I. Soil map description

Soils in Tanzania

1.0 Introduction

Tanzania has a total area of 945,000 km^2. Inland lakes have a total coverage of 59,000 km^2 (6% of total area) and the remaining land covers 886,000 km^2 (94% of total area). Despite of the complex climatic and topographic setting, the country has sufficient land to allow substantial growth in agricultural production including Push-Pull intensification. However, land degradation in form of physical loss of soil through erosion and decline in soil fertility through continuous cropping without replenishment by organic manure and mineral fertilizers are the major setbacks to agricultural production in Tanzania. Any attempts to improve and expand agriculture in Tanzania should invest in betterment of soil fertility improvement and crop husbandry practices including resilient soil and crop improvement options such as Push-Pull technology.

Recent developments in Tanzania emphasise the adoption of more holistic, participatory and community-based approaches for enhancing sustainable economic growth. Reliable land resources information is one of the major requirements for implementing this approach. Therefore, deliberate measures were made to ensure availability of reliable land resources information at national, regional and district levels.

2.0 Major Soils and their potential for agriculture in Tanzania

Tanzania adopted the World Reference Base for Soil Resources (WRB) as the system for soil nomenclature and correlation.

According to the WRB, Tanzania has 19 dominant soil groups. The structure, concepts and definitions of the WRB are strongly influenced by (the philosophy behind and experience gained with) the FAO-UNESCO Soil Classification System. The dominant soil groups are presented in Table 1.

Table 1. Major soil groups of Tanzania

Code	Major soil groups	Sq. km	Percent
AC	Acrisols	81642.50	8.63
AN	Andosols	15904.46	1.68
AR	Arenosols	21926.33	2.32
CM	Cambisols	337353.69	35.64
CH	Chernozems	4734.96	0.50
FR	Ferralsols	59852.62	6.32
FL	Fluvisols	26223.13	2.77

GL	Gleysols	1486.19	0.16
HS	Histosols	3791.45	0.40
LP	Leptosols	76738.02	8.11
LX	Lixisols	46888.61	4.95
LV	Luvisols	68706.15	7.26
NT	Nitisols	21001.11	2.22
PH	Phaeozems	22190.10	2.34
PL	Planosols	28197.84	2.98
RG	Regosols	1196.15	0.13
SC	Solonchaks	2750.92	0.29
SN	Solonetz	19626.46	2.07
VR	Vertisols	47497.85	5.02
Water bodies		58836.73	6.22

Source:

2.1.0 Organic soils
2.1.1 Histosols (HS) (3791.45 km^2; 0.40%)

Histosols occur in some parts of Kigoma, Shinyanga, Kagera and Kilimanjaro regions. The Reference Soil Group of the Histosols comprises soils formed in `organic soil materials'. These vary from soils developed in (predominantly) moss peat and forest peat in temperate ecosystems to mangrove peat and swamp forest peat in the humid tropics. Histosols are found at all altitudes but the vast majority occurs in lowlands. Common international names are `peat soils', `muck soils', `bog soils' and `organic soils'. Common soil subunits in Tanzania are Fibric Histosols (HS-fi).

The Histosols can be used for Push-Pull integration though it will need good drainage, liming and organic manure application to ensure satisfactory crop growth.

2.2.0 Mineral soils

Soils whose formation is conditioned by the particular properties of their parent materials.

2.2.1 Andosols (AN) (15904.46 km^2; 1.68%)

In the country they occur in Arusha, Mara and Mbeya regions.

The Reference Soil Group of the Andosols holds soils developed in volcanic materials. Common international names are `Andosols' (FAO, Soil Map of the World), `Andisols' (USDA Soil Taxonomy), `Andosols' and `Vitrisols' (France) and `volcanic ash soils'. Common soil subunits in Tanzania are Mollic Andosols (AN-mo), Umbric Andosols (AN-um) and Vitric Andosols (AN-vi).

Andosols have a high potential for agricultural production, are fertile soils particularly in intermediate or basic volcanic ash and not exposed to excessive leaching. Andosols are easy to till and have good rootability and water storage properties. Andosols are planted with a wide range of crops including sugarcane, tobacco, sweet potato, tea, vegetables, wheat and orchard crops. Rice cultivation is a major land use on Andosols in lowlands with shallow groundwater. Considering its extensive uses, Push-Pull integration can perform well in this kind of soil.

