Managing factors that affect the adoption of grain legumes in Tanzania in the N2Africa project

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Putting nitrogen fixation to work for smallholder farmers in Africa

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1 Introduction

1.1 Stratification

Options for the management of constraints to the adoption of grain legumes for biological nitrogen fixation include testing different mechanisms relating to the delivery and generation of knowledge and training, different models of seed multiplication and diffusion, the production, marketing and delivery of rhizobia and other inputs, and the community level the different models of selling and adding value to legume products. For other constraints that cannot be controlled but which will have an effect on the 'fit' of different legume technologies and practices, and the subsequent diversity of options it will be necessary to characterise the country and stratify those constraints so testing can take place at sites that are broadly representative of larger areas. These constraints include the climate and some general soil parameters, and to a certain extent land tenure and average land sizes, as well as some household/farm attributes.

The review of constraints to adoption and conditioning factors has shown that stratification can be applied at multiple levels. The first level is the choice of the country which defines many institutional and policy conditions that affect the delivery and availability of agricultural inputs, knowledge and market opportunities. The next level of stratification is within the country to choose broad mandate areas. The variables that are used in this stratification step should exhibit more variability across the country than within the mandate area (a region). Further levels of stratification within districts and communities will be necessary (Table 1) but this report concentrates on the stratification at the country level and characterisation of target areas and districts within those target areas.

Table 1 Constraints to the adoption of BNF technologies and practices that can be managed using stratification in the research design

Constraint	Scale / level of constraint
Biophysical relevance of technology	Multiple
Household access to Capital / Assets	Household
Land availability, quality or tenure	Multiple
Output market for agricultural (legume) products	Multiple
Availability of labour	Household and Community
Gender	Household and Community level
Education / literacy of the farm household members	Household and Community
Experience of the farm household members	Household

1.2 General Target Areas

Some general target areas have been discussed in meetings among N2Africa partners and potential partners. These meetings have been guided by the current areas of operation of partners, their experience of particular legume crops as well as the production areas of grain legumes (Ronner and Giller, 2012).

In Tanzania the Ministry of Agriculture, Food and Cooperatives classifies districts according to seven broad geographically contiguous zones – Central, Western, Lake, Northern, Southern highlands and Southern (ESAFF, 2013). All except the western zone have been chosen in which three grain legume crops are already a major component of the farming system (Table 2) or for which there is great potential. An issue that needs to be taken into account is whether similar biophysical conditions are encountered in each target area so that the other factors can be compared, or whether instead it is more appropriate to test different legume crop varieties and strains of rhizobia.

Table 2. Target areas and major grain legumes N2Africa will work with in Tanzania

Zone	Common bean	Soybean	Groundnut
Northern			
Lake			
Central			
Southern Highlands			
Southern			

Discussions with partners in Tanzania have already identified a number of districts where N2Africa could potentially work, as well as the legume crops which are considered suitable for those sites (Table 3). These legume crops are subsequently referred to as the ‘best bet’ legumes for the particular target areas.

Table 3. Districts in the target areas in Tanzania where N2Africa partners are active

Zone	Target districts	‘Best bet’ Legume crop
Northern	Arusha rural, Meru, Siha, Hai, Moshi rural, and Lushoto[1]	Common bean
	Kiteto	Groundnut
Lake	Bukombe	Groundnut
Central	Kongwa	Groundnut
Southern Highlands	Iringa	Soybean
Southern	Mtwara	Groundnut

The characterisation and suggestions for stratification in this report are focussed on these districts which can be seen in Figure 1. The characterisation focuses on three factors affecting adoption that show variation across the country: (1) Biophysical relevance of technology; (2) Land availability, quality or tenure; and, (3) Output market for agricultural (legume) products. Within each of these categories the most appropriate indicators and data are sought and are summarised for the target districts.

[1] Although Lushoto is in Tanga region (which is normally in the Eastern zone) it is considered part of the Northern Zone.

