NRSP PROJECT R8115
Improvement of Soil Fertility Management Practices in Rainwater Harvesting Systems

ANNEX B1

Local indicators of soil fertility (LISF) in Maswa and Same districts, Tanzania

Soil Water Management Research Group

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Summary

A participatory study involving farmers, extension staff and SWMRG researchers was conducted to identify the local indicators of soil fertility and quality in Project R8115 target areas, namely WPLL and Maswa district. The target villages were Tae, Mwembe and Makanya and Isulilo, Njiapanda and Bukangilija villages in WPLL and Maswa district, respectively. The local indicators of soil fertility and quality 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. Local indicators of soil fertility (LISF) both in Western Pare Lowlands (WPLL) and Maswa district are based on seven main parameters. The soil characteristics 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, qualitative and comparative, with no established critical levels and standards as basis for comparisons. However, the local indicator assist in the initial stages of soil sampling and soil mapping and in the development of soil fertility management strategies. Despite the 800-kilometre distance between WPLL and Maswa, there is convergence in the type of parameters used and their interpretations.

1. INTRODUCTION

Inadequate understanding of the dynamics of plant nutrients in soils under rainwater harvesting (RWH) systems coupled with low levels of plant nutrients in soils (low fertility status) and inadequate use of organic and inorganic soil amendments to replenish the nutrients lost/removed from soils by various processes, limit the productivity of harvested rain water, hence jeopardizing the sustainability of the systems in Tanzania. At the same time, a great deal of information of soil fertility management (SFM) is available from past research and indigenous knowledge, which has not been fully exploited. This project therefore aims to use this information to provide tools for developing SFM strategies, which are compatible with the experience and needs of local extension services, NGOs, other service providers and farmers. This report describes the local indicators of soil fertility that are used by farmers themselves to determine the status of soil fertility and to design strategies for their improvement.

Soil quality is the capacity of a soil to be functional within the limits imposed on it by the ecosystem and land use, to preserve the biological productivity and environmental quality and to promote the plant, animal and human life (Doran and Parkin, 1994; Doran and Safley, 1997). Soil quality is, therefore, the product of the interaction of the soil, plant, climatic and agronomic factors in a specific area or locality. The soil keeps a unique balance among its physical, chemical and biological factors and characteristics and this unique balance is influenced by various climatic and environmental factors and human and animal activities. The soil quality status of a soil can be assessed on the field using indicators of soil quality (ISQ). Indicators of soil quality are combinations of the physical, chemical and biological factors and functions of the soil (Doran and Parkin, 1994; Doran and Safley, 1997; Beare *et al*., 1997). For example, the water infiltration rate in a given soil is influenced by the soil texture (soil feel), the surface chemistry and behavior of the colloidal components of the soil and soil porosity (soil structure) which is influenced by the biological activities in the soil. The indicators of soil quality are integrative and reflect the simultaneous changes in the soils physical, chemical and biological characteristics. Indicators of soil quality are, therefore, the observable soil and plant attributes that are used in the qualitative identification and assessment of the main physical-chemical and bio-physical limitations of soil productivity (quality).

Local indicators of soil fertility (LISF) are the visually observable and identifiable soil properties, features and characteristics that are used for the qualitative assessment of the fertility status of soil in a given area (Barrios *et al.,* 2000; Beare *et al*., 1997; Doran and Safley, 1997). Local indicators of soil fertility include such soil properties and characteristics as the colour of the soil, the soil texture (feel), soil moisture retention capacity, soil structure, soil compaction, presence of soluble salts, stones, gravel and rocks, presence of ant-hills, soil depth, depth to the water table and the presence and appearance of various plant species on the landscape. The local indicators of soil fertility have been developed by various human societies over ages and passed down through generations. These local indicators of soil fertility have been used by farmers in the development of indigenous (local) soil fertility management strategies in their localities (areas). The local indicators of soil fertility have been developed by farmers based on indigenous knowledge on the behavior and comprehension of the various properties and characteristics of soils and their response to climate, human and animal activities. In recent years technological advances have enabled researchers to develop technical indicators of soil quality and fertility based on soil and plant material analysis. Integration of the local indicators of soil fertility (LISF) and technical indictors of soil fertility (TISF) has been a major step towards the development of appropriate technological options in soil fertility management that suit all the stakeholders.