2.2.2 Arenosols (AR) (21926.33 km^2; 2.32%)

They are found in some parts of Tabora, Iringa, Mbeya and Rukwa regions and along the entire Indian ocean coastline of Tanzania.

The Reference Soil Group of the Arenosols consists of sandy soils, both soils developed in residual sands, *in situ* after weathering of old, usually quartz-rich soil material or rock, and soils developed in recently deposited sands as occur in deserts and beach lands. Many Arenosols correlate with Psamments and Psammaquents of the USDA Soil Taxonomy. Other international soil names to indicate Arenosols are `siliceous, earthy and calcareous sands' and various `podsolic soils' (Australia), `red and yellow sands' (Brazil) and the Arenosols of the FAO Soil Map of the World. Common soil subunits in Tanzania are Albi-Gleyic Arenosols (AR-gl-ab).

Arenosols occur in vastly different environments and possibilities to use them for agriculture vary accordingly. All Arenosols have a coarse texture, accountable for the generally high permeability and low water and nutrient storage capacity. Arenosols are further marked by ease of cultivation, rooting and harvesting of root and tuber crops. In places, Arenosols have been planted to perennial crops such as rubber and pepper; coastal sands are widely planted to estate crops such as coconut, cashew, casuarina and pine, especially where good quality groundwater is within reach of the root system. Root and tuber crops benefit from the ease of harvesting, notably cassava, with its tolerance of low nutrient levels. Groundnut and bambara groundnut can be found on the better soils.

2.2.3 Vertisols (VR) (47497.85 km^2; 5.02%)

Vertisols occur in considerable proportions in Mwanza, Shinyanga, Mara, Tabora, Kigoma, Coast and Lindi regions.

Vertisols are churning heavy clay soils with a high proportion of swelling 2:1 lattice clays. These soils form deep wide cracks from the surface downward when they dry out, which happens in most years. The name Vertisols (from L. *vertere*, to turn) refers to the constant internal turnover of soil material. Some of the many local names became internationally known, e.g. `black cotton soils' (USA), `regur' (India), `vlei soils' (South Africa), `margalites (Indonesia), and `gilgai' (Australia). Common soil subunits in Tanzania are Chromi-Natric Vertisols (VR-na-cr), Eutri-Pellic Vertisols (VR-pe-eu) and Pellic Vertisols (VR-pe).

Vertisols in Tanzania have moderate to high natural fertility but often associated with salinity and sodicity in some places. They are used for cultivation of annual crops such as rice, maize, cotton, sugarcane and vegetables. They also serve as important source of natural pasture for extensive grazing. Salt-build up and overgrazing are the important cause of degradation in areas with Vertisols. Push-Pull integration is appropriate option in Vertisols.

2.2.4 Soils whose formation was markedly influenced by their topographic setting.

2.2.4.1 Fluvisols (FL) (26223.13 km^2; 2.77%)

Fluvisols are dominant soils in the plains associated with important river plains in Tanzania such as the Rufiji basin, Ruaha basin, Ruvu basin, Kilombero basin and Wami basin. The Reference Soil Group of the Fluvisols accommodates genetically young, azonal soils in alluvial deposits. The name `Fluvisols' is misleading in the sense that these soils are not confined to *river* sediments (L. *fluvius* means `river') but occur also in lacustrine and marine deposits. Many international soil names refer to this group, for example: `Alluvial soils' (Russia, Australia), `Fluvents' (USDA Soil Taxonomy), `Fluvisols' (FAO), Auenböden (Germany) and `Sols minéraux bruts d'apport alluvial ou colluvial' or `Sols peu évolués non climatiques d'apport alluvial ou colluvial' (France). Common soil subunits in Tanzania are Eutri-Gleyic Fluvisols (FL-gl-eu).

Fluvisols are planted to annual crops and orchards and many are used for grazing. Flood control, drainage and/or irrigation are normally required. Paddy rice and sugarcane cultivation is widespread on the Fluvisols with satisfactory irrigation and drainage in Tanzania. Integration of Push-Pull technology in Fluvisols can be one of the best strategy for agriculture productivity.

