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Improvement of soil fertility management practices in rainwater harvesting systems

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Organisation

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Abbreviations and Acronyms

ASDS	Agricultural Sector Development Strategy
ASDP	Agricultural Sector Development Programme
CEC	Cation Exchange Capacity
CFC	Common Fund for Commodities
CPR	Common Pool Resources
DADP	District Agricultural Development Programme
DALDO	District Agricultural and Livestock Development Officer
FAO	Food and Agriculture Organization
FEG	Farmer Extension Group
FRG	Farmer Research Group
FYM	Farmyard Manure
GIS	Geographic Information System
GPS	Global Positioning System
INM	Integrated Nutrient Management
ISFM	Integrated Soil Fertility Management
LISF	Local Indicators of Soil Fertility
LISQ	Local Indicators of Soil Quality
M&E	Monitoring and Evaluation
MIFIPRO	Mixed Farming Improvement Programme
NARS	National Agricultural Research Systems
NGO	Non Governmental Organization
NRSP	Natural Resources Systems Programme
PADEP	Participatory Agricultural Development and Empowerment Project
PRSP	Poverty Reduction Strategy Paper
PT	PARCHED-THIRST
RWH	Rainwater Harvesting
SAIPRO	Same Agricultural Improvement Programme
SARI	Selian Agricultural Research Institute
SFM	Soil Fertility Management
SPSS	Statistical Package for Social Sciences
SQMS	Soil Quality Monitoring System
SUA	Sokoine University of Agriculture
SWMRG	Soil-Water Management Research Group
TALP	Tanzania Agriculture and Livestock Policy
TISQ	Technical Indicators for Soil Quality
TIIP	Traditional Irrigation Improvement Programme
WPLL	Western Pare Lowlands
UNIDO	United Nations Industrial Development Organization
URT	United Republic of Tanzania
ZARI	Zonal Agricultural Research Institute

1. Executive Summary

The purpose of the project was to develop and promote improved strategies for integrated management of soil and plant nutrients, which benefit the poor in sub-catchment practicing rainwater harvesting. The project was to achieve this by defining the current status of soil fertility and management strategies under RWH systems; identify and promote sustainable strategies for managing soil and plant nutrient in RWH systems; increase the capacity of stakeholder to plan and provided extension on the strategies for integrated nutrient management and develop and promote mechanisms for transacting information and knowledge under RWH systems.

The project assessed the fertility status of soils using local indicators of soil fertility (LISF), developed soil fertiltiy management options to address the identified problems, strengthened capacity and use of suitable mechanisms for transacting information on integrated nutrient management. The implementation was carried out using participatory processes to tap and incorporate indigenous knowledge and expertise in soil fertility management of farmers and extension staff.

A review of the literature on the fertility status of soils, soils analytical data, fertilizer and manure trials and various crop responses to fertilizers and manures in the Lake, Northern and Eastern Zones of Tanzania was conducted with the purpose of establishing and creating baseline data and information for this project. The data collected indicate that the soils in these zones are of low to medium soil fertility status. Most of the soils were deficient in total nitrogen; had low organic matter contents and some were deficient in plant available phosphorus and potassium. In addition to the above, soil moisture (plant available soil water) was the major constraint to sustainable and increased soil productivity. It was noted from the data and information collected that a wide variety of fertilizer and manure trials for various crops on various soils have been conducted in the target zones and crop response to nitrogen, and to some extent, phosphorus and potassium, were common, confirming the deficient levels of N, P and K in the soils. The responses were however erratic reflecting the diverse conditions under which the trials were conducted. Comparison of the yield data was rather a difficult task and in most cases not realistic. It was further conceived that the soil analysis and fertilizer and manure trials were poorly coordinated and without well set purposes and goals. It was also confirmed that use of N, P and K in soils deficient in these plant nutrients was economical. Specific fertilizer and manure recommendations for various soils, crops, climatic conditions and farming and cropping systems have not been establish, a research gap that needs to be critically addressed in future research projects and undertakings.

The review further confirmed the argument that there are lots of information and data on soil fertility, soils and fertilizer manure trials and responses by crops in the target zones. However, the data is highly fragmented, repetitive, inadequate and disorganized, because most of it has been generated

from harshly planned short-term research projects mostly funded by donor organizations outside Tanzania. It is suggested that, medium to long term research agenda and projects on soil fertility and productivity be established and should be strictly and properly coordinated by the government or an institution appointed and answerable to the government.

With regard to local indicators of soil fertility (LISF), farmers' assessment of soil fertility is based on many qualitative factors rather than nutrient content. For example, indicators used reflect aspects of water availability and retention, vigour of natural vegetation, soil colour and texture, crop yield and appearance of specific plant species. These were divided into three categories namely soil characteristics, types of plants and extent of growth and survival of plants during the dry season and crop yields. Both in Western Pare Lowlands (WPLL) and Maswa district, LISF was based on seven main soil parameters. Some of the soil parameters included soil colour, soil depth, and appearances of cracks in the soils during the dry season and rocks out crops. Through the interpretation of the data the local indicators were all related to the technical attributes of soil fertility, that is the chemical, biological and physical characteristic and properties of the soils. The physical, chemical, and biological attributes of soil fertility influence the contents and availability of plant nutrients and soil moisture. The local indicators of soil fertility and quality are highly arbitrary and qualitative, with no established critical levels and standards as basis for comparisons. Soil analysis revealed that most of land identified by farmers as fertile, was not statistically different from that perceived as infertile in terms of content of plant nutrients. Categorization of soil fertility based on farmers knowledge should, therefore, be backed with scientific input to validate and quantify the various attributes of soil fertility. All the same, local indicator assist in the initial stages of soil sampling and soil mapping and in the development of soil fertility management strategies. Despite the 800km distance between WPLL and Maswa, there was convergence in both target areas in the type of LISF used and their interpretations.

Training workshops were conducted to create awareness, understanding and comprehension of the various aspects of soil fertility and soil fertility management in semi arid areas under rainwater harvesting. Workshop participants included extension staff in the various fields of the agricultural sector and progressive farmers. The training included theoretical presentations, practical skills, practical assignments and group discussion on various aspects of soil fertility and soil fertility evaluation and management. The evaluation of the training course by trainees indicated that the training was a great success and trainees acknowledged that their understanding of the various aspects of soil fertility had been greatly broadened. They suggested that such training should be made more frequent and more extension staff and progressive farmers should be involved. They requested for leaflets, posters, booklets, manuals and even detailed notes and other relevant literature on soil fertility as these would assist them in providing expert advice and serve as reference material. The project team has produced several knoweledge-sharing products in response to this request.

Among the knoweledge-sharing products produced include booklets, manuals, posters and leaflets. Booklets are on (i) soil fertility management options -Annex B13, (ii) plant material sampling and analysis for soil fertility evaluation -Annex B16, (iii) nutrient deficiency symptoms in field crops -Annex B17, (iv) fertilizers and fertilizer application methods -Annex B18 and (v) a manual on methods for participatory assessment of soil fertility status, identification and development of soil fertility management strategies -Annex B2.

The main providers of information on Integrated Nutrient Management (INM) were, research institutions, particularly National Agricultural Research Institutes (NARs) particularly Zonal Agricultural Research Development Institutes, District Agricultural and Livestock Development Offices, NGOs and some of the agricultural inputs suppliers. The NARs were providing information through the production of posters, leaflets and booklets on INM to be used by the extension staff and farmers. Farmer support agencies were facing a number of constraints. For example the Agricultural Research Institutes (ARIs) have limited capacity in terms of funds to support long-term research in INM. Messages on INM that promote and advocate the use of soil amendments are few and rarely focused on RWH systems. In addition, extension workers are few, not adequately trained in INM and inadequately facilitated to render the required services to farmers who are scattered over large areas. Furthermore, the input stockists stock very small amounts of inorganic fertilizer due to limited demand and lack of capital. Additionally, most of the sales persons cannot offer advice to farmers due to lack of knowledge on the use of inputs. This in a way explains the low use of soil amendments in the target areas, thus posing a challenge to future intervention on INM. It was concluded that efforts should be made to (i) produce KSPs required by extension staff on INM, (ii) educate the farmers on the benefits of INM, through on-farm demonstration trials on the effects of manure and fertilizer use in crop production. Given the fact that the quantities of both FYM and compost available are not enough, combined use of organic soil amendments and inorganic fertilizers should be encouraged to optimize agricultural production at reasonable and economic nutrient: crop price ratios. Additionally rotational application of manure, and placement per hill instead of spreading it is will allow small quantities to cover larger areas of cropland.

