities	- Loss of natural recreational, historical and archaeological sites - Health risks - Increased use of labor saving technologies	- Land reclamation - Disease surveillance - Promote use of protective gears - Proper screening of herbicides - Training on IPM

Source: Adapted from PADEP Environmental and Social Framework guidelines

Potential impacts during transportation and storage

68. **Main fertilizer stores**. Main importer stores are built following international norms having acceptable size, structural fitness, roofing heights allowing enough aeration, etc. Most of these stores contain only fertilizer products under their roof, thus separating storage of fertilizer from food products. Some stores may contain other agrochemicals, thus endangering health conditions of workers in the store. Vertical height of fertilizer sacks/stacks (piles reaching 20 or more sacks up wards) is very high in some of these stores posing serious risk of accident for loading and off-loading working force. The international standard warns that nitrate containing fertilizers when stored in an enclosed space without ventilation shall give rise to hazards of explosion due to decomposition and fire if exposed to carbonaceous material. Distance of stacks from walls and distance between stacks has also been specified to be not less than 60cm.

69. In most of these stores, the working force is provided with little or no protection gears (masks, hand gloves, overalls, helmets, etc.), exposing them to frequent physical injuries, respiratory ailments due to dust, skin and eye allergies due to contact with fertilizer products, etc. Moreover, neither the permanent supervising workers nor the labor force in these stores receive training on safety and health precaution that has to be observed while handling fertilizers. The socio-economic positive impact of these stores is their job creation opportunity to the local youth (loading and off-loading), thus reducing unemployment and poverty.

70. **District and agro-dealer fertilizer stores**. Almost all agents/agro-dealer keep their fertilizer inside owned or rented stores. Most district stores are spacious and structurally up to standard. However, most agro-dealer stores are sub-standard, small in size and congested due to lack of proper space, in poor condition, and contain fertilizers seeds agro-chemicals and other goods. In these stores, movement of workers to load and off-load is very difficult. Store congestion

and long vertical rows of fertilizer sacks/stacks due to shortage of space during peak fertilizer supply period severely limit circulation of air inside the stores thus creating situation of short breath and respiratory. Moreover, not well arranged long pile of fertilizer sacks can easily crumble and come down in force injuring workers. This may also cause compaction due to moisture, under weight of fertilizer sacks, etc.

71. Some of these agro-dealer stores keep agrochemicals (though the agrochemicals being of small quantity) together with fertilizer: these agrochemicals may pose serious health hazard to the labor force and other store workers. Moreover, the working forces in these stores are provided neither with protective gears to counter accidents nor training to avoid them, obliging them to work in constant danger. Premises inside these stores are often not paved. During off-loading and loading time, fertilizer material spill. Dissolved by water, the nutrients infiltrate to lower level polluting ground water resources by the accumulation of nitrate and phosphate nutrients.

Potential impacts during application of fertilizer on farmers'.

72. Farmers are mainly using blanket recommendations (50kg DAP and 50 kg Urea per acre) adopted nationally for fertilizing cereals such as Maize and rice. However lately, due to price increase of the product, lack of cash and difficult economic situation, many farmers apply fertilizer below this recommended rate. Actual application rates depend on the level of soil fertility of the plot as judged by the farmer themselves, topographic condition, type of crop, early crop stand for split application (Urea) as well rainfall condition during a given crop season.

73. Farmers also prefer apply fertilizers to ‘better’ cropping plots to ensure good return from their investment. Farmers think price escalation, absence of credit and timely delivery of fertilizer are their concerns, rather than the environmental consequences of fertilizer use. Farmers do receive some advice/training by extension agents stationed in wards on the correct rate and time of fertilizer application; on other fertility improvement methods such crop rotation, organic fertilizer (compost) and green manure use, etc. Some farmers do prepare and apply compost to compensate low level of inorganic fertilizer use. Repeated inorganic fertilizer application (without additional organic amendment) enhances activities of soil microorganisms for short duration, increasing mineralization of existing soil organic matter and depletion of carbon out of soil. Loss of soil organic carbon (humus) reduce the capacity of soil to maintain its natural nutrient reserves (fertility), deteriorate soil structure, weaken its resistance to erosion (increase erosion), reduce vegetation/biomass cover and consequently worsening land degradation situation.

74. The farmer's observation of declining soil fertility/productivity as a result of continuous inorganic fertilizer use can also relate with the aggravation of soil acidity due to nitrogen bearing inorganic fertilizer use and consequently, unavailability of nutrients essential for plants, the most important limiting nutrient being phosphorus. The indirect effects of soil acidity and aluminum toxicity include poor plant growth reduced land productivity and yield. Low soil fertility either because of low application rate of fertilizer due to high price or as result of soil acidity or depletion (exhaustion) of nutrients from reserves affects product quality hence nutrition and health of consumers. According to Food and Agriculture Organization of UN (FAO, 2006), increasing the nutrient supply from deficiency to optimal level results in better product quality, and increasing nutrient supply from optimal to luxury level may increase, maintain or decrease product quality; extreme increase of nutrient supply to toxicity range reduces quality and must be avoided. Application of Nitrogen particularly has considerable effect on plant growth as well as product quality through increases in protein quantity and its quality. However, when this is applied in excess, harmful substances may be formed reducing quality. Poor quality of produce due to both excessive and deficient nutrient supply affects human and animal nutrition and health.

75. Luxury or excessive application of fertilizer is not a problem in Tanzania smallholder farmer crop production: but balanced nutrient supply is a problem. Application of Nitrogen bearing

fertilizer (Urea) without Phosphorus or Potassium as practiced by some farmers leads to dangerous accumulation of nitrate in the soil. Nitrogen supplied as fertilizer cannot be fully utilized by the plant as absence of Phosphorus becomes the limiting factor leading to its accumulation and pollution of the environment. When Nitrogen applied together with Phosphorus the accumulation is low and within the range useful to plants (FAO, 2006). Although some K deficiencies are reported, K is generally not a major issue in cereal production and thus mainly N and P fertilizers are used.

Research, academic and regulatory institutions views on impacts of fertilizer use.

76. As fertilizer use appears to be very low in Tanzania, there are no studies done in relation to impacts of inorganic fertilizer on bio-physical and human environment. However the revised 'Fertilizer Recommendations in Tanzania' (Mlingano Agricultural Research Institute (MAFC) provides a clear guideline for technical optimum fertilizer application levels for main crops grown in Tanzania on most common soil types. The economic optimum application levels appear generally to be at 50% of those levels, while current farmer application levels remain far below.

77. On the longer term, soil research activities of the Agricultural Research Institute aim at updating the soil map of Tanzania and the classification of their agricultural potential. Furthermore, the recommendations of technical and economical optimums for fertilizer applications are being updated on continuous basis.

7. AFSP environmental and social impact analysis

78. Table 5 below analyze the potential impacts by determining whether or not they are possibly or likely occurring or cannot be determined during the present project life time. Table 6 determines the cause-effect of each potential negative impact.