2.2.4.2 Gleysols (GL) (1486.19 km^2; 0.16%)

The Reference Soil Group of the Gleysols holds wetland soils that, unless drained, are saturated with groundwater for long enough periods to develop a characteristic "gleyic colour pattern". This pattern is essentially made up of reddish, brownish or yellowish colours at ped surfaces and/or in the upper soil layer(s), in combination with greyish/bluish colours inside the peds and/or deeper in the soil. Common international names are `Gleyzems' and `meadow soils' (Russia), `Aqu-` suborders of Entisols, Inceptisols and Mollisols (USA), `Gley' (Germany), and `groundwater soils' and `hydro-morphic soils'. Common soil subunits in Tanzania are Epi-Dystric Gleyisols (GL-dye)

The main obstacle to utilisation of Gleysols is the necessity to install a drainage system. In adequately drained Gleysols can be used for arable cropping, dairy farming and horticulture.

2.2.4.5 Leptosols (LP) (76738.02 km^2; 8.11%)

Leptosols are the third largest soils in terms of coverage in Tanzania. They are mostly associated with mountainous landscapes and steep terrains, particularly in Kagera, Arusha, Singida, Dodoma, Mbeya, Rukwa, Iringa and Lindi regions. Common soil subunits in Tanzania are Eutric Leptosols (LP-eu) and Humi-Umbric Leptosols (LP-um-hu). Leptosols are very shallow soils over hard rock or in unconsolidated very gravelly material. Their topographic setting markedly influenced soil formation. Leptosols are important land use, have extensive grazing and stone quarrying. They are suitable for forestry and nature conservation.

2.2.4.6 Regosols (RG) (1196.15 km^2; 0.13%)

Regosols are of very limited occurrence in the country. They are found in Zanzibar and parts of Arusha region. Common soil subunits in Tanzania are Eutri-Humic Regosols (RG-hu-eu). They are not used for cultivation but mainly serve as source of murram for various civil works.

2.2.5 Soils that are only moderately developed on account of their limited pedogenetic age or because of rejuvenation of the soil material

2.2.5.1 Cambisols (CM) (337353.69 km^2; 35.64%)

Cambisols are the most extensive soils in the country, covering 35.64% of the area. They occur mainly in the mid-western and south-eastern parts of Tanzania.

The Reference Soil Group of the Cambisols holds soils with incipient soil formation. Transformation of soil material in this group is evident from weak, mostly brownish discolouration and/or structure formation below the surface horizon. Early soil classification systems referred to these `brown soils' as `Braunerde' (Germany), `Sols bruns' (France), `Brown soils'/`Brown Forest soils' (USA), or `Brunizems' (Russia). FAO coined the name `Cambisols'; USDA Soil Taxonomy classifies these soils as `Inceptisols'. Common soil subunits in Tanzania are Chromi-Ferralic Cambisols (CM-fl-cr), Eutri-Rhodic Cambisols (CM-ro-eu), Eutric Cambisols (CM-eu), Ferralic Cambisols (CM-fl), Rhodic cambisols (CM-ro) and Sodi-Mollic Cambisols (CM-mo-so).

Cambisols make good agricultural land and are intensively used. The Eutric Cambisols are among the most productive soils. Though they are less fertile, they are used for (mixed) arable farming and as grazing. Push-Pull technology can be integrated with other crop in this kind of soil.

2.2.6 The `typical' red and yellow soils of wet tropical and subtropical regions

2.2.6.1 Ferralsols (FR) (59852.62 km^2; 6.32%)

Ferralsols are scattered throughout the country but occur mainly in Kigoma, Rukwa, Mbeya, Morogoro, Tanga, Kilimanjaro, Dar es Salaam and Mtwara regions.

The Reference Soil Group of the Ferralsols holds the `classical', deeply weathered, red or yellow soils of the humid tropics. These soils have diffused horizon boundaries, a clay assemblage dominated by low activity clays (mainly kaolinite) and a high content of sesquioxides. Local names usually refer to the colour of the soil. Internationally, Ferralsols are known as Oxisols (Soil Taxonomy, USA), Latosols (Brazil), Sols ferralitiques (France), Lateritic soils, Ferralitic soils (Russia) and Ferralsols (FAO). Common soil subunits in Tanzania are Haplic Ferralsols (FR-ha).

Most Ferralsols in Tanzania have good physical properties. Great soil depth, good permeability and stable microstructure make Ferralsols less susceptible to erosion than most other intensely weathered red tropical soils. Moist Ferralsols are friable and easy to work. They are well drained but may in times be droughty because of their low water storage capacity. Sedentary subsistence farmers and shifting cultivators on Ferralsols grow a variety of annual and perennial crops. Low volume grazing is also common and considerable areas of Ferralsols are not used for agriculture at all. The good physical properties of Ferralsols and the often-level topography would encourage more intensive forms of land use if problems caused by the poor chemical soil properties could be overcome.