Chemical analysis of runoff water along the toposequence showed that the content of nutrients in runoff water increased from upstream to downstream areas. This finding in a way support the claims by lowlands farmers that their soils are fertile and therefore they don’t need to apply soil fertility amendments. This belief is unlikely to continue for a long time because the fertile top soils in upstream areas, which are the source of these nutrients, have over time been severely eroded and degraded. Increasingly, downstream areas are currently receiving more deposits of sand than silt and clay or organic debris. This implies that input of nutrient through runoff harvesting is decreasing. For sustainability, appropriate use of organic and inorganic soil amendments should, therefore, be encouraged.

Yield response results from the demonstration plots indicated that application of Urea, FYM and Urea-TSP-FYM increased rice grain yields, compared to those of farmers practice (Annex A, Tables 11 and 12). The observed yields in the demonstration plots under farmer's practices (no addition of soil amendments) 2,353 kg/ha (mean over two seasons) are significantly (P>0.001) higher than the control and base line yields (700 – 1000 kg/ha). The increase is attributed to the efficient use of the harvested rainwater, planting at the appropriate time and control of weeds. The response of rice in terms of grain yields, N, % P and % K contents, plant heights and tillering to Urea, TSP, farmyard manure and a combination of urea-TSP-FYM applied on demonstration plots confirmed the inherent deficiency of N in the soils. The poor response of rice to the applied P as TSP compared to the other plots confirmed the adequacy of inherent phosphorus levels for plant growth in the soils. The significant effect (average yield of 3662 kg/ha) of Urea-TSP-FYM applications against the control (average yield of 2353 kg/ha) is a reflection of the positive effect of INM on soil fertility and uptake of plant nutrients due to nutrient balance in the soils and improvement in the physical, chemical and biological properties of the soils. It can be concluded that, higher yields are realized when there is efficient use of runoff water and adoption of INM.

The most effective methods in transacting and disseminating information were farm visits to farmers' groups by researchers and extension officers and on-farm demonstration of the various soil fertility management practices. These are common methods but they are not fully exploited due to limited funding of research and extension services. A combination of more than one communication approaches was found to be more appropriate in disseminating research findings to farmers than just only one method. It is therefore, recommended that the government and private service providers, who are key players in agricultural development, should invest more in improving communication approaches to ensure that research information and findings reach the targeted users to enhance impact.

2. *Background*

It is estimated that more than 50 % of the land area of Tanzania is arid or semi-arid (LRDC, 1987). The semi-aridity is caused mainly by low amount of rainfall, high evapo-transpiration and erratic temporal and spatial rainfall rates (Nieuwolt, 1973). The main problems encountered in the semi-arid areas are inadequate soil moisture for plant growth and low soil fertility. Rainwater harvesting (RWH) is now a recognized strategy for improving crop and livestock production in the semi-arid areas of Tanzania. Many farmers have developed RWH systems, a process now supported by two major government programmes, namely the Participatory Agriculture Development and Empowerment Programme (PADEP) and the Participatory Irrigation Development Programme (PIDP). However, inadequate understanding of the dynamics of plant nutrients in RWH systems, coupled with low levels of fertilizer use (organic and inorganic), are limiting the productivity of the harvested rainwater, and jeopardizing the sustainability of the systems. Considerable information on soil fertility management (SFM) strategies is available from past research and from indigenous knowledge. Unfortunately, this knowledge has not been fully exploited in the development of SFM strategies for rainwater harvesting. Further the information on IMN is highly fragmented, inconsistent and based on poorly designed and short-term research project data and results.

3. *Project Purpose*

The purpose of the project was to develop and promotes *improved strategies for integrated management of soil and plant nutrients, which benefit the poor in sub-catchment practicing rainwater harvesting***.** The project used existing indigenous and scientific knowledge to develop improved strategies for integrated management of soil and plant nutrient. The aim was to improve the productivity of water by providing extension messages that enable farmers and others stakeholder to make informed decisions on how best to improve the soil and plant nutrient status for improved and sustained soil productivity through the use of appropriate organic and inorganic soil amendments. These strategies would provide farmers with options to exploit fully a variety of market opportunities so as to increase profitability, incomes, and returns to labour. Based on indigenous knowledge and scientific information, methods of integrated soil fertility management (ISFM) affordable by the poor were designed and promoted.

4. *Outputs*

4.1. Results and Findings

The main outputs of this project were: (1) to define the current status of soil fertility and management strategies under RWH systems; (2) to identify and promote sustainable strategies for managing soil and plant nutrient in RWH systems; (3) to increase the capacity of stakeholder to plan and provided extension on the strategies for integrated nutrient management and (4) to develop and promote mechanisms for transacting information and knowledge under RWH systems.

4.1.1. Current status of soil fertility and management strategies under RWH systems

Farmers in both catchments (i.e. Ndala and Makanya River catchments) revealed different local indicators of soil fertility (LISF) as presented in Annex A (section 4.1.2) and Annex B1. Farmers' assessment of soil fertility is based on a combination of factors which reflect aspects of water availability, vigour of natural vegetation, soil colour and texture, moisture retention, presence of salts and crop yield as summarised in Table 1.

Table 1: Local indicators for soil fertility

Fertility Category	*Study site*	
	WPLL (Makanya River Catchment)	*Maswa District (Ndala River Catchment)*
Good (fertile) soil	**Soil colour**: Black deep soils **Soil structure**: visible cracks **Soil texture:** high clay content **Water retention capacity**: low frequency of watering/irrigation; **Plant growth vigour**: vigorous growth of specific plants like wild sisal **Crop yield:** Good crop performance, like maize, millet etc without the use of fertilizers, manures and crop residues **Indicator plants**: presence/vigorous growth of a certain plants or weeds like *Solanum indicum* (*Ndulele*), Cyperus sp (*ndago*), *Cynodon sp*. (*sangari*), presence of green vegetation during dry season;	**Soil colour**: Black soils; deep soils **Soil structure**: presence of friable soils **Soil texture:** high clay content **Water retention capacity**: high moisture content and retention capacity; **Plant growth vigour**: dense plant population with a variety of plant species; vigorous growth of the vegetation **Crop yield**: high crop yields without the use of fertilizers and manure. Continuous cultivation without decline in crop yields **Indicator plants**: presence of specific plants like *"mashibili"* and *"samangombe"*, *"malaba"* on ant hills;
Poor (infertile) soil	**Soil colour:** Red or light sandy soils; **Soil structure:** compacted soils; **Soil texture**: sandy soils: presence of very coarse sands, gravel and stones on the surface. **Water retention capacity:** soils which dry up fast after rains or irrigation; **Plant growth vigour:** poor vegetation even where water is not limiting; **Crop yield:** poor crop performance even with application of fertilizer or manure; **Indicator plants:** presence of specific plants like baobab trees and *Cyperus sp. (ndago), "igulangoji, jangare, mbigiri, (minyaa)"that are mostly weeds*; **Salinity**: presence of white spots or patches on the soil surfaces; presence of salts	**Soil colour:** light colour and red soils **Soil structure:** presence of rocks and stones **Soil texture**: Sandy soils **Water retention capacity:** soils which dry fast **Plant growth vigour:** presence or growth of drought resistant trees; low and sparse plant population; **Crop yield:** low crop yields and **Indicator plants:** presence of specific plants (weeds) like *Cyperus spp (ndase), "magunguli", "hodi", "", Cyperus spp.(ndago), Striga spp (kiduha), Mlenda (makonda)* **Soil depth**: shallow soils

For example, black or dark colours of soils as indicators of good (fertile) soils are reflections of the high amounts of organic matter contents in the soils. These soils are associated with high availability of plant nutrients. Scientifically such soils have high capacities to retain nutrients in exchangeable forms, high moisture retention and storage and source of energy and carbon to soil microorganisms.