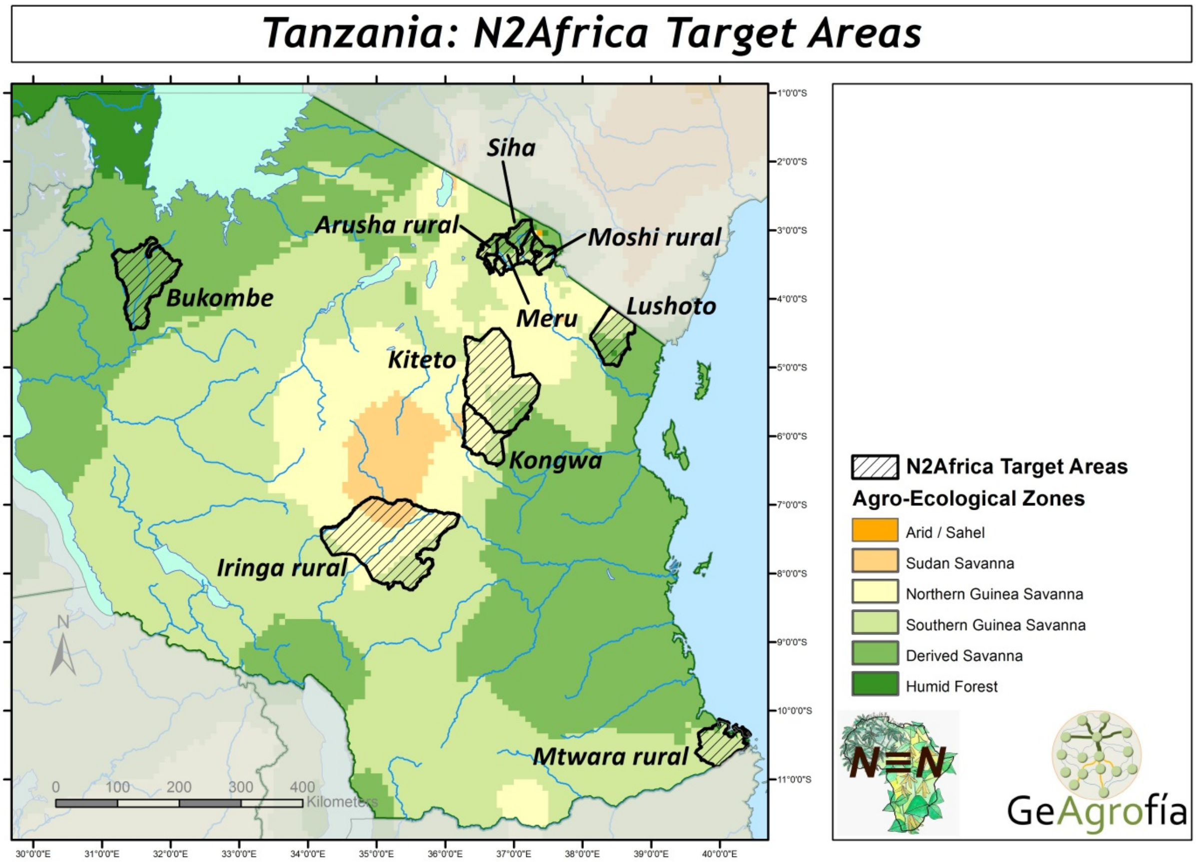

Figure 1. N2Africa Target Areas in Tanzania

2 Biophysical relevance of technology

2.1 Length of the growing period

In the target areas of Tanzania the length of the growing period (LGP) varies from 135 days in northern Iringa to 315 days on the slopes of Mt Kilimanjaro, but most target areas have a range of 150 to 225 days (Figure 2). LGP provides a good indication of the overall agricultural potential, but within the target areas the characteristics of the growing seasons are different with Northern and Lake zones characterised by bimodal rainfall, while the other target areas experience just one growing season (Pérez, 2014).