Table 5: Environment and social impacts assessment checklist of fertilizer use

Environmental and Social impact		*Main causes of impacts*	*Positive (likely/ possible)*	*Negative (likely/ possible)*	*Comment*
Ecological	Withdrawal of less fertile land from cultivation, reducing the overall pressure on land, including deforestation and overgrazing of non-cropped areas	Intensification of crop production in lieu of extensification	**x**		Presence of INM + Support to extension
	Balanced fertilization bringing more biomass residue, enhanced soil organic matter content and microbial activity	Increased aerial and sub-soil biomass production	**x**		
	Balanced fertilization for better uptake of N by plants, less nitrate leaching, reduced ground/surface water pollution and less de-nitrification	Crop and soil adapted fertilization recommendations	**x**		
	Carbon fixation and storage in the soil	Increased biomass and conservation farming practices	**x**		See Ex-Act Evaluation
Fertilizer application on the field	Ground water pollution	Leaching of weakly held nutrient forms, such as nitrate (mostly) chloride, sulphate and boric acid		**x**	Applications outside recommended rates and poor agronomic practices
	Soil acidification	When nitrate leached, it takes along with equivalent amount of cations (soil depletion of exchangeable cations such as Ca^{++}, Mg^{++} and K^{+}		**x**	
	Soil erosion/land degradation	Accelerated decomposition of soil organic matter and its loss affecting soil physical structure and effect of mono-cropping or continuous cultivation of fields		**x**	
	Soil organic matter loss and reduced microbial activity and soil nutrient reserve depletion	Accelerated decomposition of soil organic matter and low level of fertilizer application		**x**	
	Mono-cropping and reduced crop diversity	Dependency on inorganic fertilizer		**x**	
	Possibilities of pest/disease infestation	Mono-cropping and reduced crop diversity		(x)	
	Eutrophication, undesirable color, taste, odor of water bodies	*Nutrients carried away from soils with erosion, surface runoff or groundwater discharge*		(x)	At current application rates, risk mainly related to
	Effect on aquatic ecosystem and	*Increased COD and BOD*		(x)	

	death of fish	*and reduced DO due to eutrophication*			accidental incidents
	Impairment of aesthetic qualities of surface water bodies	*Excessive algal scum and Aquatic weeds and having undesirable color, taste and odor as a result of contamination*		(x)	
Socio-economic	Impairment of aesthetic qualities of surface water bodies	*Nutrients carried away from soils with erosion, surface runoff, etc.*		(x)	Absence of INM + overuse of fertilizer
	Indebtedness, asset loss and increased poverty	Price escalation of inputs		**x**	
	Enhanced production potential of soils and higher yields	Better agric. practices and input use	**x**		Improved access + Presence of INM
	Higher HH income and better socio-economic conditions	Increased yields due to adapted fertilization	**x**		
	Employment opportunities, income generation	Mainly during supply and storage operations.	**x**		Seasonal
Health and safety	Methaemoglobinaemia	Mis- and overuse of fertilizer application		(x)	Absence of INM
	Malnutrition due to reduced crop/food quality				
	Dust nuisance and respiratory ailments such as breathlessness, cough and wheezing	Truck movements around storage places and fertilizer handling in stores		**x**	During supply and storage operations
	Nerve disorders and toxicity due to storage together with pesticides	Storage of pesticides and crop protection chemicals together with fertilizers		**x**	
	Reddening of the eyes, physical injuries such as skin cuts and blackening of shoulder	Fertilizer handling and exposure		**x**	
	Improved nutrition and better health	Balanced fertilization generates improved mineral balances in diet	**x**		Presence of INM
	Fire and explosion hazards	Chemical decomposition of fertilizer products when stored in poorly ventilated and sub-standard stores or to the storage of nitrogen/nitrate containing fertilizers with carbonaceous materials		**x**	During supply and storage operations

(x): Limited risk

8. Integrated Soil Nutrient Management Plan (INMP)

79. The Integrated soil Nutrient Management Plan is prepared as a short, medium and long term plan scheduled to be accomplished within the coming three year period. Fertilizer use in the country is very low as compared to global average application rate in Western agricultural production systems. Therefore, the environmental and social adverse impacts due to fertilizer use are expected to be minimal. Accordingly, most of the suggested mitigation activities are medium to long term actions in response to future growth in fertilizer use in the country.

80. ***Moreover, the suggested actions have already been incorporated in the AFSP annual work plan and budgets as recommended by the IPMP. Furthermore, complementary research and extension related to soil fertility management and fertilizer use was integrated into the supplementary financing for ASDP approved within the AFSP.*** Finally, specific elements related to INMP implementation monitoring have been integrated within the overall AFSP and ASDP monitoring (MIS) and impact evaluation systems, including AFSP impact evaluation survey.

81. Table 6 below outlines the key potential impacts to be mitigated, actions to be taken to achieve the intended avoidance/corrective measure within a three year time period of the AFSP (most mitigation measures remain applicable during the voucher exit phase to be implemented by the Government after AFSP support to NAIVS.

82. Adequate budget has been provided under awareness creation, agro-dealer training and intensification of research and extension services, although their specific amount will be function of:

i. The number of agro-dealers and/or store attendants and farmers to be trained on proper fertilizer storage and handling;
ii. Number and duration of training programs (initial training and recycling);
iii. Promote the use of safety and protective gears and appliances to be provided to store workers at central and agro-dealer stores in the districts and villages;
iv. Number of soil samples collected and soil physical and chemical parameters analyzed;
v. Distribution of soil amelioration inputs such as lime and expenses to promote compost use, conservation agriculture, etc.; and
vi. Promotion of Sustainable Land Management (SLM) and Integrated soil Nutrient Management practices.

Table 6: Integrated Nutrient Management Plan (INMP)

Phases	Impact to be mitigated	Mitigation activities	Detailed activities & budgets *(see also IPMP)*	Implementation responsibilities
Supply and storage	Dust nuisance and respiratory ailments such as breathlessness, cough and wheezing	Improve truck movement schedule and spread water or other dust absorbents on dusty roads. Follow standards on fertilizer handling and storage, on stack building, ventilation, etc. Train agro-dealers and workers, promote use of protective gears and washing facilities.	***Activities already integrated in the ESMF/IPMP safeguards:*** *Detailed activities included in Annual work plan and budget for:* *+ Awareness creation for (i) agro-dealer and (ii) farmers* *+ Public awareness on safeguards for fertilizer use* *+ Agro-dealer training and recycling (complementary AGRA support)* *Local government staff at district and zonal level*	**MAFC: Agricultural Input Unit** **Environmental Management Unit** MAFC Information & communication unit CNFA (Training)
	Nerve disorders and toxicity	Separate storage of pesticides from fertilizers. Follow standards on fertilizer handling and storage, train agro-dealers and workers, promote use of protective gears		
	Fire and explosion hazards	Follow standards on fertilizer handling and storage, store different products in separate compartments, train agro-dealers and workers, promote use of protective gears		
	Reddening of the eyes, physical injuries such as skin cuts and blackening of shoulder	Train agro-dealers and workers, promote use of protective gears.		
	Ground water pollution and contamination	Clean premises and dispose of effluents/drainage water safely away from water bodies and train workers on fertilizer handling and storage		
Fertilizer application on the field	Ground water pollution	Educate farmers on INM, promote organic fertilizer (manure, compost), avoid excessive application of mineral fertilizer and determine fertilizer needs on the basis of soil analysis	***Main activities have been streamlined into AFSP implementation:*** Detailed activities included in Annual work plan and budget for: *+ Awareness creation at all levels* *+ Agro-dealer training and recycling (complementary AGRA support)*	**MAFC: Agricultural Input Unit Environmental Management Unit** MAFC Information & communication unit
	Soil acidification	Educate farmers on INM, promote organic fertilizers (compost, manure) use, avoid excessive application of mineral fertilizer and determine fertilizer needs on the basis of soil analysis and apply lime. Promotion of conservation farming.		
	Soil erosion/land degradation	Educate farmers on INM, promote organic fertilizers (compost, manure) use, apply Soil Water conservation measures and promote crop diversity. Promotion of		