With increasing land degradation and limited use of soil amendments there is a decline in soil fertility even in soils regarded as fertile.

Results from the limited soil sampling and analysis showed that nutrient content in all soils perceived as fertile by farmers, were very low in nutrient contents. The fertile and infertile soils as perceived by farmers were therefore not statistically different according to scientific interpretations (Annex A- Tables 6 and 7, and Annex B9). For example total nitrogen in Ndala River catchment, ranged from 0.03 to 0.06 %; while in Makanya River catchment, ranged from 0.01 to 0.3 %. Availability and access to runoff was the main consideration by farmers in classifying soil/land as fertile or infertile. Soil analysis results for Bukangilija village (Figure 1) shows that total N content in class I and II soils is lower than the scientifically accepted threshold levels and thus they qualify to be classified under class III (low fertility).

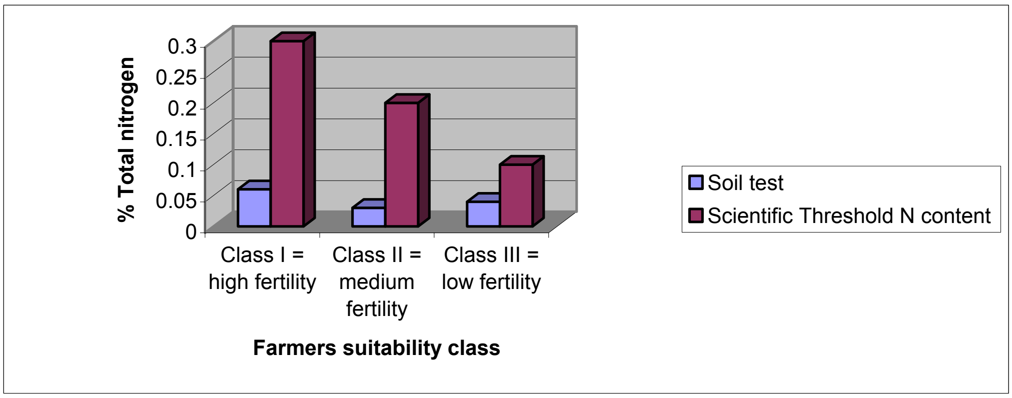

Figure 1: Percentage total nitrogen, farmers' suitability classes against scientific threshold N content for soils in Bukangilija village

The linkage between fertility and water availability by farmers was evident from maps produced during participatory mapping (Annex A- Figures 5 to 8). Land with good access to runoff was classified as fertile and vice versa. Local perceptions also considered the overall performance of a piece of land in terms of crop yield which is a function of desired combinations of the soil physical, chemical and biological attributes as is evident from in Table 1. There is a need, therefore, to introduce simple soil testing kits that can be used by both farmers and extension officers to validate the soil nutrient content. This would assist in advising farmers on suitable soil fertility amendments.

It was established that the content of nutrients in runoff water increases as water moves from upstream to downstream areas (Annex A- section 4.2; Annex B15). This supports the enrichment claims by downstream farmers who rarely use fertilizers. Analysis of soil samples collected during the dry season from fields perceived to be fertile and those regarded as infertile revealed no difference in nutrient content between them (Annex B9 -Tables 5 and 6). This indicates that nutrients originating from runoff water harvested into cropland seem to be utilised by the crop during the same growing season. Farmers also indicated that unlike in the past, runoff water contains more sand than silt and day and organic debris. Thus, increased environmental degradation upstream means that the enrichment process will progressively contribute less nutrients, necessitating the need to use soil fertility amendments.

4.1.2. Sustainable strategies for managing soil and plant nutrients in RWH systems

Indigenous soil fertility enhancement strategies are mostly practiced by farmers and have for a long time sustained the productivity of soils. Some of these include ridging, intercropping, minimum tillage, use of crop residues, application of manures, crop rotation, fallowing, use of ashes from crop residues and deep tillage as discussed in details in Annex B7-section 4.

The locally based practices were combined with scientifically proven options for integrated soil fertility management and packages suitable for the different wealth categories of farmers were developed. Development of ISFM options using participatory processes, considered runoff availability, the type of enterprise, soil type and RWH system (Annex B14- a booklet). The ISFM options include: use of manure, combined application of organic and inorganic nutrient sources, intercropping with leguminous plants to exploit their biological nitrogen fixation, use of indigenous herbaceous species known to have fertilizing effect on soils such as *Vernonia subligera* and *Tithonia diversifolia*, crop rotation and use of improved fallow involving leguminous species, mulching to minimize evaporation losses and maintain suitable soil temperature and structure hence reduced surface run-off and soil erosion, choice of crop to match the prevailing local conditions including use of crops sharing different niches, as this will ensure better nutrient exploitation, use of appropriate tillage operations, and use of acid forming fertilizers such as sulphate of ammonia or salt and alkaline tolerated crops in areas where the soils are saline, saline-sodic or sodic.

A combination of the afore-mentioned ISFM options suitable for different farmer wealth categories, runoff availability, cropping enterprises, RWH systems and soil types are shown in Tables 2 and 3. This information is drawn from a booklet designed to promote ISFM (Annex B14).

Table 2: ISFM options for maize-beans cropping system on *mthau mnkhundu* and *Ngamba* soil type in WPLL

Locations and soil types	RWH system	Runoff availability	Farmer category	ISFM options
UPPER SLOPE, MTHAU MNKHUNDU (Red`soils Oxisols)	Insitu	Adequate	Poor	Crop residues, green manure (weeds), intercropping, crop rotation
			Rich	FYM, crop residues, green manure (weeds), intercropping, crop rotation
		Inadequate	Poor	Crop residues, green manure (weeds), intercropping, crop rotation
			Rich	FYM, crop residues, green manure (weeds), intercropping, crop rotation
	Sheet flow diversion	Adequate	Poor	Crop residues, green manure (weeds), intercropping, crop rotation
			Rich	Crop residues, green manure (weeds), intercropping, crop rotation
		Inadequate	Poor	FYM, crop residues, green manure (weeds), intercropping, crop rotation
			Rich	FYM, crop residues, green manure (weeds), intercropping, crop rotation
LOWER SLOPE NGAMBA (Black soils Vertisols)	Runoff diversion	Adequate	Poor	FYM, Rotation, intercropping, minimize sand deposition
		Inadequate	Rich	FYM, Rotation, intercropping

Table 3: ISFM options for rice-based cropping system on *itogoro-ibambasi* and m*buga* soil types in Maswa

Location	RWH system	Soil type (local)	Farmer category	ISFM options
UPPER SLOPES	Insitu	Itogoro-Ibambasi	Poor	FYM, crop residues (burn and spread ashes)
			Rich	FYM, inorganic fertilizer
	Sheet flow diversion	Itogoro-Ibambasi	Poor	FYM, crop residues (burn and spread ashes)
			Rich	FYM, inorganic fertilizer
LOWER SLOPES	Insitu	Mbuga	Poor	FYM, crop residues (burn and spread ashes)
			Rich	FYM, rotation, intercropping, green manure, inorganic fertilizer
	Sheet flow diversion	Mbuga	Poor	FYM, crop residues (burn and spread ashes)
			Rich	FYM, rotation, intercropping, green manure, inorganic fertilizer

Combined use of inorganic and organic sources of plant nutrients has proved to be the most appropriate soil fertility management strategy in semi-arid-areas under RWH-system (Annex B). This is because this strategy takes into account the wealth status of the smallholder farmers in the acquisition of the plant nutrient-sources, and the physical, chemical and biological attribute of soil fertility.

Demonstration on the use of manure and other inorganic amendments was carried out in Maswa to verify some of the options proposed. Results indicated that application of Urea, FYM and Urea-TSP-FYM significantly increased rice grain yields, compared to those of farmers practice (taken as the control) (Appendix 1 and 2 in Annex A). The current rice average yield in Bukangilija village ranges from 700 to 1000 kg/ha and expected yields under appropriate soil fertility management and rainwater harvesting ranged between 5000 – 7000 kg/ha (SWMRG, 2003). The observed yields on the demonstration fields under farmers' practices (with no addition of soil amendments) varied from 2,345 to 2361kg/ha (Table 4), these are higher than the base line yields of 700 – 1000 kg/ha (Annex B12- section 3.2; and tables 2 and 3).