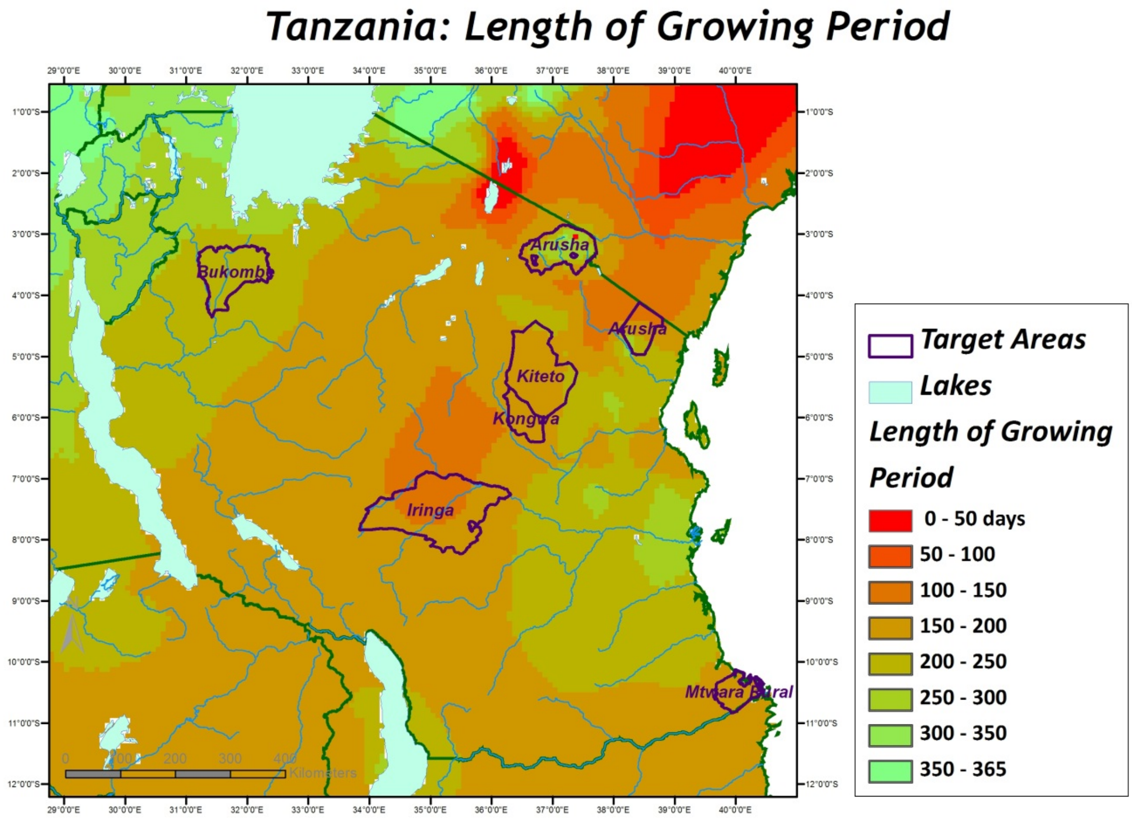

Figure 2. Length of Growing Period in Uganda. Source: van Velthuizen et al., 2007

For the purposes of stratification Arusha offers the greatest diversity of zones with differing LGP (Table 4). The target areas with the most limited set of zones are Bukombe, Mtwara and Kongwa.

Table 4. Length of Growing Period in Tanzania per district in each target area

Zone	Target districts	'Best bet' Legume crop	LGP (days)
Northern	Arusha rural, Meru, Siha, Hai, and Moshi rural	Common bean	195-315
	Kiteto	Groundnut	165
	Lushoto	Common bean	135-255
Lake	Bukombe	Groundnut	225
Central	Kongwa	Groundnut	165
Southern Highlands	Iringa	Soybean	135 - 165
Southern	Mtwara	Groundnut	195

2.2 Agro-Ecological zones

In contrast to Ethiopia there are few agro-ecological zonation schemes for Tanzania, with a zonation from 1983/84 (de Pauw, 1983a; 1983b;1984) still used by the Ministry of Agriculture Food and Cooperatives. This scheme results in 63 different zones based on the length of growing period, the reliability of rainfall and major physiographic features. Vegetation, major soil types and land cover were described for each of the zones.