		conservation farming.	***Complementary financing to ASDP (R&D) for specialized nutrient management related activities, including:*** *+ Soil fertility research (station & on farm) for updating fertilizer recommendation adapted to crops and soil types* *+ Extension/farmer training and advise activities for efficient and appropriate fertilizer use* *+ Promotion of conservation farming practices*	**Environmental Management Unit** Agricultural Research Institute (ARI) National and District Agric. extension services + ASDP
	Soil organic matter loss and reduced microbial activity	Educate farmers on INM, promote organic fertilizers (compost, manure) use. Promotion of conservation farming.		
	Soil nutrient reserve depletion	Educate farmers on INM, promote organic fertilizers (compost, manure) use and determine fertilizer needs on the basis of soil analysis. Conservation farming.		
	Mono-cropping and reduced crop diversity	Educate farmers on INM and IPM; promote crop diversification		
	Possibilities of pest/disease infestation	Educate farmers on INM and IPM; promote crop diversification		
	Eutrophication, undesirable color, taste, odor of water bodies. Impairment of aesthetic qualities of surface water bodies. Effect on aquatic ecosystem and death of fish.	Educate farmers on INM, promote organic fertilizers (compost, manure), avoid excessive application of mineral fertilizers and determine fertilizer needs on the basis of soil analysis		
Monitoring and evaluation of INMP		- Agro-dealer training outputs monitoring (CNFA) - Farmer training outputs monitoring (Extension services / ASDP) - Status of safety measures at agro-dealer level (compliance with shop organization rules; disposal of residues, use of protective gears, level of cleanliness, absence/presence of contaminated surfaces (CNFA monitoring & Impact survey) - Soil nutrient status and OM level follow-up (ARI) - Average organic and mineral fertilizer application levels (ARI follow-up) - Cropping practices (rotations, diversification) – Impact evaluation. - Land preparation practices (impact survey) - IPM/INM practices (Impact survey)	***Project monitoring:*** MIS Agricultural input unit (MAFC) ***Project Impact survey (base and annual survey)*** ***Analysis – soils and effluent receiving bodies (ARI-Milangano)***	**MAFC: Agricultural Input /Environmental Unit** ***Impact survey team*** ***ARI Milangano***

9. Conclusions and Recommendations

83. Main conclusions are:

i. Fertilizer application rate is very low; therefore, its impact on social and environment is minimal;
ii. Future fertilizer demand indicates a growing trend; hence the likelihood of increasing negative environmental impacts in the years to come;
iii. Most fertilizer stores of agro-dealers do not comply with health and safety standards for fertilizer products, thus resulting in to health and safety hazards to staffs and laborers working in them;
iv. Almost all main fertilizer stores are located within business and residential areas; consequently potential health hazards to people living around should be monitored;
v. Store managers, supervisors, etc., in fertilizer stores lack proper training with regard to fertilizer handling, health and safety precautions. Moreover, most of these stores do not provide protective devices.
vi. Organic fertilizer/ compost application is currently practiced by farmers; however, its use is not widely spread.
vii. Conservation farming practices remain limited although there long term efficiency has been shown

84. The Recommendations are:

i. As economy of the county grows and fertilizer use intensifies, additional precautionary measures must be taken in order to prevent possible negative environmental impacts;
ii. All main and small fertilizer stores should strictly follow the required standards of fertilizer storage so as to avoid health and safety problems;
iii. Future (large) fertilizer stores should be established outside business and residential areas; existing stores should work towards minimizing health and safety problems;
iv. Proper training and awareness raising programs must be organized for all those involved in supply and storage operations. Protective devices must be provided to workers handling fertilizers (and treated seeds); and
v. Alongside inorganic fertilizer use, application of organic fertilizer/compost application should be widely promoted.
vi. Conservation farming combined to increased fertilizer use should be promoted to enable rapid increases in soil organic matter levels.
vii. MAFSC should facilitate the process of developing appropriate regulations for the Fertilizer Act implementation.

Annexes

Annex 1: Fertilizer Act 2008

Annex 2: Standards for Urea, DAP, MRP

Fertilizer - Urea - Specification

0 Foreword

Urea [CO $(NH_2)_2$] which is sometimes called carbamide is the highest nitrogen containing solid fertilizer.

This Tanzania Standard is intended to guide manufactures, importers, traders and consumers of urea fertilizer to produce and select the product of desirable quality.

In the preparation of this Tanzania Standard assistance was drawn from the following publications:

KS 03 – 288:1998, *Specification for urea fertilizer* published by the Kenya Bureau of Standards.

Manufacturers' specifications

Official methods of analysis : 1990 published by the Association of Official Analytical Chemists, Washington, DC, USA.

In reporting the results of a test or analysis made in accordance with this Tanzania Standard, if the final value observed or calculated is to be rounded off, it shall be done in accordance with TZS 4: 1979 (see clause 2).

1 Scope

This Tanzania Standard prescribes the requirements and the methods of sampling and test for urea fertilizer.

2 References

For the purpose of this Tanzania Standard, the following references shall apply:

TZS 4: 1979, *Rounding off numerical values.*

TZS 157: 1983, *Triple super phosphate – Specification.*

TZS 777: 2003, *Fertilizer – Calcium ammonium nitrate(CAN) – Specification.*

TZS 782:2003, *Fertilizer – Methods for determination of heavy metal contaminants.*

TZS 780: 2003, *Fertilizer – Code of practice for handling and storage.*

TZS 781:2003, *Fertilizer – Methods of sampling.*

3 Requirements

3.1 Physical

Fertilizer shall be in the form of a free flowing white granules or prills, free from foreign matter and impurities. The particle size shall be such that not less than 90 percent by mass of the material shall be of particles of size range of 1mm – 4mm for granules and 1mm – 3mm for prills.

3.2 Chemical

The fertilizer shall comply with the requirements specified in table 1.

Table 1 - Chemical requirements for urea fertilizer

Characteristics	Requirements	Methods of test
Total nitrogen, percent by mass, *minimum*.	46	Annex A of TZS 777:2003 (see clause 2)
Biuret, percent by mass, *maximum*.	1	Annex A
Moisture, percent by mass, *maximum*.	0.5	TZS 157: 1983 (see clause 2)

3.3 Heavy metal contamination

Heavy metal contamination in urea fertilizer shall not exceed the following limits when determined by the method described in TZS 782: 2003 (see clause2)

Arsenic	20 ppm
Cadmium	7 ppm
Mercury	0.1 ppm
Selenium	1.0 ppm
Lead	30 ppm
Chromium	500 ppm

4 Packaging, labeling and marking

4.1 Packaging

The fertilizer shall be packed in UV stabilized woven polypropylene (wpp) bags with 1 ply polyethylene (pe) inner lining. A the bottom of the bag, the woven fabric and the *pe* shall be hemmed then folded and secured together in lock stitches. At the top the inner lining and outer bag, shall be hemmed together. The bag shall be securely closed in lock stitches and without any opening. The stitching thread must be acid and heat resistant and of sufficient strength to hold the package secure and withstand multiple stages of handling.