Table 4: Response of Rice to N, P and FYM application (2002/2003 and 2003/2004) seasons at Bukangilija, Njiapanda and Isulilo villages, Maswa, District, Tanzania

	ISFM options (Treatments)	Yield (kg/ha) 2002/2003	Yield (kg/ha) 2003/2004
1	Urea (40 kg N/ha)	3020 b	3184 b
2	Urea+ TSP+ FYM (20 kg N/ha, 15 kg TSP, 3.5 tons FYM/ha)	3642 a	3681 a
3	TSP (30kg P/ha)	2345 c	2688 c
4	FYM (7 ton/ha)	2580 bc	2885 c
5	None (Farmers practice)	2345 c	2361 d
	CV %	12.05	10.89
	LSD	517.42	265.225
	F Test	***	***

The responses of rice in terms of grain yield to Urea, TSP, farmyard manure and a combination of urea-TSP-FYM applied on demonstration plots confirmed the inherent deficiency of N in the soils as was revealed by soil analysis. The poor response of rice to the applied P as TSP compared to the other treatments confirms the adequacy of the inherent phosphorus levels for plant growth in the soils. The significant effect of Urea-TSP-FYM applications on yield is a reflection of the positive effect or advantages of INM on soil fertility and uptake of plant nutrients due to nutrient balance in the soils and possibly their improvement in the physical, chemical and biological properties. The increase is also attributed to some extent, to the efficient use of harvested rainwater, planting at the appropriate time and control of weeds following interventions by the support agencies and comprehension by farmers. This is evident from the monitoring and evaluation data where increased use of soil amendments like FYM manures by 24, 6, and 10 percent for Bukangilija, Makanya and Njiapanda respectively were recorded/ attained. For the same villages, use of compost increased by 5, 32, and 14 percent respectively (Annex B5-Table 1).

4.1.3. Capacity of stakeholders to plan and provide extension on strategies for integrated nutrient management

Farmer's support agents in dissemination of agricultural technologies in the target catchments were identified. These include villages extension and district extension officers/ staff; private service providers such as input stockists and traders and NGOs. Zonal Agricultural Research Institutes (ZARIs) have the mandate to provide technological information. Within the study areas these include Ukiriguru Agricultural Research Institute based in Mwanza in the Lake zone and Selian Agricultural Research Institute (SARI) based in Arusha in the Northern zone.

Assessment of the capacity and performance of these farmer support agencies revealed that with the exception of the researchers from the ZARIs, the rest have limited knowledge in INM. It was also found out that district extension staff own most agro-inputs shops (Annex 11, section 3.6, para 2). However, the sales persons have limited agricultural knowledge, thus lacked technical capacity to advice farmers on INM. There is a need, therefore, to develop capacity of these agencies.

Different mechanisms were used to develop capacity of support agencies for transacting information to support farmers in making decisions on the use of soil fertility amendments. Awareness creation seminars and workshops were conducted for policy makers at district and national level (Annex 3 and 8). These were envisaged to influence policy and the planning process so that strategies can be formulated with pro-poor focus. The research team facilitated training of extension service providers at village levels to create a common understanding of the concepts of integrated soil fertility management. Training of extension agents emphasised imparting knowledge and skills in soil sampling and analysis, soil fertility assessment using local indicators of soil fertility and participatory mapping. In summary the following training, field visits and workshops were carried out successfully;

- Twenty three extension staff (12 in Maswa and 11 in WPLL target areas) were trained on LISF, soil sampling and participatory mapping
- Ten young farmers (five male and five female) from Maswa visited PIDP irrigation schemes in Shinyanga and Tabora to study issues related to water management and soil fertility in rice production.
- Two workshops were conducted in WPLL and Maswa target areas to District Councillors and districts leaders (63 in Maswa and 40 in WPLL) on aspects of soil fertility management and participatory mapping.

The critical issues for soil and plant nutrients management were identified and communication products were produced to support farmer support agencies in information transaction. The knowledge sharing products that were produced include the following:

- Methods for participatory assessment of soil fertility status, identification and development of soil fertility management strategies (Manual)-Annex B2
- Soil fertility management options (booklet) -Annex B13
- Plant material sampling and analysis for soil fertility evaluation (booklet) -Annex B16.
- Fertilizers and fertilizer application methods (booklet) Annex B18.
- Nutrient deficiency symptoms in field crops (booklet) Annex B17.
- Manual on soil sampling for fertility evaluation (booklet) Annex B19.
- Preparation of good quality manure (booklet) Annex B20.
- Inorganic fertiliser (poster), Annex B21.
- Manures (poster) Annex B22
- Soil fertility management strategies for rice and maize under RWH systems (leaflet), Annex B23.

Stakeholders suggested that future training sessions should combine both farmers and extension staff so that they could share knowledge and experience in soil fertility management. It was also realised and concluded that understanding of indigenous knowledge and use of participatory approaches was essential in the designing and development of appropriate and sustainable soil fertility management strategies.

4.1.4. Mechanisms for transacting information (Ref Annex B14)

The existing communication methods and media for the dissemination of soil fertility management strategies/practices in the study areas include farm visits by extension staff and researchers, fertilizer and manure demonstrations trials meetings (farmer groups or village meetings); study tours, written materials such as booklets, posters and leaflets, etc. (Figure 2).

Assessment of the different methods/media used to transact information on agricultural aspects revealed that farm visits, demonstrations and meetings were rated as the most common, appropriate and effective communication methods for transacting information and research findings to smallholder farmers (Figure 3). These communication methods were perceived as more interactive and responsive to the immediate needs and aspirations of the smallholder farmers. Low preference of written materials like books, leaflets, booklets and posters as communication methods may be attributed to the non availability of the books, booklet and leaflets and the inability of some of the smallholder farmers to read and write.

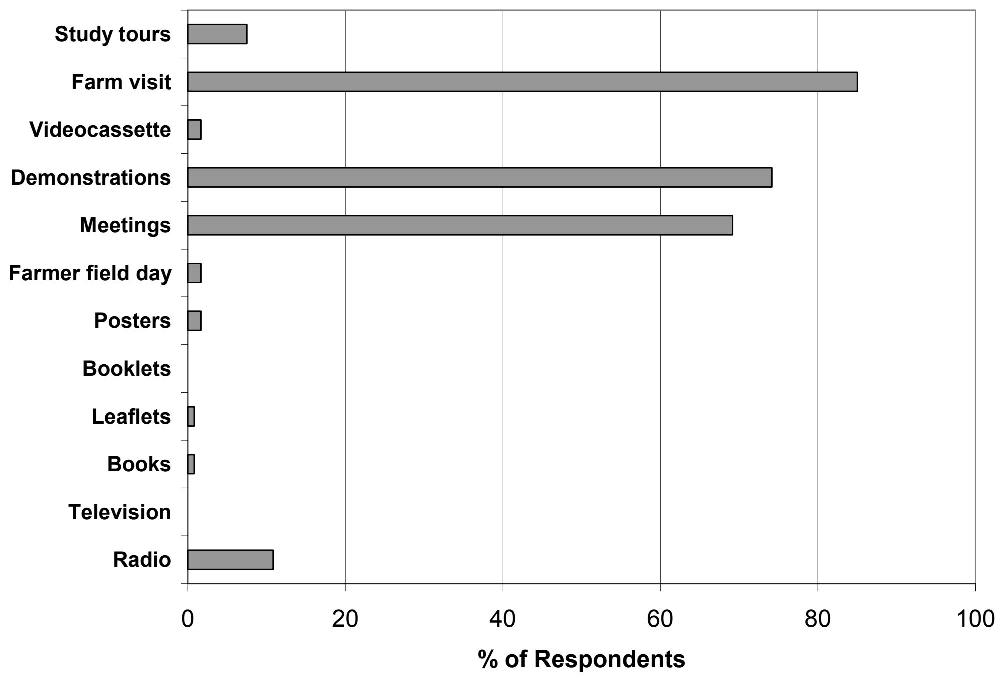

Figure 2: Existing communication methods in the study areas

Against expectations, popularly used radio was rated low by farmers as a media of communication compared to others. Farmers' felt that this is a one-way communication method since they can't get immediate responses in case they have questions. In addition, farmers admitted that currently there are many broadcasting stations that have music programmes that attract many people especially the youths. Agricultural shows and campaigns were reported to be very expensive to conduct and have turned out to be more of social occasions than opportunities for learning.