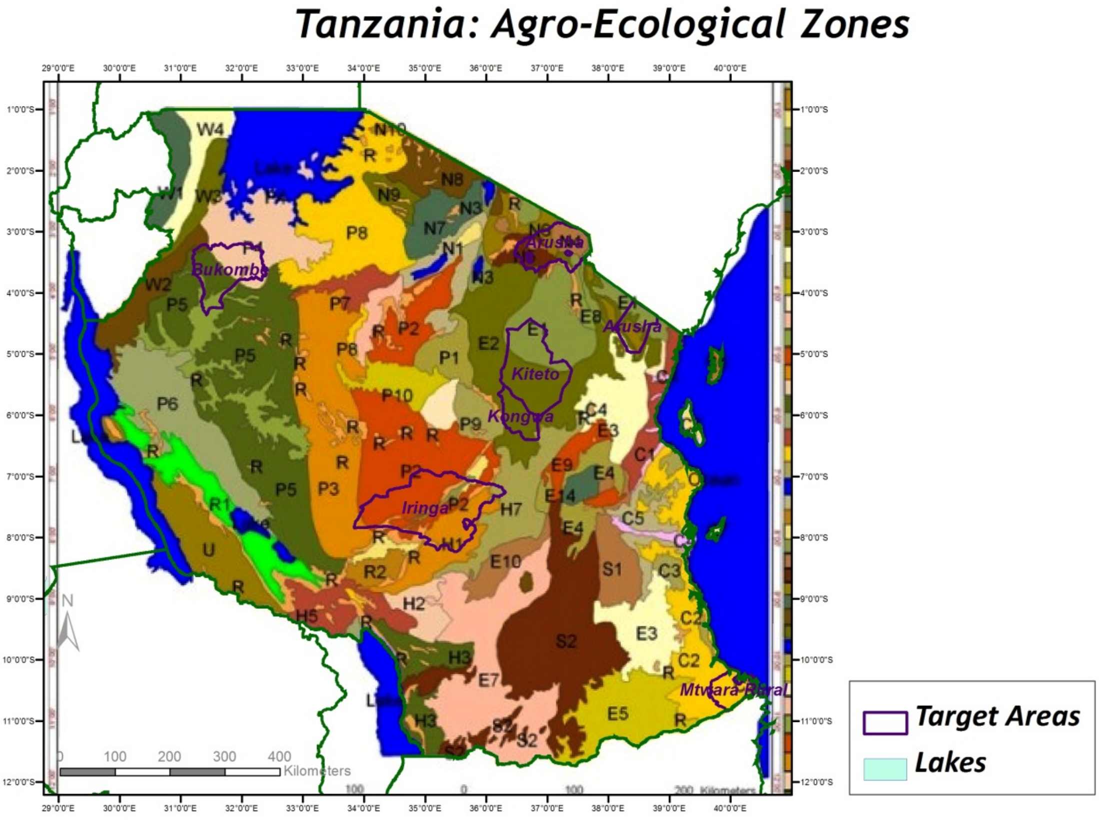

Figure 3. Agro-ecological zones of Tanzania (see Table 6 for description of zones). Source: MAFSC, 2014.

The diversity of different agro-ecological zones within the target districts is a consequence of the differing length of growing period which are often associated with the topography. As a result the target areas with most diversity are the mountainous areas of Arusha and Lushoto. Nevertheless there are also some areas which have a fairly constant length of growing period – such as Bukombe – but with a number of different AEZs which are differentiated by topography and soils.

Table 5. Agro-ecological zones per district in each target area

Zone	Target districts	'Best bet' Legume crop	Agro-ecological zones
Northern	Arusha rural, Meru, Siha, Hai, and Moshi rural	Common bean	N4, N5, N6, E1, and E2
	Kiteto	Groundnut	E1 and E2
	Lushoto	Common bean	E1, E2 , E3 and E12
Lake	Bukombe	Groundnut	P4, P5 and P13
Central	Kongwa	Groundnut	E2
Southern Highlands	Iringa	Soybean	H1 and P2
Southern	Mtwara	Groundnut	C2

Each agro-ecological zone was also assessed for its suitability for crops and pasture (Table 6) (NSS, 2006). Only one of the zones in the target areas (E3 in Lushoto) was thought suitable for soybean, but this assessment may not have considered newer soybean varieties. Common beans are considered suitable for E12, H1, N4, N5, P4, and P5 zones, but not the E1, E2, E3 and N6 encountered in Lushoto and Arusha. Groundnuts were not considered suitable in C2, E1, E2, P5 or P13 but were considered suitable for P4. In general these suitability assessments appear restrictive and the descriptions of the rainfall patterns (with many northern areas classed as unimodal) are at odds with other sources which reduces the overall confidence of the assessments.