The outer *wpp* fabric shall measure not less than 12 x12 mesh weave of minimum 900 denier. The inner *pe* lining shall be of minimum of 70 microns thickness.

It is recommended that fertilizer is packed in 50 kg bags or as agreed to between the purchaser and supplier.

4.2 Labeling

The bags shall be labeled with the following information:

a) name of the product i.e. "Urea Fertilizer";

b) total nitrogen content;

c) name and address of the manufacturer/packer and importer/ distributor;

d) net content by mass in kg;

e) batch number;

f) handling instructions, including the words "Use No Hooks";

g) country of origin and

h) production date and expiry date.

4.3 The bags shall also be marked with the TBS Standards Mark of Quality.

NOTE –The TBS Standards Mark of Quality may be used by the manufacturers only under license from TBS. Particulars of conditions under which the licences are granted, may be obtained from TBS.

5 Storage

Urea fertilizer shall be stored, handled and transported as prescribed in TZS 780: 2003 (see clause 2).

6 Sampling and testing

6.1 Sampling

Sampling of fertilizer shall be done as prescribed in TZS 781: 2003 (see clause 2).

6.2 Testing

Testing of the fertilizer shall be done as prescribed by the methods given in table 1 and their respective annexes.

Fertilizers – Mono-ammonium phosphate and di-ammonium phosphate (MAP & DAP) – Specification

0 Foreword

Mono-Ammonium Phosphate (MAP) and Di-Ammonium Phosphate (DAP) fertilizers are among the major sources of phosphorous, which is an essential nutrient for the growth and development of plants.

This Tanzania Standard is aimed at guiding the manufacturers, importers, traders and farmers in producing and selecting fertilizers of good quality.

In the preparation of this Tanzania Standard, assistance was derived from manufacturers' specifications.

In reporting the results of a test or analysis made in accordance with this Tanzania Standard, if the final value observed or calculated, is to be rounded off, it shall be done in accordance with TZS 4 (see clause 2).

1 Scope

This Tanzania Standard prescribes requirements and methods of sampling and tests for MAP and DAP fertilizers.

2 References

For the purpose of this Tanzania Standard the following references shall apply:

TZS 4:1979, *Rounding off numerical values*

TZS 156:1983, *Fertilizer – Terminology*

TZS 779:2003, *Fertilizer – Potassium chloride – Specification*

TZS 159:2006, *Fertilizer – Methods of sampling and test*

TZS 780:2003, *Fertilizer – Code of practice for handling and storage*

3 Requirements

3.1 Physical

MAP and DAP fertilizers shall be in the form of crystals or granules; the fertilizers shall be free flowing and free from any foreign matter. The particle size shall be such that not less than 90% by mass of the material shall pass through 4 mm sieve and be retained on 1 mm sieve. Not more than 5% shall be below 1 mm sieve. The colour of the fertilizers shall be grayish.

3.2 Chemical

The fertilizer samples when determined by the methods described in TZS 159 (see clause 2) shall comply with the requirements given in table 1.

Table 1 – Chemical requirements for Mono-Ammonium Phosphate (MAP) and Di – Ammonium Phosphate (DAP) fertilizers

Characteristics	Requirements	
	MAP	DAP
Ammoniacal nitrogen, as N, per cent by mass, minimum	11	18
Total phosphates, as P_2O_5, per cent by mass, minimum	48	46
Water soluble phosphates, as P_2O_5, per cent by mass, minimum	45	41
Moisture content, per cent by mass, maximum	0.7	0.7

3.3 Heavy metal contamination

Heavy metal contamination in the fertilizers shall not exceed the limits given in table 2 when determined by methods described in TZS 159 (see clause 2).

Table 2 – Heavy metal contamination

Element	Maximum limit, mg/kg (ppm)
Arsenic	20
Cadmium	7
Mercury	0.1
Selenium	1
Lead	30
Chromium	500

4 Packaging and labelling

4.1 Packaging

MAP and DAP fertilizers shall be packed in ultra violet (UV) stabilized woven polypropylene (wpp) bags with one polyethylene (pe) inner lining. At the bottom of the bag the woven fabric and the pe shall be hemmed then folded and secured together in lock stitches. At the top, the inner lining and outer bag shall be hemmed together. The bag shall be securely closed in lock stitches and without any opening. The stitching thread must be acid and heat resistant and of sufficient strength to hold the package secure and withstand multiple stages of handling. The outer wpp fabric shall measure not less than 12 x 12 mesh weave of minimum 900 denier. The inner pe lining shall be of minimum of 70 microns thickness.

It is recommended that fertilizer is packed in 50 kg bags or as agreed to, between the purchaser and supplier.

4.2 Labelling

The container shall be labelled with the following information:

a) Name of the fertilizer i.e. Mono-Ammonium Phosphate fertilizer (MAP) or Di-Ammonium Phosphate fertilizer (DAP)
b) Name and address of the manufacturer/packer
c) Net content by mass in kg
d) Nutrient content
e) Country of origin
f) Handling instructions – including the words 'use no hooks'
g) Production date and expiry date
h) Batch number

5 Storage

MAP and DAP fertilizers shall be stored, handled and transported as prescribed in TZS 780 (see clause 2).

6 Sampling and testing

6.1 Sampling

Sampling of MAP or DAP fertilizers shall be carried out as prescribed in TZS 159 (see clause 2).

6.2 Testing

Testing of the fertilizer shall be done as prescribed in the methods of analysis indicated in respective standards.

MINJINGU ORGANIC HYPER PHOSPHATE (MRP)[16]

MRP is favorable for the following reasons when compared to the most highly renown naturally occurring phosphate fertilizers:

1. Particle size composition
2. Nutrient composition
3. Heavy metal composition
4. Solubility:
    - Water Soluble Phosphorous
    - Neutral Ammonium Citrate Soluble Phosphorous
    - 2% Citric Acid Soluble Phosphorous
    - 2% Formic Acid Soluble Phosphorous

Analysis by: Southern and Eastern African Mineral Institute (SEAMIC, 2007)

Global Comparison:

Country	Deposit	Reactivity	P^2O^5 %	As Mg/kg	Cd Mg/kg	Cr Mg/kg	Pb Mg/kg	Se Mg/kg	Hg µ/kg	U Mg/kg	V Mg/kg
Algeria	Djebel Onk	High	29.3	6	13	174	3	3	61	25	41
Burkina Faso	Kodjari	Low	25.4	6	<2	29	<2	2	90	84	63
China	Kaiyanga	Low	35.9	9	<2	18	6	2	209	31	8
India	Musoorie	Low	25.0	79	3	56	25	5	1672	26	117
Jordan	El Hasssa	Medium	31.7	5	4	127	2	3	48	54	81
Mali	Tilemsi	Medium	28.8	11	8	23	20	5	20	123	52
Morocco	Khouribga	Medium	33.4	13	3	188	2	4	566	82	106
Niger	Parc W	Low	33.5	4	<2	49	8	<2	99	65	6
Peru	Sechura	High	29.3	30	11	128	8	5	188	47	54
Senegal	Taiba	Low	36.9	4	87	140	2	5	270	64	237
Syrian AR	Khheifiss	Medium	31.9	4	3	105	3	5	28	75	140
UR of Tanzania	**Minjingu**	**High**	**28.6**	**8**	**1**	**16**	**2**	**3**	**40**	**390**	**42**
Togo	Hahotoe	Low	36.5	14	48	101	8	5	129	77	60
Tunisia	Gafsa	High	29.2	5	34	144	4	9	144	12	27
USA	Central Florida	Medium	31.0	6	6	37	9	3	371	59	63
USA	North Carolina	High	29.9	13	33	129	3	5	146	41	19

A 100% natural fertilizer, Minjingu Organic Hyper Phosphate does not react as quickly as the chemical P fertilizers and the rate of fixation is minimal. The higher the fixation rate, the greater amount of P fertilizer required to raise P level in the soil. With chemical P, it is known that 75 – 80% P will not be available for plant's uptake.
Urea used in a very large quantity in farming leads to undigested nitrogen resulting in weaker plants, bad tasting crops and produce that go bad quickly. Minjingu Organic Hyper phosphate+ helps the absorption of nitrogen thus reducing the amount of undigested nitrogen.

Minjingu Organic Hyper phosphate+ is a natural phosphate that has a slow nutrient release pattern when compared to chemical phosphate. Natural phosphates are equally effective and reduce the damaging effects on the soil.

Suitable for any soil type:

Phosphorus is an essential element for plants to grow vigorously. Unlike other fertilizers, Minjingu Organic Hyper phosphate+ can fertilize acid, neutral and even slightly alkaline soils.

[16] http://www.minjingumines.com/link5.htm

Annex 3: Information on the FAO Guide to Efficient Plant Nutrient Management[17]

1. The FAO Guide to Efficient Plant Nutrient Management is a consequence of the organization's concern about the importance of crop fertilization for maintaining and enhancing agricultural production. The Guide, a result of an expert consultation, provides guidance for sound plant nutrition practices as a tool for accelerated growth in crop productivity and agricultural incomes and for environmentally-friendly intensification of production systems. It aims at providing clear information to a wide public about concepts and methods. The summary below presents an overview of what the Guide contains.

2. Maintaining and enhancing agricultural production through improved plant nutrition management, correctly integrated with sound water management and improved use of other production factors, is a complex challenge. Agricultural intensification requires increased flows of plant nutrients to crops, supporting higher uptake of those nutrients and higher levels of stocks of plant nutrients in soils, a prerequisite for higher yields. This intensification results in larger amounts of crop residues, manures and organic wastes from the consumption of agricultural products, which are sources of plant nutrients. Excessive applications of nutrients, inefficient management of cropping systems, and inefficient use of residues and wastes, result in losses of plant nutrients and thus economic loss to the farmer. An inadequate and insufficient plant nutrient supply creates an insidious depletion of plant nutrient stocks on the farm, which is also an economic loss for the farmer. Environmental hazards may be created through an oversupply of nutrients compared to the capacity for their uptake by cropping systems, while the depletion of nutrient stocks is a major, but often hidden, form of environmental degradation. Plant nutrition management depends largely on prevailing economic and social conditions. Farmers' decisions depend on their economic situation and their socio-economic environment, on their perception of economic signals and on their acceptance of risks.

3. The fundamental assumption of the Guide is that sound plant nutrition management can contribute to meeting the challenge of food security and the required increased production of agricultural products by using the land and water resource base in a way which safeguards the environment.

4. The Guide addresses all parties engaged in or influencing the production, distribution and use of sources of plant nutrients: local organic products, mineral fertilizers and biological inoculants. It proposes responsibilities, guidelines and a basis for agreement of the parties concerned to share the promotion and development of sound intensified plant nutrition management guided by accurate policies through coherent plans for action.

5. The Guide proposes the adoption of Integrated Plant Nutrition Systems (IPNS) which enhance soil productivity through a balanced use of the available local and external sources of plant nutrients on the farm; maintain or improve soil fertility; and are environmentally friendly. In the medium term, IPNS help accumulate plant nutrient stocks (in soils and crop residues) as capital for the sustainable continuation of the intensification process.

6. The Guide emphasizes the urgent necessity for participatory identification and development of locally-adapted technology and decision-making mechanisms for sound plant nutrition practices. Circulation of information for, and training of, small-scale farmers are key issues for the promotion of intensified and environmentally friendly farming practices, supporting the raising of farmers' income.

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[17] (COAG 1997)

7. The essential components of efficient plant nutrition management, which the Guide aims at communicating, are described below:

(a) The sources of plant nutrients are described and information is provided on their efficient use for agricultural intensification and their potential impact on the environment.

(b) Optimization of the management of plant nutrients, as a part of sound agricultural intensification, results from a balanced supply of plant nutrient sources, maintaining or increasing the capital of plant nutrients on the farm and the productivity of the nutrients involved in crop production and generating the maximum income for farmers within the local economic context.

(c) Advice on plant nutrition management should include assistance in decision-making at plot and farm level, to optimize the use of local resources and the capacity for intensification of farming according to production objectives and the economic environment. Advice should also be provided at the village or small watershed level for the correct management of, or investment in, local sources of nutrients through sound use of vegetation and livestock. In order to optimize the cost-effectiveness of the various channels providing advice to farmers, private and public sectors need mobilizing and to cooperate with each other, so as to best serve the different categories of farmers. Information should be provided to all partners about the potential environmental impact of plant nutrient management. Correct research back-up is essential.

(d) The possible environmental impact of the overuse, underuse and misuse of plant nutrient sources is discussed.

(e) National policies should facilitate the development of sound plant nutrition management and the corresponding investment for intensifying production systems by farmers, while conserving the natural resource base.

8. The major aspects of the Guide put forward for consideration are: (i) assessment of plant nutrient requirements to meet crop production targets; (ii) choice of sources and methods of supply; (iii) determination of the optimum level of domestic fertilizer production; (iv)- price levels and the issue of subsidies on plant nutrient sources; (v) legislative aspects; (vi) support for extension and research.

9. Policy-making in these areas determines the extent to which farmers have access to plant nutrient sources and are able to increase their production while maintaining soil fertility. A farmer needs purchasing power to obtain external inputs, as well as advice on how to use them in a balanced way. The Guide outlines appropriate policies in the areas of assessment, marketing, transport and storage, pricing, labeling, packaging, and training advice and planning. It emphasizes that the right balance of government and private participation in the production, import and distribution of fertilizers, needs to be found. In addition, it advocates setting up national plant nutrition management units. These would advise, formulate and establish a well-integrated plant nutrition policy, and regulate availability and quality through the production and trade of plant nutrient sources (in particular fertilizers), in accordance with the government's overall plant nutrition strategy.