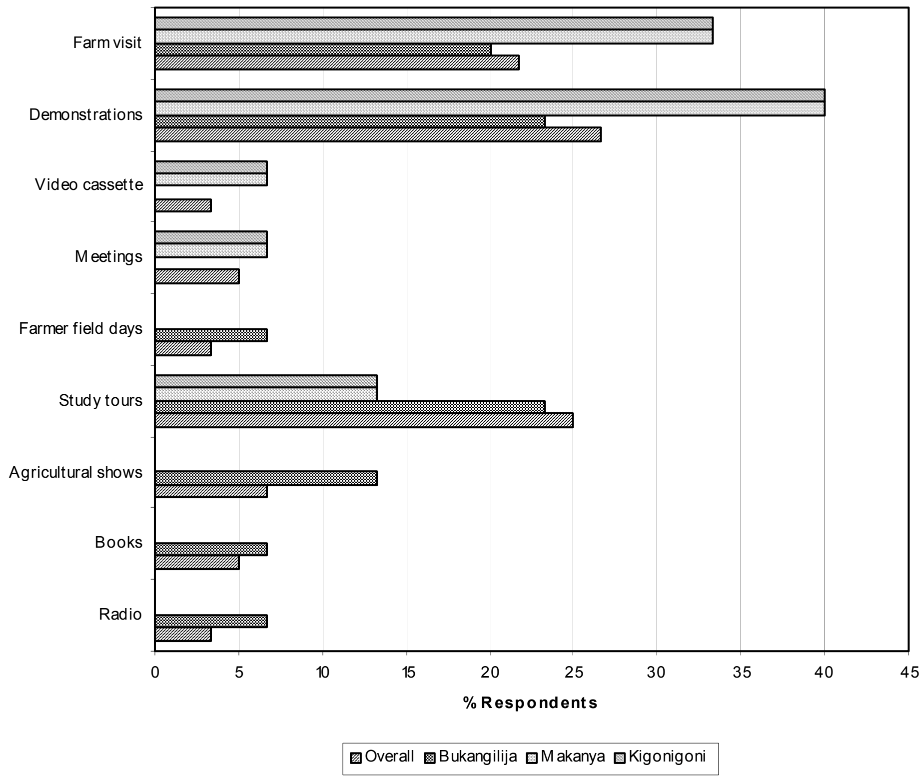

Figure 3: Effective communication methods as identified by farmers in study villages

Study tours and farmer field days as communication methods were not used frequently because of the cost implications in organization and implementation. The government funding for extension activities has been declining over the years limiting activities and approaches that could be undertaken. The unpopularity of television and videos as communication media is due to the fact that very few smallholder farmers can afford television set and videocassettes. Moreover, electricity has not reached all rural areas.

In summary, the current communication methods identified as effective are not fully exploited and not delivering required information on soil fertility management (Annex A-section 4.5; Annex 11 and 14). Reasons include inadequate packaging of messages appropriate and specific to different areas; inadequate number of extension officers in the villages; inadequate communication skills and under funding of communication activities. It is, therefore, recommended that the government and private service providers, who are key players in agricultural development, should invest more in improving communication approaches to ensure that research findings reach the targeted users to enhance impact.

5. Research Activities

The activities listed in the project log frame were carried out in order to achieve the project outputs. A brief description of the methods used is as presented in the following subsections.

5.1 Activities 1.1 to 1.4 for Output 1

Identification of local indicators of soil fertility was conducted using participatory processes involving selected farmers and extension staff. Selection of farmers was based on agreed criteria that included gender; age; wealth status; positions of their farms on the landscape (catchments); type of enterprises; types of crops cultivated and the type of RWH systems used. Based on these criteria, 45 farmers were selected in WPLL, and 50 in Maswa district. Participatory methods used include focus group discussions, key informants' discussions; transect walks, participant observations and participatory mapping (Annex B1).

Some limited fieldwork were undertaken to verify some the information and data gathered during the discussions and interviews. Criteria such as amount and frequency of receiving runoff, presence of water sources, distance from water source, vegetation type/species and crop yields were used to define cropland suitability classes (Annex A-section 4.1.1, Table 5).

The scientific soil fertility evaluation involved limited soil sampling and analysis. Soil sampling was based on perceived soil fertility classes identified in the participatory mapping. In each soil class composite soil samples were taken at 0-30 cm depth. Soil parameters analysed included pH, organic carbon, total nitrogen, available phosphorus, CEC, particle size distribution and micronutrient (Zn and Cu) using standard methods (Annex A). The analytical data generated were compared with the farmers' perceptions (Annex A-section 4.1.2, Tables 6 and 7).

Geostatistics was used to describe and map spatial patterns of the soils based on the nutrient analysed. Based on soil properties and GPS coordinates, soil fertility spatial pattern maps were generated using ArcView GIS software and geostatistical analyst extension (Annex B6 and Annex B15-an MSc. Dissertation).

A case study to assess the role of macro-catchment on soil fertility variability along the toposequence was carried out in Makanya River catchment. Tae village located in the upstream, Mwembe village in the midstream and Makanya village downstream were chosen as sites for data collection. A participatory reconnaissance survey was carried out in the three villages for areas representing crop fields in each of the perceived land suitability class (Annex A-Figures 3 to 8; Annex B6). Soil and runoff samples were collected for laboratory analysis. The detailed information is presented in Annex B15-an MSc. Dissertation.

5.2 Activities 2.1, 2.2, and 2.4 for Output 2

The identification of soil fertility management options suitable under different RWH systems was made based on the local and scientific indicators of soil fertility. Group discussions between researchers and farmers from different socio-economic categories were carried out to design the best soil fertility management strategies.

Selected ISFM options were demonstrated in three villages in the Ndala River catchment. Three farmers from Bukangilija, three from Njiapanda and two from Isulilo were requested to avail 0.5 ha each of their farms for demonstrations. Integrated soil fertility management (ISFM) options tested include the following:

(i) Option 1: Urea (40kgN/ha)
(ii) Option 2: Urea (20kgN/ha), TSP (15 kg P/ha) and FYM (3.5 ton/ha)
(iii) Option 3: A control without any soil fertility amendment.
(iv) Option 4: TSP (30kgP/ha)
(v) Option 5: FYM (7tons/ha)

Agronomic practices such as planting time, water management, and weeding and pest control were adhered to during the growing cycle of the rice crop. Yield data collected include plant height, number of tillers per hill, dry matter and contents of N, P, and K in plant material using standard methods (Annex B12). The increases in yield were in the order Option 2> Option 1> Option 5> Option 4 > control treatments in terms of rice drymatter and grain (Annex A, Tables 11 and 12). A baseline survey was conducted at the beginning of the project in 2002, followed by monitoring and evaluation (M&E) to assess changes in use of the soil amendments, in crop production (Annex A, section 4.3.4). Yield response results from the demonstration plots in indicated that application of Urea, FYM and Urea-TSP-FYM increased rice grain yields, compared to those of farmers practice (Appendix 12 Tables 2 and 3). The current rice production in Maswa district and in particular at Bukangilija village ranges from 700 to 1000 kg/ha and the expected yields under appropriate soil fertility management under rainwater harvesting ranged between 5000 – 7000 kg/ha (SWMRG, 2002). The observed yields in the demonstration plots under farmer's practices (no addition of soil amendments) 2,353 kg/ha (mean over two seasons) are significantly (P>0.001) higher than the control and base line yields (700 – 1000 kg/ha). The increase is attributed to the efficient use of the harvested rainwater, planting at the appropriate time and control of weeds.

5.3 Activities 3.1 to 3.3 for Output 3

Assessment of the capacity and performance of farmers' support agencies in the target districts involved focused group discussions with farmers, extension staff and NARS researchers. A checklist was designed to facilitate collection of information and data on sources of information, needs for capacity building and communication products required to improve efficiency in supporting farmers.