The local indicators of soil quality and fertility are identified, comprehended and appreciated through dialogues with farmers (Barrios *et al.*, 2000). On the Makanya River and Ndala River catchments, in WPLL Same and Maswa districts, respectively, various local indicators of soil fertility are used in the assessment and categorization of the fertility status of the soils on the catchments. Project R8115 envisages to identify the local indicators of soil fertility in the semi-arid and arid areas in WPLL and Maswa district where RWH is being practiced. The specific objectives of the participatory study involving farmers, extension staff and Project R8115 researchers included the identification of;

a) Soil characteristics, properties and features locally used by farmers to classify/categorized the fertility status of the soils on their farms/land; that good and poor soils

b) Plants that are used to characterize and classify soil fertility;

c) Landscape features that correspond to various soil fertility status/classes/categories; and

d) The extent of the use of the identified local indicators of soil fertility in the development/ designing of soil fertility management strategies that are appropriate in the two catchments.

2. METHODOLOGY

2.1 Identification and Selection of Farmers

For both in the Makanya and Ndala River Catchments, the village leaders, administrators and extension staff were requested by Project R8115 researchers to identify and select farmers from their villages who participated in the study, that is, identification of local indicators of soil fertility. The criteria that were agreed upon in the selection of the farmers included gender, age, wealth status, positions of their farms on the landscape (catchments), type of enterprises, types of the crops cultivated by the farmers and the type of water harvesting systems/techniques used by the farmers. Based on the above criteria, 25 farmers were selected from Makanya village and 20 farmers from Mwembe village for WPLL, while 14, 19 and 17 farmers were selected from Isulilo, Njiapanda and Bukangilija villages respectively, for Maswa. For Tae village in WPLL, the study was conducted at a village meeting gathering.

2.2 Identification of the Local Indicators of Soil Fertility

The identification of the local indicators of soil fertility was conducted through interviews and discussions between the selected farmers for each village, the extension staff and the Project R 8115 researchers. Some limited field work were undertaken to verify some of the information and data gathered and generated during the discussions and interviews. On the identification of the local indicators of soil fertility, the soils were broadly categorized into two groups; fertile (good) soils and infertile (bad) soils with respect to crop yields.

3. RESULTS

3.1 WPLL Target Area

At the end of the study in the WPLL, the local indicators of soil fertility that were identified were as follows

3.1.1 Fertile (Good) soils

i) Black colour of the soils, surface and sub surface soil layers
ii) Low frequency of watering/irrigation
iii) Visible cracks on the soils during the dry season
iv) Good crop performance, like maize, millet etc without the use of fertilizers, manures and crop residues,
v) Presence / vigorous growth of a certain plants like "*mingurere*", *Solunum indicum (Ndulele), "ndago", "sangari", "lufundofundo", "mhoko", "iziga", "makongwe", "baraso", "ikongwe", " zigo", " mirage", "makongwe"*
vi) Presence/growth of plants that survive during the dry season
vii) Presence of green vegetation during the dry season
viii) Presence of wild sisal and many ever green trees/vegetation

3.1.2 Infertile (Poor/bad) soils

i) Poor crop performance even with the application of fertilizers or manures
ii) Occurrence of red or light coloured sandy soils
iii) Poor natural vegetation even where water is not limiting
iv) Presence of baob trees, "*ndago*" *(Cyperus rotundus), "igulangoji, jangare, mbigiri, minyaa"*
v) Compacted soils
vi) Presence of sandy soils
vii) Prominence of coarse sand depositions on the landscape
viii) Stunted plants even during the rain season when water is adequate
ix) Fast drying up of soils after rains or irrigation
x) Presence of white spots/patches on the soil surfaces
xi) Presence of salts or salt patches on the soil surface.
xii) Presence of very coarse sands, gravel and stones on the landscape.