Table 6. Agro-ecological zone descriptions

AEZ CODE	pH (H_2O)	Temperature (°C)	Altitude (m)	Rainfall total (mm/Yr) / Pattern
C2	5-7	29-31, 19-23	< 500	800-1000, Monomodal
Soils and Topography:				
Nearly level to gently rolling plains and plateaux, slopes ranging from 0-10%, developed on Quaternary, Neogene, Jurrasic and Cretaceous sediment. Soils are well drained, moderately deep to deep, red, yellowish red or orange sands and loamy sands with sandy loams in subsoil and poor structure and with very low natural fertility; and moderately well to imperfectly drained, shallow to deep usually calcareous, black, dark grey or brown cracking clays often overlying paler subsoil with ephemeral structure and moderate natural fertility.				
Length of Growing Period and Soil Moisture Properties :				
One dependable growing period (DGP) per year with duration of 3-4½ months, with variation of 3-4 weeks depending soil moisture storage capacity and crop rooting habits. Unreliable onset dates. Soils have moderate to high AWC (80-150 mm/m) and favourable moisture storing characteristics (Smax 150-350 mm)				
Suitable crops:				
Cashew, coconut, mangoes, cassava, simsim, sorghum, cow pea, pigeon pea, sweet potato, passion fruit, finger millet, sisal, jatropha.				
AEZ CODE	**pH (H_2O)**	**Temperature (°C)**	**Altitude (m)**	**Rainfall total (mm/Yr) / Pattern**
E1	5-7	27-30 15-18	500 - 1200	400-500 Monomodal
Soils and Topography:				
Mainly well drained, gently undulating to rolling plains and plateaux with altitude variability, developed on gneissic rocks, includes some poorly drained, flat and wide topographical depressions developed on young alluvium. Dominant soils are well drained, moderately deep to deep, dark reddish brown, yellowish red or red sandy clay loams and sandy clays with weak or moderate structure and low natural fertility; and moderately well to imperfectly drained, deep, brown, pale yellow, light grey or white mottled sands and loamy sands with poor structure with very low natural fertility.				
Length of Growing Period and Soil Moisture Properties :				
One DGP per year with duration of less than 2 month, varying by less than 1 week in response to soil moisture storage properties and crop rooting habits. Onset dates are very unreliable. Soils are medium to heavy textured with moderate AWC (70-120mm/m) and poor moisture acceptance to due to surface sealing (Smax 40-60mm)				
Suitable crops:				
Pastures (grasses and legumes) strictly considering land carrying capacity. Carrying capacity 2 Livestock Unit per sq. km.				
AEZ	**pH (H_2O)**	**Temperature (°C)**	**Altitude (m)**	**Rainfall total**

CODE				(mm/Yr) / Pattern
E2	5-7	27-30 15-18	500-1200	800-1000 Monomodal

Soils and Topography:

Mainly well drained, gently undulating to rolling plains and plateaux, altitude 500- 1200 m developed on gneissic rocks. There are poorly drained flat wide topographical depressions developed on young alluvium.

Sloppy areas are strongly dissected, often rocky and severely eroded. Dominant soils are well drained, moderately deep to deep, dark reddish brown, yellowish red or red sandy clay loams and sandy clays with weak or moderate structure and low natural fertility; and moderately well to imperfectly drained, deep, brown, pale yellow, light grey or white mottled sands and loamy sands with poor structure with very low natural fertility (Pare, Usambara and Lower Kilimanjaro)

Length of Growing Period and Soil Moisture Properties :

One DGP per year with duration of 2 - 2½ months varying by less than 2 weeks in response to soil moisture storage capacity crop rooting habits.

Unreliable onset dates.

Soils are medium to heavy textured with moderate to high AWC (AWC 80- 150 mm/m) but with poor moisture acceptance properties due to tendency for surface sealing (Smax 40-60 mm).