Two workshops were conducted to raise awareness of District Councillors and leaders (63 in Maswa and 40 in WPLL) on aspects of soil fertility management and participatory mapping. These workshops also involved Members of Parliaments, NGOs and Private service providers. Consultation meetings were also held with individual district officials including policy makers and planners for Maswa, Mwanga and Same districts.

A one-day workshop was also conducted at the Ministry of Agriculture and Food Security (MAFS) headquarters. Directors and Assistant Directors from the Department of Research and Development, Irrigation and Technical Services, Special Research Programme (responsible for natural resource management, research, policy and planning) participated. The aim of the workshop was to create awareness on the RWH potential, constraints and the need for supporting farmers in the process of scaling up. The trainees suggested that such trainings should be made more frequent and more extension staff and progressive farmers should be involved. They at the end requested for leaflets, posters, booklets, manuals and even detailed notes and other relevant literature on soil fertility as these tools would assist them in providing experts advice and to serve as reference material. Knoweledge sharing products (KSPs) produced in response to this request are listed above in section 4.1.3.

Two days training of village extension staff (12 in Maswa and 11 in WPLL target areas) were organised in WPLL and Maswa district. In collaboration with district officials, trainees were identified from the target villages. Training on LISF covered aspects of participatory mapping and soil sampling, which are key issues in ISFM. The details are presented in Annex B3.

5.4 Activities 4.1 to 4.3 for Output 4

Surveys were carried out to collect information on sources and transaction mechanisms of soil fertility management technologies. Interviews were conducted using both structured and semi-structured questionnaires. Sixty smallholder farmers were selected from the study areas and interviewed. The primary data were coded and analysed.

Baseline survey to monitor extent of change of farmers' strategies for managing soils and plant nutrient and use of different sources of information was carried out in the target villages. The survey involved 204 households in Maswa and 100 households in WPLL. These were selected randomly. The data was analysed and formed the basis of comparison of first monitoring and evaluation survey/study conducted in July 2004. A detailed account is given in Annex B5, and Annex A-section 4.5.2-Table 14.

6. Environmental assessment

6.1 What significant environmental impacts resulted from the research activities (both positive and negative)

Increased use of inorganic fertiliser amendments was observed in WPLL (Annex B5), but the extent of use is comparatively still low. Negative impact known to originate from the use of inorganic fertilisers on water quality is thus unlikely. Similarly, use of organic amendments increased especially in Maswa district. Use of organic amendments is known to improve soil structure and water retention capacity. Further, the increase in the number of farmers practicing RWH is expected to reduce 'fugitive' runoff, and hence reduce soil erosion and sedimentation in large water bodies like Lake Victoria and Pangani River Basins. However when infield methods for control of runoff are not well planned it may cause over harvesting that may results in sand deposition in farm fields.

6.2 What will be the potential significant environmental impacts (both positive and negative) of widespread dissemination and application of research findings?

Widespread use of inorganic fertilizer amendments may result in increased concentration of N in water sources in future, which is known to have health hazards. Promotion of such technologies needs to be accompanied with information on the correct combination and use to reduce any likely negative effect on the environment.

6.3 Has there been evidence during the project's life of what is described in Section 6.2 and how were these impacts detected and monitored?

None.

6.4 What follow up action, if any, is recommended?

None.

7. Contribution of Outputs

7.1 Contribution of outputs towards NRSP purpose

The NRSP's purpose aimed at developing and promoting strategies for improving the livelihoods of poor people, by increasing the productivity of water in rainfed agriculture, through the use of appropriate RWH and/or soil nutrient management practices in target areas. The project contributed towards this purpose through (i) Productivity of water through proper combination of inputs was defined (see section 5.2 above) (ii) Feasible strategies for improving ISFM for different categories of farmers were designed (see Annex B14), (iii) development and promotion of ISFM packages through KSPs to different categories of stakeholders (see section 4.1.3, para 4 above) (iv) items (i) to (iii) form a good linkage (are inputs to) with on-going Government programs specifically Agricultural Sector Development Programme (ASDP), Participatory Agricultural Development and Empowerment Project (PADEP), District Agricultural Development Programmes (DADPs) (v) production of GIS based maps on cropland suitability and (vi) identification of the most effective transaction methods for ISFM. The attainment at purpose levels is presented in the following section.

7.2 Attainment of OVIs at Purpose Level

OVI 1: *By 2003, District Agricultural Development Programmes (DADPs) for implementing ASDS in at least two districts, contain a comprehensive component for integrated soil and plant nutrient management.*

Presence of soil fertility management amendments existed among the many extension messages disseminated to farmers even before the current interventions. These included use of farmyard manure, compost and inorganic fertilisers. Deficiencies in the capacity and performance of farmer support agencies limited wider adoption of these innovations. Enhanced capacity of district leaders and farmer support agencies through awareness raising, development and promotion of knowledge sharing products led to its integration in DADPs in the target districts (Maswa and Same).

OVI 2: *By December 2004 extension messages delivered to farmers by extension agents and other farmers support agencies in at least one district, contain 15% more aspects of integrated management of soil and plant management as compared to the situation in 2002.*

The increase in number of farmers using FYM and compost was 24% and 5% respectively in Bukangilija village in Maswa district. In Makanya village Same District, there was an increase in use of FYM and compost by 6% and 32% respectively against the baseline (Annex B5). The increase in the use of organic soil amendments may be attributed to the increased in number of messages transacted to farmers by extension agents trained by SWMRG (see Annex A, section 4.3.4, Table 13). Furthermore, communication products produced by SWMRG and distributed to farmers and other farmer support agencies have increased the acceptance on the importance and usefulness of organic and in organic soil amendments in enhancing and sustaining soil fertility and productivity.

There was an increase in the extent of use of farmers support agencies on ISFM by farmers. The increase in the number of farmers in/ on contact with researchers is on average 16% in WPLL and 3% in Maswa; while other farmers support institutions (NGOs) registered an increase of 11% and 9% in Maswa and WPLL respectively. Support from extension agents also increased by 25% in Same district (Annex A-section 4.5.2, Annex B5). This may be due to increased interaction between researchers and extension agents in the target area.

OVI 3: *By 2005 in the target districts for different categories of farmers as a result of improved availability of information and knowledge and against 2002 baseline levels of utilization of organic and inorganic fertilizers is increased by: 25% in farm using in-situ RWH techniques; 15% in farms using macro-catchment RWH techniques without storage reservoirs and 10% in farms using macro-catchment RWH techniques with storage reservoirs for supplementary irrigation.*

Baseline information revealed that on average only 10% of farmers in Maswa district were not practicing RWH, while in WPLL there were no farmers not using any form of RWH techniques. The follow up survey indicated that all farmers in Maswa are now practicing one form or a combination of RWH techniques (Annex B5). Use of animal traction in land preparation in Maswa is a common practice; hence in-situ RWH (increased infiltration) is wide spread in the district. There was an increase in the number of farmers practicing macro RWH without storage (e.g. bunded basins). The increase was from 16 to 27 percent from the baseline data (Annex B5). The increase in the number of farmers using harvested rainwater by bunded basins was attributed to the observed use efficiency of the harvested rainwater in rice production. Rice is a multipurpose crop used both as food and cash crop. It is almost replacing cotton, which was a traditional cash crop in Sukumaland.

In WPLL, the amount of rainfall is very low such that without practicing RWH farmers would not harvesting any crop. Adoption of macro RWH systems like individually owned charco dams have increased in Makanya village from nil to 46. These are used for vegetable gardens and livestock. Investments in construction and rehabilitation of ndiva to increase the capacity to hold more water are also on the increase. At least three ndivas have been rehabilitated and increased in size in the last three years in Tae (Indini ndiva), in Mwembe (Makafara ndiva) and Bangalala (Manoo ndiva).

The observation that all the farmers in Maswa and WPLL are harvesting rainwater for agricultural activities indicates the importance of rainwater harvesting in semi-arid areas. There is also adoption of Chinese type of underground tanks known as ‘Sausage tanks’ that are used for vegetable production as a result of interventions by other institutions like RELMA and SASAKAWA Global 2000. Farmers have demonstrated that by capitalizing on harvested rainwater agricultural productivity could be enhanced and sustained in semi arid areas where soil water is the major constraint to agricultural production.