2.2.6.2 Nitisols (NT) (21001.11 km^2; 2.22%)

Nitisols occur in Mbeya, Iringa, Manyara, Kilimanjaro and Mara regions.

The Reference Soil Group of the Nitisols accommodates deep, well-drained, red, tropical soils with diffuse horizon boundaries and a subsurface horizon with more than 30 percent clay and moderate to strong angular blocky structure elements that easily fall apart into characteristic shiny, polyhedric (`nutty') elements. Nitisols are strongly weathered soils but far more productive than most other red tropical soils. Nitisols correlate with `Terra roxa estruturada' (Brazil), kandic groups of Alfisols and Ultisols (Soil Taxonomy, USA), `Sols Fersialitiques' or `Ferrisols' (France) and with the `Red Earths'. Common soil subunits in Tanzania are Eutric Nitisols (NT-eu), Haplic Nitisols (NT-ha) and Humi-Umbric Nitisols (NT-um-hu). Nitisols have relatively high contents of weathering minerals and surface soils may contain several percent of organic matter, in particular under forest or tree crops. In Tanzania Nitisols are planted to plantation crops such as tea, coffee, rubber and pineapple, and are also widely used for food crop production on smallholdings, this kind of soil can allow Push-Pull integration.

2.2.6.3 Acrisols (AC) (81642.50 km^2; 8.63%)

Acrisols are the second most extensive soils in the country. They occur in Mara, Tabora, Singida, Dodoma, Tanga, Kilimanjaro, Morogoro, Iringa, Mbeya, Ruvuma, Lindi and Mtwara regions.

The Reference Soil Group of the Acrisols holds soils that are characterized by accumulation of low activity clays in an *argic* subsurface horizon and by a low base saturation level. Acrisols correlate with `Red-Yellow Podzolic soils' (e.g. Indonesia), `Podzolicos vermelho-amarello distroficos a argila de atividade baixa' (Brazil), `Sols ferralitiques fortement ou moyennement désaturés' (France), `Red and Yellow Earths' and with several subgroups of Alfisols and Ultisols (Soil Taxonomy, USA).

Common soil subunits in Tanzania are Chromi-Ferric Acrisols (AC-fr-cr).

Large areas of Acrisols are under forest and open woodland. Most of the tree roots are concentrated in the humus surface horizon with only few taproots extending down into the subsoil. Acrisols are suitable for production of rain-fed and irrigated crops only after liming and full fertilization. Rotation of annual crops with improved pasture can also be done and Push-Pull integration is possible.

2.2.6.4 Lixisols (LX) (46888.61 km^2; 4.95%)

Lixisols are important soils in Iringa, Mbeya, Ruvuma, Lindi and Mtwara regions.

The Reference Soil Group of the Lixisols consists of strongly weathered soils in which clay has washed out of an eluvial horizon (L. *lixivia* is washed-out substances) down to an *argic* subsurface horizon that has low activity clays and a moderate to high base saturation level. Lixisols were formerly included in the `Red-Yellow Podzolic soils' (e.g. Indonesia), `Podzolicos vermelho-amarello eutroficos a argila de atividade baixa' (Brazil), `Sols ferralitiques faiblement désaturés appauvris' and `Sols ferrugineux tropicaux lessivés' (France), `Red and Yellow Earths', `Latosols' or classified as oxic subgroups of Alfisols (Soil Taxonomy, USA).

Common soil subunits in Tanzania are Chromi-Arenic Lixisols (LX-ar-cr), Chromic Lixisols (LX-cr), Haplic Lixisols (LX-ha), Rhodi-Profondic Lixisols (LX-pf-ro), Rhodic Lixisols (LX-ro). Perennial crops are preferred over annual crops, particularly on sloping land. Cultivation of tuber crops (cassava, sweet potato) or groundnut increases the danger of soil deterioration and erosion. Therefore, rotation of annual crops with improved pasture has been recommended to maintain or improve the soil's organic matter content (Deckers et al, 1998).