Suitable crops:

Sorghum, hyacinth bean (Lablab purpurens). Pastures (grasses and some legumes), sisal

AEZ CODE	pH (H_2O)	Temperature (°C)	Altitude (m)	Rainfall total (mm/Yr) / Pattern
E3	4-7	29-31 19-23	200-750	800-1000 Monomodal

Soils and Topography:

Mainly well drained, flat to rolling plains, low altitude developed on intermediate metamorphic rocks. Major soils are well drained, moderately deep to deep, reddish and yellowish sandy clay loams and sandy clays, often with more sandy topsoil, with weak structure and low natural fertility; and somewhat excessively to moderately well drained, moderately deep to deep, reddish, brown or grey loamy sands, sandy loams and sandy clay loams with weak structure and low natural fertility; and well drained, moderately deep to deep, yellowish or reddish sandy clays with weak structure, very low to low natural fertility.

Length of Growing Period and Soil Moisture Properties :

Mainly one DGP 3 - 4½ months varying by 1-4 weeks depending on soil moisture storing properties and crop rooting habits. Onset dates are unreliable.

Soil texture varies from medium to heavy textured alluvial with moderate to high AWC (80-150 mm/m) and favourable moisture storing properties (Smax 200-350mm). Natural soil fertility shows marked differences between sites, and soil acidity may be common

Suitable crops:

Maize, sorghum, rice, cassava sweet potatoes, sugar cane, cow pea, pigeon pea, hyacinth bean, citrus, mangoes, passion fruit, pine apple, cashew, coconut, **ground nuts**, **soya bean**, sunflower, tobacco, cotton, sisal, jatropha. Grasses and legumes for animals

AEZ CODE	pH (H_2O)	Temperature (°C)	Altitude (m)	Rainfall total (mm/Yr) / Pattern
E12	4½-7	22-25 10-15	1000- 2000	2000-3500 Monomodal

Soils and Topography:

Dissected, rolling to hilly mountains plateaux, slope range 10 – 40%, in parts affected by severe water erosion. Mainly covered by well drained, deep yellowish or reddish sandy clays with moderate to strong structure, with moderate natural fertility; and well drained, moderately deep to deep, yellowish or reddish sandy clays to clays with weak structure with very low to low natural fertility.

Length of Growing Period and Soil Moisture Properties :

One DGP per year duration of 5-6½ months, varying by 1½ months according to soil moisture storage capacity and crop rooting habits. Onset dates are unreliable. The soils have moderate AWC 70-120 mm/m and favourable moisture storing properties (Smax 200-400mm). Chemical barriers to root development may occur in some soils.

Suitable crops:

Coffee, tea, maize, **beans**, vegetables, sorghum, finger millet, wheat. Various tropical grasses and legumes for fodder

AEZ CODE	pH (H_2O)	Temperature (°C)	Altitude (m)	Rainfall total (mm/Yr) / Pattern
H1	5-7	22-25 10-15	1500-2000	600-1600 Monomdal

Soils and Topography:

Mainly flat and undulating to rolling plains and plateaux at high altitude, developed on granites and gneisses. Major soils are well drained, deep yellowish or reddish sandy clays to clays with moderate to strong structure, with moderate natural fertility; and well drained, moderately deep to deep, reddish and yellowish sandy loams and sandy clays, often with more sandy topsoils, with weak structure and low natural fertility.

Length of Growing Period and Soil Moisture Properties :

One DGP per year with duration of 5-6 months depending on soil moisture storage capacity and crop rooting habits. The zone has reliable onset dates, moderate AWC (120 mm/m) and favourable moisture storing properties (Smax 300-400 m).

Suitable crops:

Tea, coffee, mango, maize, sorghum, banana, wheat, cassava, irish potato, sweet-potato, pyrethrum, finger millet, **common bean**, pigeon pea, hyacinth bean, passion fruit, pineapple, macadamia, castor, simsim, sunflower, tomato, carrot, eggplant, fruit trees. Various tropical grasses and legumes for fodder.

AEZ CODE	pH (H_2O)	Temperature (°C)	Altitude (m)	Rainfall total (mm/Yr) / Pattern
N4		16-30 5-10	900-3500	500-1400 Monomodal

Soils and Topography:

Volcanic mountains with gentle to steep ash and lava slopes stretching from medium (900-1600 m) to high altitude (2000-3500 m). Major soils are well drained, deep, reddish friable or firm clay loams and clays with strong structure with high natural fertility and accumulation of partly decayed plant material in permanent swamps or alpine meadows.