3.2 Maswa District

On the Ndala River Catchment, in Maswa District the observations were as follows;

3.2.1 Fertile (Good) soils

i) High moisture content and retention by the soils
ii) Occurrence of black soils
iii) High clay content in the soils
iv) Presence of friable soils
v) High crop yields without the use of fertilizers and manures
vi) Dense plant population with a variety of plant species
vii) Vigorous growth of the vegetation
viii) Presence of specific plants like "*mashibili*" and "*samangombe*", "*malaba*" on anti hills
ix) Continuous cultivation without decline in yields
x) Occurrence of deep soils

3.2.2 Infertile (poor or bad) soils

i) Presence and occurrence of sandy soils
ii) Presence of soils which dry fast
iii) Light colour and red soils
iv) Occurrence of soils with low soil moisture retention capacity.
v) Presence/growth of drought resistant trees
vi) Low and sparse plant population
vii) Presence of specific and peculiar plants like "*ndase"* and "*magunguli"*, "*hodi"*, "*ndago"*, (cyperus) "*kiduha"*, "*makonda"*
viii) Low crop yields
ix) Presence of rocks and stones
x) Occurrence of shallow soils

4. TECHNICAL INTERPRETATION OF THE LOCAL INDICATORS OF SOIL FERTILITY

Good or fertile soils refer to those soils with very few or minimum limitations with respect to crop production. Good soils are assumed to have the desired combinations of the soils, physical, chemical and biological attributes or aspects of soil fertility and productivity. Such soils require minimum or insignificant amounts of soil amendments for optimal soil productivity. However, with continuous cultivation, appropriate soil fertility management strategies have to be adopted so as to replace the nutrients lost from the soils so as to sustain and enhance the fertility status of the soils. Natural or inherent high soil fertility is related to the mineralogical composition of the parent materials of the soils, organic matter contents and the water and aeration status of the soils.

Bad or infertile soils are those soils with many limitations with respect to crop production. The limitations are mostly due to imbalances in the levels and interactions of the physical, chemical and biological processes and factors of soil fertility. Productivity of such soils can be improved or raised through the application of the appropriate soil fertility management strategies and organic and inorganic soil amendments. Natural soil infertility is attributed to the low contents of the plant nutrients in the parent or initial materials of the soils, low organic matter contents and extensive loss of plant nutrients from the soils through natural processes, like leaching, volalization and erosion. Further natural soil infertility may be associated with the negative interactions of the factors of soil formation and development. The technical interpretation of the local indicators of soil fertility used by farmers in the WPLL and Maswa district (section 3.0) would be as follows:

4.1 Local Indicators for Good\ Fertile Soils

4.1.1 Black/ dark soils

The black or dark colours of soils as indicators of good soils (fertile soils) are reflections of the high amounts of organic matter contents in the soils. Soil organic matters contribute to soil fertility as follows;

(i) Through the process of decomposition and mineralization of organic matter, the plant nutrients contained in its components are released into the soil to support plant growth;

(ii) Organic matter is a source of carbon and energy for the soil micro organisms which are involved in many natural biological processes in soils;

(iii) Organic matter increases the water retention and storage capacities of soils, hence increasing the magnitude and extent of plant available water /soil moisture;

(iv) During the process of decomposition, some of the decomposition products of soil organic matter are synthesized into humic compounds, which have high capcities to retain plant nutrients (ions) in exchangeable forms;

(v) Organic matter stabilizes soil reaction, that is act as a buffer of soil pH and other chemical processes and reactions in soils.

(vi) Organic matter contributes to the formation and development of good soil structure and increases the stability of the soil aggregates so formed;

(vii) During the decomposition of soil organic matter, organic acids are produced which solubilize some soil minerals and compounds hence releasing the nutrients contained in them in forms available to plants; and

(viii) Humus is capable of forming complex compounds with plant nutrient ions, hence preventing them from being lost from the soil through the process of leaching;

Therefore, black or dark colours of soils are associated with high soil organic matter (humus) contents hence high availability of plant nutrients, high capacities to retain nutrients in exchangeable forms, high moisture retention and storage and supply of energy and carbon to soil micro-organisms. However, all dark or black soils are not always good or fertile. Some soils are black due to the dispersed humus, which is common in sodic soils that are associated with semi-arid and arid areas.

4.1.2 The ability of soils to support vigorous plant/crop growth and high yields without the use of fertlizers and manures

This is an indication of the ability and capacity of soils to supply adequate quantities of the essential plant nutrients, water and aeration and other growth factors to the plants for growth and development. The ability and capacity of soils to furnish the above growth requirements to plants are attributed to the capacities of the soils to retain large quantities of the nutrient ions in solution and exchangeable forms and to maintain and sustain a balanced equilibrium between the ions in the soils. Such soils have high contents of the 2:1 clay minerals and high organic matter contents. These good soils occur at the bottom of the toposequence/catchments, which are the zones of deposition in the process of soil erosion by water and gravity. These soils are suitable for most crops if not all crops.