2.2.7 Reference Soil Groups in arid and semi-arid regions

2.2.7.1 Gypsisols (GY) (No polygon)

Gypsisols occur in Same district (Makanya) along the vast Pangani river plain. Are soils with substantial secondary accumulation of gypsum (CaSO4.2H2O). They are found in the driest parts of the arid climate

zone, which explains why leading soil classification systems labelled them `Desert soils' (USSR), Aridisols (USDA Soil Taxonomy), Yermosols or Xerosols (FAO, 1974).
Common soil subunits in Tanzania are Petric Gypsisols. Though Gypsisols produce excellent yields of hay, wheat, maize and grapes if irrigated. Unfortunately, large areas in the country with Gypsisols are in use for extensive grazing. Also, large amounts of gypsum are mined for the cement industry in Tanzania.

2.2.7.2 Solonchaks (SC) (2750.92 km^2; 0.29%)

Solonchaks are common soils of the Pangani river basin in Kilimanjaro and Tanga regions. The Reference Soil Group of the Solonchaks includes soils that have a high concentration of `soluble salts' at some time in the year. Solonchaks are largely confined to the arid and semi-arid climatic zones and to coastal regions in all climates. Common international names are `saline soils' and `salt-affected soils'. Common soil units in Tanzania are Carbonati-Sodic Solonchaks (SC-so-cn). Solonchaks are strongly salt-affected soils have little agricultural value: they are used for extensive grazing of sheep, goats and cattle.

2.2.7.3 Solonetz (SN) (19626.46 km^2; 2.07%)

Solonetz occur in Mara, Arusha, Singida, Dodoma, Iringa, Mbeya and Rukwa regions.

The Reference Soil Group of the Solonetz accommodates soils with a dense, strongly structured, clay illuviation horizon that has a high proportion of adsorbed sodium and/or magnesium ions. Solonetz that contain free soda (Na_2CO_3) are strongly alkaline (field pH > 8.5). Internationally, Solonetz are referred to as `alkali soils' and `sodic soils', `Sols sodiques à horizon B et Solonetz solodisés' (France), Natrustalfs, Natrustolls, Natrixeralfs, Natrargids or Nadurargids (USA) and as Solonetz (USSR, Canada, FAO). The suitability of Solonetz for agricultural uses is almost entirely dictated by the depth and properties of the surface soil. A deep (say >25 cm) humus-rich surface soil is needed for successful arable crop production. Unfortunately, most Solonetz have only a much shallower surface horizon, or have lost the surface horizon altogether. This type of soil can accommodate Push pull integration.

2.2.8 Soils that occur in the steppe zone between the dry climates and the humid Temperate zone

2.2.8.1 Chernozems (CH) (4734.96 km^2; 0.50%)

Chernozems are limited in extent and occur in Arusha and Kilimanjaro regions**.**
The Reference Soil Group of the Chernozems accommodates soils with a thick black surface layer rich in organic matter. Russian soil scientist Dokuchaev coined the name "Chernozems" in 1883 to denote the typical "zonal" soil of the tall grass steppes in continental Russia. Some international synonyms: `Calcareous Black Soils', `Eluviated Black Soils' (Canada), and (several suborders of) `Mollisols' (USDA Soil Taxonomy).
Common soil subunits in Tanzania are Sodi-Luvic Chernozems (CH-lv-so).
They present favourable soil structure through timely cultivation and irrigation at low watering rates. Application of P-fertilizers is required for high yields. Wheat, barley and maize are the principal crops that are grown, alongside other food crops and vegetables. Part of the Chernozem area are used for livestock rearing. Push-Pull integration is possible in this kind of soil.

2.2.8.2 Phaeozems (PH) (22190.10 km^2; 2.34%)

Phaeozems occur in considerable proportions in Mara, Arusha, Manyara, Dodoma, Shinyanga and Morogoro regions.
The Reference Soil Group of the Phaeozems accommodates soils of wet steppe (prairie) regions. Phaeozems are much like Chernozems and Kastanozems but are more intensively leached in wet seasons. Consequently, they have dark, humus surface soils that are less rich in bases than surface soils of Chernozems and Kastanozems and Phaeozems have no (signs of) secondary carbonates in the upper metre of soil. Commonly used international names are `Brunizems' (Argentina, France), `Degraded Chernozems' (former USSR), `Parabraunerde-Tsjernozems' (Germany), `Dusky red prairie soils' (USA) or `Udolls' and

`Aquolls' in the order of the Mollisols (USDA Soil Taxonomy). The common soil subunits in Tanzania are Chromi-Luvic Phaeozems (PH-lv-cr) and Haplic Phaeozems (PH-ha).
In the country, Phaeozems are in use for the production of maize, beans, coffee (and other small grains). Phaeozems on the volcanic outwash plains in Mwanga, Moshi and Rombo districts support rainfed as well as irrigated maize, beans and vegetables. Considering its properties, Push-Pull integration can be practised.