Length of Growing Period and Soil Moisture Properties :

One DGP per year with duration increasing from 3-5 months to 6-11 months with altitude, soil moisture storage capacity and crop rooting habits. Onset dates are unreliable. The zone mainly covered by volcanic ash soils with low to moderate AWC (50-100 mm/m) and moderate moisture storing properties (Smax 100-200).

Suitable crops:

Tea, coffee, mango, maize, sorghum, banana, wheat, cassava, Irish potato, sweet-potato, finger millet, **common bean**, pigeon pea, hyacinth bean, passion fruit, pineapple, pyrethrum, macadamia, castor, simsim, sunflower, tomato, carrot, eggplant, apples, plums, peaches, grapes, apricots. Various tropical grasses and legumes for fodder

AEZ CODE	pH (H_2O)	Temperature (°C)	Altitude (m)	Rainfall total (mm/Yr) / Pattern
N5	6½-8½	27-30 15-18	1300-1700	600-1200 Monomodal

Soils and Topography:

Mainly flat to rolling plains at medium altitude, developed on volcanic ash and sediments. Major soils are well drained, shallow to deep, dark brown or dark grey calcareous sandy loams with weak structure with moderate natural fertility; and well drained, deep, dark grey or brown loamy sands, sandy loams and loams rich in allophanic clays with weak structure, low bulk density and high natural fertility.

Length of Growing Period and Soil Moisture Properties :

One DGP per year with duration decreasing toward south from 4-6 months to 2- 2½ months. Unreliable onset dates. The zone mainly covered by volcanic ash soils with low to very high AWC (50-200mm/m) and moderate to very favourable (high) moisture storing properties (Smax 100 – 600mm).

Suitable crops:

Maize, sorghum, wheat, cassava, Irish potato, sweet-potato, finger millet, **common bean**, pigeon pea, hyacinth bean, tobacco, castor, simsim, sunflower. Various tropical grasses and legumes for fodder

AEZ CODE	pH (H_2O)	Temperature (°C)	Altitude (m)	Rainfall total (mm/Yr) / Pattern
N6	6½-8½	27-30 15-18	1300-1700	400-500 Monomodal

Soils and Topography:

Mainly flat to rolling plains at medium altitude, developed on volcanic ash or lava or lahars. Soils are heterogeneous with important proportions of shallow soils, well drained, dark (sandy) loams on volcanic ash and pumice and dark cracking clays of topographical depressions.

Length of Growing Period and Soil Moisture Properties :

One DGP per year with duration of less than 2 - 2½ months depending on soil moisture storage capacity and crop rooting habits and exposure to rain shadow effect of Mt Kilimanjaro and Mt Meru. Onset dates unreliable, with low to moderate AWC (50-100 mm/m) and moderate soil moisture storing properties (Smax 100-200 mm).

Suitable crops:

Not suitable for agriculture (too short growing period). Grasses for livestock observing strictly carrying capacity.

AEZ CODE	pH (H_2O)	Temperature (°C)	Altitude (m)	Rainfall total (mm/Yr) / Pattern
P2	5-7	27-30 15-18	1100-1300	550-600 Monomodal

Soils and Topography:

Mainly gently undulating plains, for the most part well drained, at medium altitude, developed on granites and gneisses. Major soils are well drained, moderately deep to deep, red, yellowish red or orange sands and loamy sands with sandy loams in depth, with poor structure and very low natural fertility; and well drained, moderately deep to deep, red or brown, often gravely, sandy loams and sandy clay loams with week structure and low natural fertility; and immature soils which are complexes of rock outcrops, surface ironstone, very stony, and very shallow (< 25 cm); and moderately well to imperfectly drained, shallow to deep frequently calcareous, black, dark grey or brown cracking clays often overlying paler subsoil with ephemeral structure and high natural fertility.

Length of Growing Period and Soil Moisture Properties :

One DGP per year with duration of 3-3½ months depending on soil moisture storage capacity and crop rooting habits. Reliable onset dates.