10. Finally, if the Guide is to achieve its aims wide distribution is needed. Ways of implementing the advice contained in the Guide at national, regional and international levels are suggested, as are follow-up measures, such as the monitoring of soil productivity status, productivity of the supplied nutrients and environmental impact of plant nutrient management. All parties addressed by the Guide are urged to observe and promote its general principles in the knowledge that efficient plant nutrition management at farm and country levels is a key to ensuring sustainable food security and rural development.

11. FAO Members are alerted to this Guide, which is expected to be published in May 1997, and are invited to give it the widest distribution.

Annex 4: Technical elements[18] on 'SOIL NUTRIENT MANAGEMENT'

Soil Fertility Management.

12. The declining per capita food production in East Africa is associated with declining soil fertility in smallholder farms. This is because nutrient capital is gradually depleted by crop harvest removal, leaching and soil erosion (IFPRI 1996). The use of crop residues by farmers as fodder, and none or shorter fallow periods due to a shrinking land resource base, should be balanced by addition of chemical fertilizers and organic manure, which most smallholder farmers in the region cannot afford.

13. There is, therefore, a need to develop appropriate soil nutrient and cropping systems that minimize the need for chemical fertilizers and also find ways to integrate livestock into the farming system. The focus of any soil fertility replenishment should be integrated nutrient management involving the application of leguminous mulches, agroforestry, composting as well as technologies that reduce the risks of acidification and salinization. Sanchez et al. (1997) suggest that soil fertility replenishment should be considered as an investment in natural resource capital. Studies by Murage et al. (2000) show that soil fertility depletion results from an imbalance between nutrient inputs, harvest removals and other losses, and that it is reaching critical levels among smallholders in East Africa (with depletion of soil organic matter being a contributory factor). For example, Smaling et al. (1993) estimate that 112, 2.5 and 70 kg ha-1 per year of nitrogen, phosphorus and potassium respectively, are lost from agricultural soil in Kenya. In many small-scale farms, crop residues are harvested and fed to livestock, and very little is returned to the soil to replenish lost nutrients. The depletion of organic matter thus exacerbates this condition.

14. The concept of "poor" and "fertile" soil may mean different things to different communities and conditions. Soil fertility refers to the capacity of soil to produce crops by providing adequate supply of nutrients in correct proportions, resulting in sustained high crop yields. In addition, a fertile soil has good rooting depth, good aeration and good water holding capacity. It is also necessary that there is a strong presence of soil organisms, e.g., earthworms, adequate amounts of organic matter, the right pH balance and no adverse soil-borne pests and diseases (Landon 1991; Njoroge 1994). Efficient farm management practices should result in greater stimulation of activities of soil organisms, nutrient additions to the soil, minimal nutrient exports from the soil and optimal nutrient recycling within the farming system (Landon 1991; Young 1976). Therefore, it should be possible to say accurately whether a soil is fertile or not, based on well-defined criteria.

15. In the sub-humid highlands of Kenya, soil fertility management among smallholder farmers is quite widespread. For instance, in Embu District, 99 percent of farmers use mineral fertilizers, 91 percent use farmyard manure and 74 percent do crop rotations, while in Vihiga, western Kenya, 75 percent use compost manure, 79 percent use green manure and cover crops, 91 percent use farmyard manure and 93 percent use crop residues (Amudavi 2005). Other soil fertility-enhancing interventions include improved fallows, biomass transfer and crop residues. In soil and water management, technologies that improve soil fertility and productivity are as important as those that reduce erosion and loss of water. These include practices such as residue mulching, contour tillage and tied ridging, minimum tillage, sub-soiling, crop rotation, cover cropping, rotational grazing, contour ripping and direct application of organic matter, farmyard manure and inorganic fertilizers.

Use of Mineral Fertilizers

16. The use of mineral fertilizers in East Africa, though not a traditional practice, has been catching on quite well, albeit with low application rates. In Ethiopia, fertilizer use trials have been

[18] (Extracted from 'Overview of Water and Soil Nutrient Management under smallholder rainfed Agriculture in East Africa. IWMI, Working paper 105, 2005)

done with farmer experimentation in Galessa and Meta Robi districts, in Welmera and Ilala Gojo areas near Holetta (Sinebo et al. 2002; Agegnehu 2002; Aregu, et al. 2002) and in many other areas as well for wheat, pea, barley and teff. The response of crops to fertilizer has been good, showing great potential for increasing crop production. However, the cost of fertilizers is beyond the reach of poor farmers, nevertheless this practice has become popular among wealthier farmers. A study in 1995 (Eyasu 2002) revealed that 78 percent of the farmers interviewed used mineral fertilizers and virtually all the nonusers were poorer farmers. The major type of fertilizer used was DAP. The quantity of fertilizer used depends on the socioeconomic level of the farmers, with richer farmers using more fertilizers. Field trials on maize and sorghum with and without fertilizer application in the semi-arid areas of eastern Ethiopia showed that a substantial yield increase occurred when fertilizers were used along with water conservation practices. However, over 50 percent of the increase in yield was attributed to water conservation (Eyasu 2002).

17. In Kenya, the use of mineral fertilizers has been common among smallholder farmers for commercial crops such as coffee, tea and tobacco, but their use has been very low for food crops. The mean application rates are about 35kg ha^{-1} (World Bank 2003), which is below the basic requirement for most types of soil. Although the application rates for cash crops are closer to the recommended level the application rates for food crops are way below the required level. Even though expensive, the use of inorganic fertilizers needs to be promoted, as many types of soil lack adequate levels of phosphorus and nitrogen. Mati and Mutunga (2005) observed that farmers were not using fertilizers in Kusa, Nyando District of Kenya, partly because they were not available locally, and that the nearest shop where fertilizers could be obtained was over 40 km away. They (Mati and Mutunga 2005) recommended that farmers be trained in using fertilizers suitable to their requirements and the proper methods of application. It was also suggested that modalities be found to bring fertilizers closer to the people through local shops, and packing them in small quantities to ensure affordability. Most farmers know only of DAP, and as such, there is a need to educate them on the differences and uses of various fertilizers, why application is necessary, appropriate timing of application and the rates of application. In addition, farmer experimentation should be encouraged.

Use of Organic Manure

18. Levels of organic carbon have been shown to be the overriding factor affecting soil fertility. Murage et al. (2000) observed that among soil organic pools and fractions, total organic C was the most sensitive soil quality indicator, suggesting that within a narrow range of soil it may serve as a suitable indicator of soil quality. Other studies in Kenya (Irungu et al. 1996; Kapkiyai et al. 1998) report that soil organic matter fractionation may offer insight into soil fertility changes and the sustainability of past management systems. The use of organic manure in Ethiopia is constrained by shortage of organic materials such as crop straws and animal dung. Many smallholder farmers feed crop residues to livestock and the manure is dried and used as fuel. Thus, nutrients are not returned to the soil (soil mining) leading to declining soil fertility, reduced soil moisture retention and ultimately poor yields (Tefera et al. 2002). Owing to declining holding-size, farmers in many high potential areas have resorted to continuous cultivation, thereby further exacerbating land degradation and poor crop production.