4.1.3 Presence of vigorous growth of specific plants

The presence and vigorous growth of specific plants like *solum indicum*, and *mingurere* in the WPLL and *mashibil*i and *somangome* in Maswa, as local indicators of soil fertility is a manifestation of the soils ability to supply sufficient nutrients and water for the above plants with very high demands for plant nutrients and water (heavy feeders). Also the growth of the above plants is related to the significant thickness of the soil layers. The high contents of the plant nutrients and water in the soils are due to the dominance of the 2:1 day minerals in the soils, high organic matter, the extensive thickness of the A and B horizons and the presence of the water table close to the B-horizon. Such soils are dominant on the bottom (plains) of the toposequences (catchments). However, such soils may occur at the top and middle of the catchments on locations/positions where the slopes are not prohibitive (not too steep) and in depressions.

4.1.4 Development of visible cracks by the soils during the dry season

This is an indication of the high content of clays in the soil dominated by the 2:1 expanding lattice clay minerals like montinorillonite and vermiculite. These clays expand when wet and contract when dry. The cracking is due to the differential contraction in response to water loss through evaporation. The 2:1 clay minerals are characterized by high surface charge, hence the ability to retain ions on their surfaces in exchangeable forms. Further the 2:1 clay minerals have high capacity to retain water. The above qualities contribute to the high fertility status of the soils, which develop cracks during the dry season, or after the rainy seasons or irrigation. These soils are mostly suitable for rice/paddy cultivation.

4.1.5 Presences/occurrence of friable soils

The friable soils are equivalent to the loam soils, which have the desired proportions of the clay, sand and silt fractions. The friable soils under natural conditions have the ideal or optimal characteristics and requirements for good plant growth and performance. Such characteristics include good water holding capacities, high or adequate nutrient contents available to plants, sufficient aeration and the capacities of the soils to positively respond to soil fertility management practices under intensive crop production.

Accordingly, the friable soils are dominant on the middle and bottom positions on the catchments/ toposequences. However, the friable soils may be found at the summit or top positions of the catchments where soil erosion is minimal. The friable soils are suitable for most crops. The clay mineralogy of the friable soils are combinations or mixtures of 2:1 and 1:1 and the amorphous clay minerals and the hydrous oxides of Al and Fe. The soils are however, not extensively weathered.

4.1.6 Ability of the soils to support plant growth during the dry seasons

This is a reflection of the ability of the soils to supply adequate amounts of water and nutrients to the plants. The adequate or sufficient amounts of water for plant growth during the dry season is attributed to the high capacities of the soil to retain and store water in plant available forms and the pronounced thickness of the soil layers (deep soils). The capacities of the soils to retain water are attributed to the high contents of the 2:1 clay minerals in the soils, sufficient or high levels of organic matter in the soils, dominance of micropores in the soils and the extensive thickness of the soil layers. The plant roots scavenge the deep soils for water and nutrients during the dry seasons, hence the ability of such soils to support plant growth during the dry seasons.

The ability of certain soils to support plant life during the dry season is related to the positions of the water tables within the soil profiles. The water tables may be close to the surfaces of the soils or deep in the profiles. However the rooting characteristic in response to moisture stress during the dry season would dictate the extent and magnitude of the growth of the plants. Plants, which grow normally during the dry seasons, are those with extensive and deep rooting characteristics. Soils, which can support plant growth during the dry season, are mostly restricted to the bottom and middle positions on the landscape/catchments.

4.1.7 Presence or occurrence of \deep soils

Deep soils are mostly found at the bottom positions of the landscapes or catchments as a consequence of the depositional phase of soil erosion by water and gravity. Deep soils vary considerable in texture, structure, mineralogy and organic matter contents and available plant nutrients. The characteristics of the soils are determined by the soil erosion episodes. However, based on their extensive/pronounced thickness (depth), the overall total moisture, (water) and nutrient contents that can be accessible to plants are significantly high hence their local characterization/qualification as good (fertile) soils. These soils are suitable for most crops.