2.2.9 The brownish and greyish soils of humid temperate regions

2.2.9.1 Luvisols (LV) **(68706.15 km^2; 7.26%)**

Luvisols are important soils in Morogoro, Dodoma, Arusha, Manyara, Kilimanjaro, Tanga and Ruvuma regions.
The Reference Soil Group of the Luvisols holds soils whose dominant characteristic is a marked textural differentiation within the soil profile, with the surface horizon being depleted of clay and with accumulation of clay in a subsurface *`argic'* horizon. Luvisols have high activity clays and lack the *abrupt textural change* of Planosols, *albeluvic tonguing* as in Albeluvisols, a *mollic* surface horizon as in steppe soils, and the *alic properties* of Alisols. Local names for these soils include `Pseudo-podzolic soils' (Russia), `sols lessivés' (France), `Parabraunerde' (Germany), `Grey Brown Podzolic soils' (earlier USA terminology) and `Alfisols' (USDA Soil Taxonomy). The common soil subunits in Tanzania are Cutani-Chromic Luvisols (LV-cr-ct), Haplic Luvisols (LV-ha), Humi-Rhodic Luvisols (LV-ro-hu) and Profondic Luvisols (LV-pf). Luvisols are fertile soils and suitable for a wide range of agricultural uses, Push-Pull integration can also be practiced.

2.2.9.2 Planosols (PL) (28197.84 km^2; 2.98%)

Planosols are important soils in Mara and Mwanza regions. They occur also in some parts of Shinyanga, Manyara, Tanga and Coast regions.
The Reference Soil Group of the Planosols holds soils with bleached, light-coloured, eluvial surface horizons that show signs of periodic water stagnation and abruptly overly dense, slowly permeable subsoil with significantly more clay than the surface horizon. These soils were formerly regarded as `pseudogley soils' but are now recognized as `Planosols' by most soil classification systems. The US Soil Classification coined the name `Planosols' in 1938; its successor, USDA Soil Taxonomy, includes most of the original Planosols in the Great Soil Groups of the Albaqualfs, Albaquults and Argialbolls. The common soil subunits in Tanzania are Calci-Hyposodic Planosols (PL-sow-cc). Natural Planosol areas support a sparse grass vegetation, often with scattered shrubs and trees that have shallow root systems and can cope with temporary water logging. Land use on Planosols is normally less intensive than on most other soils under the same climatic conditions. Vast areas of Planosols are used for extensive grazing. Wood production on Planosols is much less than on other soils under the same conditions.

References:

1. Ministry of Agriculture, Food Security and Co-operatives. 2006. Soils of Tanzania and their Potential for Agriculture Development. Mlingano Agricultural Research Institute Department of Research and Training, Tanga, Tanzania.
2. De Pauw, E. 1984. Soils, Physiography and Agro-Ecological zones of Tanzania. Crop Monitoring and Early Warning Systems Project, Food and Agriculture organization of the United Nations. GCPS/URT/047/NET, Ministry of Agriculture, Dar es Salaam. Tanzania.
3. Eschweiler, J.A., 1998. SOTER database Tanzania, FAO, AGLL Working Paper No 8, Rome.
4. FAO/UNESCO. 1974. Soil Map of the World 1:5 million, Volume I, Legend, Rome.
5. FAO. 1990. Guidelines for Soil Profile Description, AGLS, Rome.
6. FAO/ISRIC/CSIC. 1995. Multilingual Soil Database, World Soil Resources Reports No. 81, Rome.
7. FAO. 1998. The soil and terrain database for north eastern Africa and Crop Production System Zones of the IGAD sub region, FAO - Land and Water Digital Media Series nr. 2
8. National Soil Service - Tanzania. 1998. A Soil Profile Database for Tanzania, Technical report FAO contract CMT 132036, Mlingano/Rome.
9. van Engelen V.W.P. and T.T. Wen (eds). 1995. Global and National Soils and Terrain Digital Databases (SOTER) - Procedures Manual (rev. version) UNEP/ISSS/ISRIC/FAO, Wageningen.

II. Push-Pull sites

The sites were selected by the Tanzania Agriculture Research Institute (TARI) team in collaboration with Agricultural extension agents and policy makers in Mara region. Primary and secondary information of the area were also used during site selection.