19. With farmers keeping small ruminants, the need to diversify the sources of manure has grown. Farmers keeping goats use “goat manure” with good results. Experiments at Kibos, near Kisumu in Kenya (Onim et al. 1990) showed that goat manure had superior soil fertility impacts when compared with DAP fertilizers, which is popular among farmers in Kenya, despite its relatively high pH. Moreover, goat manure is more economical and it has low direct costs. The use of manure has been growing as a result of farmers getting more sensitized, especially with conservation technologies. The main problem, however, has been the decline in the quality of manure, which is attributed to substandard storage facilities and irresponsible handling.

Green Mulches/Manure

20. Green mulches are usually leguminous plants that cover the ground as runners, grown together with other crops. They are sometimes also termed as green manure because of the ability of the companion legume to fix nitrogen in the soil. The legume could be cut and incorporated into the soil while green as manure. Alternatively the legume is used as a cover crop. Other types of crops such as pumpkins and water melons have proved useful green mulches. The author found that in a papaya plantation in Embu District of Kenya, the use of water melons as a companion crop improved soil moisture conservation. Trials by farmer experimenters in Mbozi District, southern Tanzania (Hilhorst and Toulmin 2000; Thomas and Mati 2000) showed that by planting velvet bean under coffee the weeds were reduced (smothered by the cover of the bean), while the coffee yield increased due to water conservation and soil fertility improvement, as a result of nitrogen fixation by the beans.

Plant Teas

21. Occasionally, liquid manure is prepared in the form of "plant tea." Plant teas are especially necessary to quickly provide the crop with adequate natural plant food during the growing season, and as a top dressing. In preparation, plant teas utilize green sappy leaves and young branches of leguminous trees, which are chopped and put in a drum of clean water (figure 4.1). The drum is covered and left to stand. Depending on type of plant material used and the temperature, the plant tea is ready for use within two to three weeks. It is then diluted at least by 1:2 parts per volume before application (Njoroge 1994).

Composting

22. Composting is gaining importance, especially among smallholder farmers, particularly with those who are more progressive and innovative. Composting is the natural process of turning organic materials, such as crop residues and farmyard manure, into valuable plant food or humus (Njoroge 1994). The ingredients that produce good quality compost, such as leguminous residues and manure, are just as important as the methodology of composting. Composting has been one of the most common features among farmer innovators in East Africa (Kibwana 2000; Critchley et al. 1999; Reij and Waters-Bayer 2001) and farmers involved in organic farming (Thomas 1997). The normal procedure in composting is to first make a foundation onto which ashes are spread to prevent termite infestation. Then layer after layer of dry crop residues (chopped), green vegetation e.g., *Lantana camara* and *Tithonia diversifolia* and topsoil are placed over each other, wetting with fresh water (non-chlorinated). The heap is then covered with soil and a stick driven into the middle to act as a thermometer. The compost is turned (and wetted) after around 22 days. In most parts of East Africa, the compost is ready for use within 45 days (Njoroge 1997).

Mapambano Compost Making

23. "Mapambano" compost making is an innovation by farmer, Ms Susanna Sylvesta of Dodoma, Tanzania (Mutunga and Critchley, 2001). She makes 15 tons of compost each year. The composting system is based on locally available materials and pits of over 1 m deep and up to 3 m in diameter. Ash is spread at the bottom of the pit, and then a layer of grass is added, followed by alternating layers of crop residues, grass, tree leaves, sisal leaves, manure, bedding, animal urine and ash. Domestic wastewater is added to keep the mixture moist. The pit is filled (built above ground level) and topped off with a final layer of ash and a cap of grass. Wastewater and urine continue to be added to keep it moist until it is fully decomposed. This takes about 3 months and produces a rich compost, which is applied to the maize crop at the rate of 1.5 t/ha/year. There were plans to package the compost for sale even in the export market (Lameck personal communication).

Compost Baskets

24. Another system of composting known as "compost baskets" is also common in various parts of East Africa (Hamilton 1997). The idea of a compost basket is to do *in-situ* composting in which the crop utilizes the compost as it decomposes, and thus is expected to last longer (figure 4.2). Compost baskets are woven from twigs and driven into the prepared beds at a spacing of 1 m

as follows: holes of at least 15 cm deep and 30 cm wide are dug along the centre line of the prepared bed at a spacing of about 1 m. Sticks of about 60 cm long are then driven into the ground around. Each hole, and long flexible twigs woven around to form aboveground baskets. The baskets are filled with manure and well-decomposed household wastes. The manure is translated from the soil below the basket into the root zone through natural processes. Due to hydrotropism the roots also tend to grow towards the basket. This technique has been tried in Funyula division of western Kenya for tomato production. Yields recorded indicated a production value of Ksh 100 (about US$1.40) per square meter of land (Bittar 2001). In eastern Kenya, KIOF has popularized the use of compost baskets, which farmers have found requires less labor than normal composting.

Double-dug Beds

25. Double-dug beds (DDBs) are made to prepare the soil for cultivation by breaking the soil in the hard pans and creating a deep layer of loose soil that is fertile (figure 4.2). This practice aerates the soil, improves water absorption and retention, allows plants to use available nutrients more efficiently and increases rooting depth (Njoroge 1994; Hilhorst and Muchena 2000). These beds can be used for intensive cultivation and will produce higher yields than in shallow tillage. Commonly recommended dimensions of a double-dug bed are approximately 1.5 x 7m wide and 60 cm deep. The bed is filled with about six wheelbarrows of compost, which can be used for four consecutive cropping seasons before the process needs repeating. Farmers have adapted this method in various ways, digging less deeply when the soil is rocky or when labor is scarce, changing the length of the beds and adding a variety of organic materials. Composting and DDB seem more widely used in higher areas than in medium potential areas. This may be due to two reasons: 1) water is more easily available in high potential areas; and, 2) manure can be readily obtained from zero-grazing units. Tests, however, show that DDB and composting produce higher yields of maize, better gross margins and returns to labor in a medium potential area such as Machakos when compared to high potential Nyeri District of Kenya. This is probably because hard pans are more frequent in Machakos (Hilhorst and Muchena 2000).

26. Double-dug beds have been promoted by NGOs since the late 1980s in Ethiopia, Tanzania and Kenya, where they are mainly used for cultivating high-value cash crops such as vegetables (Hamilton 1997). The construction technique involves preparing the garden beds by digging out the topsoil and subsoil separately. The bottom of the trench is further tilled to improve infiltration. The topsoil is then mixed with organic manure and returned to the bed. Care is taken not to step on the bed in order to avoid compaction. High-value crops are then grown on the beds with very good results since the bed absorbs more water than in conventional tillage. Their adoption and subsequent adaptation are closely linked to increased production of compost, which should be added when the double-dug beds are prepared. As found in a survey, 22 percent of farmers who had been trained in Low External Input Sustainable Agriculture farming technologies used double-dug beds. (Thomas and Mati 2000).

Mulching

27. The objective of mulching is to conserve soil moisture, reduce runoff flows, evaporative losses and wind erosion, prevent weed growth, enhance soil structure and control soil temperature. Mulching in East Africa normally utilizes natural materials and involves covering the soil with cut grass, crop residues, straw or other plant material. In East Africa, mulching is practiced by farmers in the wetter areas due to the availability of vegetative materials. Most smallholders do mulching only for special crops such as tomato, cabbage and potatoes due to the shortage of crop residues.