This increase is as a result of the training, awareness raising and sensitisation of farmers by the SWMRG and other institutions on the importance of RWH and the consequent increase in crop production. Detailed information is presented in Annex B5.

8. Publication and other communication materials

8.1 Books and book chapters

None

8.2 Journal articles

8.2.1 Peer review and published

None

8.2.2 Pending publication (in press)

None

8.2.3 Drafted

None

8.2.4 Institutional Report Series

None

8.4 Symposium, conference and workshop papers and posters

- Kajiru, G.J.; Mrema, J.P.; Mbilinyi, B.P.; Rwehumbiza, F.B.; Hatibu, N. Mowo, J.G. and Mahoo H.F. (2005) Assessment of soil fertility Status under Rainwater Harvesting Systems on the Ndala River Catchment Northwest Tanzania: Farmers' versus Scientific Approaches. Paper presented at the East African River Basin Management Workshop, ICE, SUA Morogoro Tanzania 7-9th March 2005. 16pp
- Ludovick, R.A., B.P. Mbilinyi, J.P.Mrema. 2005. Spatial variability of soil fertility under rainwater harvesting systems along the catchment toposequence. Proceedings of Tanzania Society of Agricultural Engineering Vol. 9. Pp 122 – 126.
- Kajiru, G. J., Mrema, J.P., Rwehumbiza F. B and N. Hatibu (2004). Evaluation of the fertility status of the soils on the Ndala river catchment Maswa district for rice production under rainwater harvesting systems. Proceeding of the soil science society of East Africa-Vol. 22 (in press).

- Ludovick, R. A., B. P. Mbilinyi, and J. P. Mrema (2004) spatial variability of some soil fertility attributes, patterns and management practices under rainwater harvesting in the Makanya River catchment Tanzania, Proceedings of the Soil Science Society of East Africa. Vol22 (in press.)

8.5 Newsletter articles

None

8.6 Academic Theses Report Series

- Mshana, M.M. (2004). An assessment of the effective communication mechanisms to disseminate agricultural research findings to peasants in semi-arid areas in Tanzania: A case study of rainwater harvesting researches in Makanya, Kigonigoni and Bukangilija villages. Unpublished MA Dissertation, Mzumbe University, Morogoro, Tanzania. 76 pp (Annex B14).
- Ludovick, R.A. (2004). Assessment of spatial and temporal variability of soil fertility under rainwater harvesting systems: A case study of Makanya river catchment. Unpublished MSc Dissertation, Sokoine University of Agriculture. Morogoro, Tanzania. 121 pp (Annex B15).

8.7 Extension leaflets, brochures, policy briefs and posters

- SWMRG 2005). Soil fertility management options (booklet) -Annex B13
- SWMRG 2005). Plant material sampling and analysis for soil fertility evaluation (booklet) - Annex B16.
- SWMRG 2005). Nutrient deficiency symptoms in field crops (booklet) Annex B17.
- SWMRG 2005). Fertilizers and fertilizer application methods (booklet) Annex B18.
- SWMRG 2005). Manures (poster)
- SWMRG (2005) Soil Fertility Management Strategies for Rice and Maize under Rainwater Harvesting Systems. SUA, Morogoro. 2 pp (Leaflet).
- SWMRG (2005). Preparation of Good Quality Manure SUA, Morogoro. (Booklet)
- SWMRG (2005). Inorganic fertiliser. SUA, Morogoro 1 pp (poster).

8.8 Manuals and guidelines

- SWMRG (2005). Manual on Soil Sampling for Soil Fertility Evaluation SUA, Morogoro. 21pp
- SWMRG (2003) A manual on Procedures and Methods for participatory assessment of Soil fertility status, Identification and Development of soil Fertility Management strategies. - Annex B2

8.9 Media presentations (videos, web sites, TV, radio, interviews etc)

- BBC (2003). Gathering in the Rain: communicating RWH in Tanzania and beyond. BBC Radio programme. (Cassettes and CDs).

8.10 Report and data record

None

8.10.1 Project technical report including project internal workshop papers and proceedings

SWMRG (2003). Local Indicators of Soil Fertility (LISF) in Maswa and Same Districts, Tanzania. SUA. Morogoro, Tanzania. 16pp

SWMRG (2003). A manual on procedures and methods- Participatory assessment of soil fertility status, identification and development of soil fertility management strategies/options SUA. Morogoro, Tanzania. 14pp

SWMRG (2003). Training of Extension Staff and Agents in Maswa and West Pare Lowlands on Local Indicators of Soil Fertility, Soil Sampling and Participatory Mapping. SUA. Morogoro, Tanzania. 15pp

SWMRG (2003). Extent of RWH in Maswa District. Database. SUA. Morogoro, Tanzania. 29pp

SWMRG (2003). Extent of RWH in Western Pare Lowlands of Same and Mwanga Districts. Database. SUA. Morogoro, Tanzania. 26pp

SWMRG (2003). Monitoring and evaluation framework baseline data and information for Maswa and Same districts. SUA. Morogoro, Tanzania. 20pp

SWMRG (2004). Mapping Suitability of Common Pool Resources, Land Tenure Systems and Land Use Conversion: A Combination of GIS and Participatory Approaches. SUA. Morogoro, Tanzania. 38pp.

SWMRG (2003). Local Strategies of Soil Fertility Management and their Impacts on Soil Fertility and Productivity. SUA. Morogoro, Tanzania. 12pp.

SWMRG(2003). Needs for Training, Awareness and Information. SUA, Morogoro, Tanzania. 8pp.

Bugress, R. and Sayed. A. (2003) ADELPHI vs VISUAL BASIC. Nottingham University, UK. 16pp.

Bugress, R. and Sayed, A. (2003). NUTRIENT Pointers. Nottingham University, UK. 14pp.

SWMRG (2004). Soil fertility status and response of various crops to inorganic fertilisers and manures in the Lake, Northern and Eastern zones of Tanzania, SUA, Morogoro. 51pp

SWMRG, (2004). Capacity and performance of farmer support agencies in supporting agricultural technological dissemination. SUA, Morogoro, Tanzania.

SWMRG, (2005). The first update of monitoring and evaluation of adoption of innovations and changes with reference to the baseline data for project R 8115. SUA, Morogoro, Tanzania. 18pp

SWMRG (2005). Effects of nitrogen phosphorus and farmyard manure on rice growth under rainwater harvesting in semi-arid areas of Maswa district, Tanzania. SUA, Morogoro, Tanzania. 23pp

8.10.2 Literature reviews

SWMRG (2003). Soil Sampling, and Analysis for Soil Fertility Evaluation (Nutrient Database) of the Soils From WPLL and Maswa Districts. SUA. Morogoro, Tanzania. 19pp.

SWMRG (2004) Review of the Soil Fertility Status and Response of Various Crop to Inorganic Fertilizers and Manures in the lake, Northern and East Zones of Tanzania. (Annex B11)

8.10.3 Scoping studies

None

8.10.4 Datasets

None

8.10.5 Project web site, and/ or other project related web addresses

http://www.suanet.ac.tz/swmrg

9. *References cited in the report, sections 1-7*

Land Resources Development Center (LRDC) 1987. Tanzania: Profile of agricultural potentials NRI, London. 26pp.

Nieuwolt, S. 1973. Rainfall and evaporation in Tanzania. BRALUP Research paper No.24, University of Dar es Salaam.47 pp

SWMRG (2003). Monitoring and evaluation framework baseline data and information for Maswa and Same districts. SUA. Morogoro, Tanzania. 20pp

.