Based on the information collected and different agro ecologies existing in Mara region three main sites were selected for project implementation: Northern zone (Northern part of Tarime district, Southern part of Tarime district and Rorya district), Central zone/Intermediate (Musoma and Butiama districts) and Lowland zone (Bunda district).

Table 1. Agro-ecological zones in Mara region -Tanzania (UPSCALE project site)

Agro ecology	**Location**	**pH (H_2O)**	**Temp. (^{0}c) Max; Min**	**Soils and Topography**	**Altitude (m)**	**Rainfall total (mm/year) / Patten**	**Length of Growing Period and Soil Moisture Properties**
Northern zone	Northern part of Tarime district	6.5-7	22-30 10-18	Level to undulating or rolling plains at medium to high altitude developed on volcanic ash and sediments, often with steep hills. Major soils are well drained, deep, dark brown non-calcareous loams, silty loams and clay loams with moderate structure with high natural fertility; and moderately well to imperfectly drained, shallow to deep mostly calcareous,	1300-2300	1,250-2,000 Monomodal	One Dependable Growing Period (DGP) per year with duration of 3-3½ months, varying depending on soil moisture storage capacity and crop rooting habits. Onset dates are unreliable. Volcanic ash soils, mostly well drained clays with moderate to high AWC (70-150 mm/m) and favourable moisture storing properties (Smax 200-400 mm).

				black, dark grey or brown cracking clays often overlying paler subsoil with ephemeral structure with high natural fertility.			
	Southern part of Tarime district	5-6.5	22-25 15-18	Undulating to rolling plateaux and plains of medium to high altitude, developed on lavas and granites. Major soils are well drained, deep yellowish or reddish sandy clays to clays with moderate to strong structure, with very low to low natural fertility; and well drained, moderately deep or deep yellowish or reddish sandy clays to clays with weak structure and moderate natural	1300-1800	1200-1600 Monomodal	One DGP per year with duration of 6½ - 9½ months depending on soil moisture storing properties and crop rooting habits. Onset dates difficult to determined due to overlap of growing periods. Covered by soil with moderate to high AWC (70-150 mm/m) and favorable moisture storing capacity (Smax 200-400 mm).

				fertility; well drained, moderately deep to deep, red or brown, often gravely, sandy loams and sandy clay loams with weak structure and low natural fertility.			
	Rorya district	6.5-7	27-30 15-18	Flat to gently undulating plains developed partly on granites, partly on old colluvium; medium altitude. Major soils are imperfectly drained, shallow, dark grey or brown sands to sandy clays with hardpan within 50 cm from the surface, often calcareous and sodic in the subsoil (ESP 10-15) with moderate natural fertility; and moderately	1000-1200	1100-1400 Mono/Bimodal	One DGP per year with duration of 3-3½ months depending on soil moisture storage capacity and crop rooting habits. Onset dates unreliable. The zone mainly covered by hardpan soils with poor moisture storing properties AWC (30-100), with important proportions of dark cracking clays of topographical depressions with

				well to imperfectly drained, shallow to deeper, usually calcareous, black, dark grey or brown cracking clays often overlying paler subsoil with ephemeral structure and with high natural fertility; and well drained, moderately deep to deep, red or brown often gravely, sandy loams and sandy clay loams, with weak structure and low natural fertility.			moderate moisture storing properties AWC 150 mm/m; Smax 75-150 mm; and sandy and medium textured with moderate to high moisture storing properties (AWC 50 – 100 mm/m; Smax 50-300 mm).
Central zone/Intermediate	Musoma and Butiama districts	6.5-7	27-30 15-18	Flat to gently undulating plains developed partly on granites, partly on old colluvium; medium altitude. Major soils are imperfectly drained, shallow,	800-1200	900-1300 Monomodal	One DGP per year with duration of 3-3½ months depending on soil moisture storage capacity and crop rooting habits. Onset dates unreliable. The zone mainly

				dark grey or brown sands to sandy clays with hardpan within 50 cm from the surface, often calcareous and sodic in the subsoil (ESP 10-15) with moderate natural fertility; and moderately well to imperfectly drained, shallow to deeper, usually calcareous, black, dark grey or brown cracking clays often overlying paler subsoil with ephemeral structure and with high natural fertility; and well drained, moderately deep to deep, red or brown often gravely, sandy loams and sandy clay loams, with weak structure and low			covered by hardpan soils with poor moisture storing properties AWC (30-100), with important proportions of dark cracking clays of topographical depressions with moderate moisture storing properties AWC 150 mm/m; Smax 75-150 mm; and sandy and medium textured with moderate to high moisture storing properties (AWC 50 – 100 mm/m; Smax 50-300 mm).