4.2 Indicators for Bad or Infertile Soils

These bad soils, that is soils of low fertility status and productivity are mostly confined to the summit/top and middle positions on the landscapes or catchments. However, at the summit and middle positions on the landscapes, the soils in depressions, are exceptional to the above observations. The technical interpretations or equivalents of the local indicators of bad soils of Tae, Mwembe and Makanya and Isulilo, Njia panda, and villages are as follows;

4.2.1 Poor crop growth, scanty and stunted natural vegetation

This is an indication /reflection of the inadequate supply of plant nutrients and water by the soils to the plants. The nutrients might be in the soils in forms not available to plants either due to low moisture contents in the soils, the nutrients are strongly fixed or retained by the soil components hence not exchangeable or the nutrients have been converted into insoluble compounds/substances through various transformations in the soils. Further, such soils may fail to support plants growth because the soils are naturally poor or deficient in the essential nutrient elements due to the low contents of the elements in the parent materials of the soils coupled with low soil organic matter contents. The low contents of the plant nutrients in such soils can also be due to extensive weathering coupled with significant losses of plant nutrients through the processes of leaching, volatilization and soil erosion. Due to the extensive weathering and removal of the nutrient ions, particularly the basic ions, the soils have strong acidic reactions with significant quantities of exchangeable Al^{3+} and H^{+}, which inhibit plant growth. The highly weathered soils are dominated by 1:1 clays minerals and hydrous oxides of Al and Fe, and low organic matter contents, hence the low nutrient contents, characteristic manifested by such soils.

It could be argued that the poor and stunted growth of plants is a manifestation of the poor and improper balance of the physical, chemical and biological attributes of soil fertility, soil moisture and plant nutrient contents playing the major part. The soils may be found on any position or location on the landscape as would be determined by the forces and extent of weathering and extent of soil erosion coupled with the slope characteristics of the landscapes/catchments.

4.2.2 Presence or occurrence of light and red coloured soils

The above local indicator of low soil fertility (bad soils) is related to the very low organic matter contents in the soils and significant amounts of Fe oxides and hydroxides. The high contents of the oxides of Fe in the soils are due to the high contents of Fe in the parent materials of the soils and extensive weathering of the soils. These highly weathered soils also have high contents of the 1:1 clay minerals, oxides of Al and they are extensively leached. The red and light colours of the soils are due to the high contents of the oxides of Fe and Al, respectively. These red and light coloured soils have low soil; moisture/water and nutrient retention capacities, acidic soil reactions, low percent base saturation, hence their local categorization as bad soils.

Because of the low nutrient and water retention and supply capacities of such soils coupled with strong acid soil reactions, the soils can only support plants with low nutrients and water demands and those which can tolerate acid soil conditions. These soils may occur at any location or position on the landscape but are mostly found on the top and middle positions on the landscapes/catchments. Areas with the red and light coloured soils are mostly reserved for grazing or forestation in areas where availability of the land for various agricultural/farming enterprises is not limiting.

4.2.3 Presence/growth of specific plants

The growth and proliferation of specific and peculiar plants like *ndase, magunguli, kiduha* (weeds) etc. (Maswa District) and *Cyperus rotundus, jangare, mbigiri* etc. (WPLL), plants (weeds) which have the abilities and capacities to withstand various growth hardships is a reflection of the low fertility and productivity status of such soils. The above plants, mostly weeds, have the abilities to extract nutrients and water from soils deficient in the plant nutrients and water. Their nutrient and water requirements are not that high as compared to the other crop plants. The above weeds have a very elaborate and extensive root systems and the roots grow/extend deep into the soil layers in search for water and nutrients. The inability of these soils to support crop growth other than the weeds mentioned above prompted the farmers to categorize these or such soils as bad or of low fertility status. The low nutrient and water retention capacities of the above soils could be attributed to the low contents of the essential plant nutrient elements in the parent materials of the soils, extensive weathering coupled with extensive leaching and losses of plant nutrients through various processes and the dominance of the 1:1 clay minerals and oxides of Al and Fe in the soil and low organic matter contents.