10. *Project log frame*

RD1 – CN01/009	**PS ref.: 1.3.1(e)**

Narrative summary	**Objectively verifiable indicators**	**Means of verification**	**Important assumptions**
Goal			
SA Output 1 Strategies that can improve the livelihoods of the poor living in semi-arid areas through improved integrated management of natural resources under varying tenure systems **Developed** and **Promoted**	By 2002, livelihood strategies of poor individuals, households and communities and the nature of their dependence on the NR base, including the relative importance of access to common pool resources, in target areas in at least 2 target countries, understood. By 2005, strategies for improving the livelihoods of poor people, by increasing the productivity of water in rainfed agriculture, through the use of appropriate rainwater harvesting and/or soil nutrient management practices, developed and promoted in target areas in at least two target countries. By 2005, strategies that improve access to common pool resources by the poor under the most appropriate tenure and management regime identified, tested and promoted in at least one target area in each of 2 target countries	Reviews by programme manager Reports of research team and collaborati ng /target institutions	
Purpose			
Improved strategies for integrated management of soil and plant nutrients, which benefit the poor in sub-catchment practising rainwater harvesting **Developed** and **Promoted**	By 2003, District Agricultural Development Programs (DADP) for implementing ASDS in at least two districts, contain a comprehensive component for integrated soil and plant nutrient management By December 2004, extension messages delivered to the farmers by Extension	Approved DADP Documents Reports and records of activities of different	The Agricultural Sector Development Strategy (ASDS) and Rural Development Strategy

	Agents and other farmers' support agents in at least one district, contain 15% more aspects of integrated management of soil and plant nutrients as compared to the situation in 2002 By 2005, in the target districts, for different categories of farmers, as a result of improved availability of information and knowledge and against (2002) baseline levels of utilisation of organic and inorganic fertilisers is increased by: • 25% in farms using in-situ RWH techniques • 15% in farms using macro-catchment RWH techniques without storage reservoirs • 10% in farms using macro-catchment RWH techniques with storage reservoirs for supplementary irrigation	Extension Agents Reports from District Agricultura l Developme nt Offices (DALDO) Sale records of fertiliser stockist NRSP impact assessment report	(RDS) are implemented as planned to create an enabling environment
Outputs			
1. Current status of soil fertility and management strategies under RWH systems **Defined**	By September 2004, a database of spatial and temporal variations in soil fertility patterns and management strategies included in GIS, in at least one district	Database available	RWH systems for ensuring adequate soil-moisture are continued and improved
2. Sustainable strategies for managing soil and plant nutrients in RWH systems, which take account of circumstances of different categories of farmers **Identified**, **Verified** and **Promoted**	By June 2004, communication products on improved strategies for soil and plant nutrient management tailored to specific categories of RWH users, distributed and accessible to extension agents and other farmers' support agents in target districts	Project monitoring and evaluation reports	
3. Capacity of stakeholders (GO, NGOs and PVOs) who are active in extension, to plan and provide extension on strategies for integrated nutrient management, that address the needs of the poor, **Increased**	By March 2004, number of farmers in each category, who acknowledge to have worked with support agencies to develop their strategies for soil plant nutrients **increased**, by 15% against a baseline (December, 2002) in the target districts	Project baseline, Monitoring and evaluation reports	
4. Mechanisms for transacting information and knowledge understood and therefore	By December 2004, 20% of farmers in at least one district, requesting information and assistance are directing their requests	Records kept by	

alternative sources of information to support farmers' crop production decisions under RWH conditions **Identified** and/or **Developed** and **Promoted**	to the identified alternative sources	different categories of Extension Agents	

Activities	Milestones & Budget	Assumptions
1.1 Assess the fertility status and patterns on the toposequence under different RWH systems, crops and categories of farmers using Local Indicators of Soil Fertility (LISF), and limited soil sampling and analysis. 1.2 Identify local strategies of soil fertility management in RWH systems, and their impact in relation to biophysical characteristics, different categories of farmers, and types of production enterprises. 1.3 Quantify the role of macro-catchment RWH systems on soil and plant nutrients availability and balance at farm level and watershed scale. 1.4 Build the data collected in activities 1.1 – 1.3 into GIS at SUA and at least one target district and up-date from time to time. 2.1 Design soil and plant nutrients management options suitable for different categories of farmers, locations, soils, RWH systems, runoff availability and crop systems. 2.2 Investigate and recommend how the improved fertility management options can be effectively used under different RWH systems conditions. 2.3 Develop Decision Aide (based on PARCHED-THIRST) and use to undertake analysis of impacts and risks for the different strategies and thus recommend the most balanced options. 2.4 Design and produce suitable extension products for identified critical issues in soil and plant nutrients management. 3.1 Assess capacity and performance of farmer-support agencies (suppliers, credit, extension service, NGOs etc.) to facilitate management of soil and plant nutrients. 3.2 Facilitate training and awareness raising of capacity building in identified areas. 3.3 Conduct baseline survey and monitor extent of change of farmers' strategies for managing soil and plant nutrients under RWH systems, and build into GIS. 4.1 Assess the way information on plant nutrient management is transacted between support agencies and farmers	**2002 Dec:** Monitoring and evaluation database in place in two target districts **2003 Mar:** Activities 1.1, 1.2 and 1.3 completed and GIS database established at SUA **2003 Mar**: Report on training needs produced **2003 Jun:** Initial drafts of training and communication products for testing produced **2004 Mar**: Acceptable management options ready **2004 Mar**: Initial drafts of extension products for testing produced **2004 Mar**: 1st up-date of monitoring data undertaken **2004 Jun**: Alternative sources and delivery of information to farmers identified **2004 Jun:** 1st training implemented **2004 Dec**: 2nd up-date of monitoring data undertaken **2004 Dec:** 2nd Training implemented **2005 Jan**: Final versions of extension products produced	Adequate funds and facilities are provided to the extension service NGOs are well funded and they continue to work in the semi-arid areas

agencies and farmers. 4.2 Identify and develop alternative sources as well as delivery mechanisms for information and extension in management of soil and plant nutrients. 4.3 Test the viability of the alternative sources and delivery mechanisms and improve accordingly.	Budget UK staff cost = £ 6,018 Staff cost TZ = £ 66,249 Overheads = £ 29,814 Equipment = £ 11,858 Communication = £ 18,865 Miscellaneous = £ 34,466	

11. Keywords

Integrated nutrient management, soil fertility, local and technical indicators of soil fertility, semi-arid, Tanzania, soil quality, rainwater harvesting, organic and inorganic soil amendments; poor rural farming communities, stakeholders, information and service providers.

12. List of Annexes

Annex	Description/Title
Annex B1	Local Indicators of Soil Fertility (LISF) in Maswa and Same Districts, Tanzania
Annex B2	A manual on procedures and methods- Participatory assessment of soil fertility status, identification and development of soil fertility management strategies/options
Annex B3	Training of Extension Staff and in Maswa and West Pare Lowlands on Local Indicators of Soil Fertility, Soil Sampling and Participatory Mapping
Annex B4	Monitoring and evaluation framework baseline data and information for Maswa and Same districts
Annex B5	The first update of monitoring and evaluation of adoption of innovations and changes with reference to the baseline data
Annex B6	Mapping Suitability of Common Pool Resources, Land Tenure Systems and Land Use Conversion: A Combination of GIS and Participatory Approaches
Annex B7	Local Strategies of Soil Fertility Management and their Impacts on Soil Fertility and Productivity
Annex B8	Needs for Training, Awareness and Information
Annex B9	Fertility Status of Soils in WPLL and Maswa District
Annex B10	Review of the Soil Fertility Status and Response of Various Crops to Inorganic Fertilizers and Manures in the Lake, Northern and Eastern Zones of Tanzania
Annex B11	Capacity and performance of farmer support agencies in supporting agricultural technological dissemination
Annex B12	Field trials on effects of nitrogen, phosphorus and farmyard manure on rice growth under rainwater harvesting in semi-arid areas
Annex B13	Soil Fertility Management Options
Annex B14	An assessment of the effective communication mechanisms to disseminate agricultural research findings to peasants in semi-arid areas in Tanzania: A case of rainwater harvesting researches in Makanya, Kigonigoni and Bukangilija.
Annex B15	Assessment of spatial and temporal variability of soil fertility under rainwater harvesting systems: a case study of Makanya river catchment
Annex B16	Plant material sampling and analysis for soil fertility evaluation
Annex B17	Nutrient deficiency symptoms in field crops (booklet)
Annex B18	Fertilizers and fertilizer application methods
Annex B19	Manual on soil sampling for fertility evaluation (booklet)
Annex B20	Preparation of good quality manure (booklet)
Annex B21	Inorganic fertiliser (poster)

Annex B22	Manures (poster)
Annex B23	Soil fertility management strategies for rice and maize under RWH systems (leaflet)