				natural fertility.			
Lowland zone	Bunda district	6.5-7	27-30 15-18	Flat to gently undulating plains developed partly on granites, partly on old colluvium; medium altitude. Major soils are imperfectly drained, shallow, dark grey or brown sands to sandy clays with hardpan within 50 cm from the surface, often calcareous and sodic in the subsoil (ESP 10-15) with moderate natural fertility; and moderately well to imperfectly drained, shallow to deeper, usually calcareous, black, dark grey or brown cracking clays often overlying paler subsoil with	600-1000	700-900 Monomodal	One DGP per year with duration of 3-3½ months depending on soil moisture storage capacity and crop rooting habits. Onset dates unreliable. The zone mainly covered by hardpan soils with poor moisture storing properties AWC (30-100), with important proportions of dark cracking clays of topographical depressions with moderate moisture storing properties AWC 150 mm/m; Smax 75-150 mm; and sandy and medium textured with moderate to high moisture

				ephemeral structure and with high natural fertility; and well drained, moderately deep to deep, red or brown often gravely, sandy loams and sandy clay loams, with weak structure and low natural fertility.			storing properties (AWC 50 – 100 mm/m; Smax 50-300 mm).

De Puaw, 1984. Soils, Physiography and agro-ecological zones of Tanzania. Crop Monitoring and early warning systems project GCS/URT/047.NET. Ministry of Agricultural, Dar Es Salaam. Food and Agriculture organization of the United Nations

Ministry of Agriculture, Food Security and Co-operatives. 2006. Rainfed Agriculture Crop Suitability for Tanzania. Mlingano Agricultural Research Institute Department of Research and Training Tanga, Tanzania

III. Push-Pull region

Selection of Mara region as a pilot area in Tanzania for UPSCALE project implementation was basically based on four important criteria:

1. Existence of different Agro ecologies in the proposed site: According to De Puaw, (1984), agro-ecology of the area shows aspects of environment that may constitute a significant resources or constraints to agriculture productivity. Basically it constitute: Soil types, total annual rainfall and pattern (Mono vs Bimodal), length of growing season and altitude.

It is the project expectations that its goals will be achieved when implemented in more than one agro ecologies. Mara region which is the pilot area for the project in

2. Biotic and abiotic constrains for maize production in the region

Factors affecting maize production in the sites such as Striga weed, Stem borer, Fall armyworm, inadequate rainfall and low soil fertility were among the major factors considered during site selection.

3. Existing Push-Pull fields in the selected sites and farmers to implement the technology: Mara region had experience on Push-Pull technology for more than fifteen years. It has been implemented extensively by farmers in Bunda, Butiama, Musoma, Tarime and Rorya districts. At the start of UPSCALE project there were more than 250 fields in Mara region. Considering the importance of the technology the number of fields are increasing and other farmers are expanding the size of their Push-Pull fields. The technology has now extended to Primary and Secondary schools, Non Governmental Organizations and Community Based Organizations.

4. Presence of stakeholders/farmers practising mixed farming of maize and Push pull companion plants: A good number of stakeholders/farmers in the Mara region which were growing maize, Napier/Brachiaria grass and desmodium plants for improvement of food security and livelihood of small holder farmers who are encountered by food and animal feed deficit during the season and off-season. Such organizations includes Heifer International-Tanzania, Project Concern International, Mogabiri Farm Extension Centre, Africa Inland Church Tanzania and Mara Agri-Link Tanzania Limited.

5. Other information about Mara region include:

i) Population increase

According to the 2002 Population and Housing Census, there were 1.37million inhabitants in Mara region where as in 2012 the population increased up to 1.74 million, this was 27% population increase. This indicates that the increase of population density can result to food deficit if there will be no strategic measures for increasing food crop production in the region.

ii) Crop Production

a) Mara region has sufficient land for crop production, land available to smallholders is 487,543 ha. The regional average land area utilized for agriculture per household was only 1.9 ha. Therefore, land can be used for crop intensification including PPT, cereal, vegetables and legumes integration.

Reference

1. United Republic of Tanzania. 2002/2003. National Sample Census of Agriculture Regional Report-Mara Region

2. United Republic of Tanzania, Population and Housing Census 2012. Tanzania National Bureau of Statistics