4.2.4 Presence/ occurrence of sandy soils and soils which dry fast

The above local indicator of fertility status of soils is the reflection and manifestation of the inability of sandy soils to retain (hold) water and plant nutrients for plant growth and development. The sandy fractions of soils are dominated by quartz, which is an inert soil component with limited surface charges and thus very limited capacity to retain water and plant nutrients. These soils cannot be used for crop production and may be found on all positions on the landscape/catchments as would be determined by the extent and magnitude of removal, transportation and deposition of the soil materials during the erosion process or episodes.

The sandy soils are highly weathered and their physical, chemical and biological attributes to soil fertility are negative or extremely limited. The soils dry fast or lose water very fast because the water is easily desorbed from the surfaces through the application of external forces. Further most of the water in sandy soils is under the influence of the gravitation force (gravitational potential), and thus drain freely and fast through the many macro pores present in such soils.

4.2.5 Presence of rocks and stones

This is an indication of the shallowness of the A and B horizons of the soils. Presence of rocks and stones could be attributed to extensive weathering of the soils with extensive and intensive erosion, or the soils are still young hence most of the rocks and stones are yet to be weathered. Because of the shallowness of the soils, their total water storage and nutrient contents are very low, and their abilities and capacities to provide mechanical support and anchorage to plants are limited. The presence of rocks and stones on the landscapes/catchments are dominant on the top and middle positions, as a consequence to soil removal and transportation. Areas dominated by rocks and stones are not suitable for crop production.

4.2.6 Soils with low moisture retention capacities

The low moisture retention capacities of soils is the manifestation of high proportions of sand sized particles in soils (sandy soils), high proportions of the 1:1 clay minerals which have low capacities to retain and hold water and low organic matter (humus) contents in the soils. Such soils may either be highly weathered or extremely young. However, in the cases of WPLL and Maswa, the soils are highly weathered. Additions of water to such medium/ soils either through natural precipitation or irrigation would percolate out of the soils very fast and the soils moisture deficit regime restored in a very short time/period.

Soils with low water/moisture retention capacities are dominant on the top and middle of the landscapes except for soils with high organic matter contents. Soils with low soil water /moisture retention capacities are suitable for the cultivation of crops with low water demands and drought resistant crops and to some extent deep rooted plants that can exploit the soil water/moisture deep down the soil profiles.

4.2.7 Compacted soils

The compaction of soils could be caused by the presence of heavy clays with significant amounts of Al and Fe oxides and other strong cementing compounds/materials in soils. Inappropriate tillage practices, like the use of heavy machinery during various farm activities, continuous cultivation coupled with preparation of very fine seedbeds and very shallow cultivation might also give rise to soil compaction.

Compacted soils or presence of compacted soil layers (hard pans) within the A and B horizons, hinder/limit root growth and extension, drastically limit water movement within the soil, limit water percolation down the soil profiles and reduce the aeration status of the soils. All the above conditions have negative effects on nutrient mobilities and uptake by plants. Compacted soils are prone to erosion by surface water flow due to reduced water infiltration and percolation. Compacted and highly cemented soils may be found at all the positions on the landscape, depending on the origin and causes of the formation and development of the compacted soils.

4.2.8 Presence of salts or white parches /spots on the surfaces of soils

This is an indication of the presence of sodic, sodic-saline or saline soils. The white particles may be deposits of Ca, Mg, Na-chloride, sulphates, carbonates or bicarbonate. Such soils are dominant in semi-arid and arid areas. Because of the high salt content, hence the osmotic potential of the soil solution, such soils can only support the growth of salt tolerant crops. These soils are mostly found at the bottom of the landscape coupled with poor drainage.

Generally, the different indicators of soil fertility as were observed in both catchments could be summarized as presented in Table 1 bellow.

Table 1: Local Indicators of soil fertility in WPLL and Maswa district.

Fertility Category	Study site	
	WPLL	**Maswa District**
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 *Solunum 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

5. CONCLUSION

Local indicators of soil fertility (LISF) both in Western Pare Lowlands (WPLL) and Maswa district are based on seven main parameters namely soil colour, soil structure, soil texture, soil water retention capacity, plant growth vigour, crop yield, and presence of specific plant species. There was convergence in the type of parameters used and their interpretations both in WPLL and Maswa district. The LISF were subsequently used in a participatory exercise in soil mapping and in the development of appropriate soil fertility management strategies for both Western Pare Lowlands (WPLL) and Maswa district.

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