28. Depending on availability of residues, mulch densities range between 30 percent and 70 percent, based on availability of residues obtained from the previous season's crop (Kibwana 2000; Mruma and Temu 1999). The importance of mulches in reducing surface runoff, soil erosion and evaporation losses cannot be overstated. In an experiment in the Laikipia District of Kenya, it was observed that in the absence of mulch, 40-60 percent of the rain that fell was lost to evaporation, and that if 40-50 percent of the ground was covered with mulch, surface runoff losses were reduced to almost zero and evaporation losses halved (Liniger 1991). Crop yields were found to double or triple and biomass to feed the livestock increased. In a participatory experiment with farmer

innovators in Mbozi District, Tanzania, the Indigenous Soil and Water Conservation Program (ISWCP)—(Kibwana 2000; Mruma and Temu 1999) tested the use of crop residues to mulch the coffee crop grown in the marginal Mbozi District. The farmers found that coffee yield nearly doubled under the mulched plots, a factor that was associated with soil moisture conservation.

Agroforestry

29. Agroforestry, though an indigenous intervention among many communities in East Africa, gained its prominence in the 1980s after the establishment of the International Council for Research in Agroforestry (ICRAF, now called "World Agroforestry Center"), which set up office in Nairobi with field activities in the region. In Kenya, Ethiopia and Tanzania, seedling production was taken up as a component within the SIDA-supported Soil and Water Conservation Project (SWCP) of the respective Ministries of Agriculture. The initial focus was on the nurseries, but from 1988, there was a shift towards a more holistic and supportive role in recognition of the need to work in a participatory manner with farmers. More emphasis was put on farmers' training rather than production of seedlings. Production of information material for extension staff, farmers and schools became an important component (Muturi 1999). Enthusiasm for farm forestry activities increase in response to the prevailing political push and intensification of extension. A variety of institutions became involved in seedling production. They included government ministries, nongovernmental organizations (NGOs), rural development projects, farmer groups and rural communities. By mid-1991 there were 4,161 documented tree seedling nurseries established by various institutions in Kenya alone (Muturi 1999), while soil and water conservation projects in Ethiopia and Tanzania all had a strong agroforestry component (Lundgren and Taylor 1993; Assmo and Eriksson 1994).

30. A majority of the smallholder farmers practicing agroforestry prefer to grow multipurpose trees. They have realized that through agroforestry trees provide nutrient inputs to crops by capturing nutrients from atmospheric deposition, biological nitrogen fixation, tapping nutrients from deep in the subsoil and storing them in the bio-mass (Sanchez et al. 1997). Trees also enhance nutrient cycling through conversion of soil organic matter into available nutrients (especially nitrogen and phosphorus). It is, therefore, possible to recycle nutrients through leaf-fall, root decay and green manure (Biamah and Rockström 2000). Agroforestry also benefits farmers directly through the provision of poles for building, fruits for sale and consumption, fuel wood and fodder for livestock. The trees also prevent soil erosion, conserve soil water and improve soil fertility and the micro climate. The environmental benefits of trees include soil conservation, bio-diversity conservation and the conservation of terrestrial carbon.

Hedgerow Intercropping

31. Hedgerow intercropping or alley cropping was popularized by ICRAF in the 1980s, but adoption by farmers has been poor. It involves growing leguminous tree shrubs in narrow strips across the slope, then the shrubs are lopped and the material used as a green mulch. Popular species include *sesbania sesban, caliandra calothyrsus* and *leucena sp* (Thomas 1997). Nitrogen fixation by the hedge roots and its incorporation through pruning is supposed to replace the need for nitrogen fertilizers thus saving costs. However, competition for moisture between crop and hedges was a major limitation factor in the dry areas. With the exception of the aforesaid problem, hedgerow intercropping can be quite effective in soil conservation as explained below. ICRAF tested low hedgerows of *Cassia siamea*, a leguminous and nitrogen-fixing shrub, planted on the contours to enable the development of natural formation of terraces on a 14 percent land slope at Katumani, Machakos (Lundgren and Taylor 1993). One night in April 1990, 52 mm of rain fell in just 30 minutes on slopes that were already saturated. Fields with only crops lost more than 34 tons of soil per hectare. , while fields with hedgerows lost, at most, 6 tons per hectare. Where maize and cowpeas were grown between hedgerows the produce was two to three times the harvests from fields with sole crops. (Lundgren and Taylor 1993).

Improved Fallows and Biomass Transfers

32. Improved fallows have been described (Sanchez 1999) as the deliberate planting of leguminous tree species with the primary purpose of fixing nitrogen as part of a crop fallow. Improved fallows have been introduced more recently in the Lake Victoria region where

agroforestry techniques form a major focus on soil fertility initiatives, to enable the enrichment of a natural fallow with leguminous trees or shrubs (Place et al. 2005; Woomer et al. 2004). These shrubs include *Sesbania sesban, Crotalaria grahamiana* and *Tephrosia vogelii*.

33. Another system, biomass transfer (Nair 1989) is the incorporation into the soil of leafy shrubs, which accumulate high concentration of nutrients in their leafy biomass and mineralize rapidly. It is a form of cut and carry mulching, and shrubs such as *Lantana camara* and *Tithonia diversifolia* are used in this system. In western Kenya, *Tithonia diversifolia* is the most commonly used biomass material because it is readily available, easy to propagate and relatively richer in nutrients. One ton of dry weight of *Tithonia diversifolia* leaves contains an average of 33 kg of nitrogen, 3.1 kg of phosphorous and 30.8 kg of potassium (Mureithi et al. 2002).

Low External-input Farming Systems

34. There are different synonyms used to describe low-input farming technologies which include Alternative Agriculture, Low-Cost External Input Agriculture, Bio-Intensive Agriculture, Sustainable Agriculture and “Permaculture” or LEISA (Low External Input Sustainable Agriculture). In its most extreme form, low-input agriculture is known as organic farming. Organic farming has been defined (Njoroge 1994) as an agricultural system that promotes environmentally sound means of production. Organic farming uses natural methods to keep the soil fertile and also keep crops and livestock healthy. The approach keeps the land productive using materials found on the farm. In conventional farming systems, much effort goes into to bringing chemical inputs and animal feeds from outside the farm, instead of making full use of what is found on the farm. For example, expensive inorganic fertilizers, sprays, vaccines and medicines are used. With the compaction of soil as a result of using heavy machinery more fertilizers and pesticides are required to increase the yield. Owing to the inherent weaknesses of artificially-fed plants, new pests and diseases are emerging all the time and even others commonly found become resistant to pesticides, while beneficial soil organisms get killed. In contrast, the organic farmer puts effort into improving soil fertility through composting, proper cultivation, rotation of crops, mixed planting, growing trees, proper care of crops and animals and the natural control of pests and diseases. Because of the better natural balance, agricultural products are healthier and fetch a much higher price than conventionally grown crops and, in general, ensure good health and environmental safety all around. In East Africa, most farmer innovators practice a certain degree of low-external input agriculture, which is necessary to reduce costs of production and the dependence on “imported” inputs and also to ensure sustainability of the ecosystem.