Soils are generally moderately deep sandy or loamy with low to moderate AWC (30-100 mm/m) and poor moisture storing properties mostly for sandy and loamy soils susceptible to surface capping (Smax 50-150mm); and favourable for other loamy soils (Smax 150-300 mm). In some units with salt affected soils effective soil depth is restricted by impervious subsoil, often high ESP.				
Suitable crops:				
Drought tolerant crop: sorghum, millet, **ground nut**, sunflower, sweet potato				
AEZ CODE	**pH (H_2O)**	**Temperature (°C)**	**Altitude (m)**	**Rainfall total (mm/Yr) / Pattern**
P4	5-7	27-30 15-18	1200-1300	800-1000 Monomodal
Soils and Topography:				
Mainly flat to gently undulating plains with scattered hill-footslope associations at medium altitude, developed on granites, banded ironstones and young alluvium. Soils exhibit heterogeneous pattern with important proportions of well drained, moderately deep to deep, red, yellowish red or orange sands and loamy sands with sandy loams in depth, with poor structure and very low natural fertility; and well drained, moderately deep to deep, red or brown, often gravely, sandy loams and sandy clay loams with week structure and low natural fertility; and immature soils which are complexes of rock outcrops, surface ironstone, very stony, and very shallow; and moderately well to imperfectly drained, shallow to deep frequently calcareous, black, dark grey or brown cracking clays often overlying paler subsoil with ephemeral structure and high natural fertility.				
Length of Growing Period and Soil Moisture Properties :				
One DGP per year with duration of 3½-5 months depending on soil moisture storage capacity and crop rooting habits. Unreliable onset dates. Soils are moderately deep to deep with low to moderate AWC (50-100 mm/m) that may present 'chemical barriers' (e.g. salts) to root development in which case moisture reserve that can be used by crops is very low (Smax 30-50 mm). Where no chemical barriers exist, the moisture storing properties are moderate (Smax 100-200 mm).				
Suitable crops:				
Sorghum, millet, simsim, cotton, **ground nut**, sweet potato, sisal, cassava, early maturing maize, **beans**.				
AEZ CODE	**pH (H_2O)**	**Temperature (°C)**	**Altitude (m)**	**Rainfall total (mm/Yr) / Pattern**
P5	5-7	27-30 15-18	1100-1300	800-1000 Monomodal
Soils and Topography:				
Mainly gently undulating plains, for the most part well drained, at medium altitude, developed on granites and gneisses. Major soils are well drained, moderately deep to deep, red, yellowish red or orange sands and loamy sands with sandy loams in depth, with poor structure and very low natural fertility; and well drained, moderately deep to deep, red or brown, often gravely, sandy loams and sandy clay loams with week structure and low natural fertility; and immature soils which are complexes of rock outcrops, surface ironstone, very stony, and very shallow (< 25 cm); and moderately well to imperfectly drained, shallow to deep frequently calcareous, black, dark grey or brown cracking clays often overlying paler subsoil with ephemeral structure and high natural fertility.				
Length of Growing Period and Soil Moisture Properties :				
One DGP per year with duration of 5-6 months depending on soil moisture storage capacity and crop rooting habits. Reliable onset dates. Soils are generally moderately deep sandy or loamy with low to moderate AWC (30-100 mm/m) and poor moisture storing properties mostly for sandy and loamy soils susceptible to surface capping (Smax 50-150mm); and favourable for other loamy soils (Smax 150-300 mm). In some units with salt affected soils effective soil depth is restricted by impervious subsoil, often high ESP.				

Suitable crops:				
Mango, maize, sorghum, banana, wheat, rice, Irish potato, sweet-potato, finger millet, **common bean**, pigeon pea, hyacinth bean, passion fruit, cotton, sisal, castor, simsim, sunflower, cassava. Various tropical grasses and legumes for fodder				
AEZ CODE	**pH (H_2O)**	**Temperature (°C)**	**Altitude (m)**	**Rainfall total (mm/Yr) / Pattern**
P13	5 - 8½	27-30 15-18	900-1200	800-1000 Monomodal
Soils and Topography:				
Flat, seasonally inundated lowland plains with important proportion of permanent or semi-permanent swamps. . Major soils are moderately well to imperfectly drained, shallow to deep often calcareous, black, dark grey or brown cracking clays mostly overlying paler subsoil with ephemeral structure and high natural fertility; and imperfectly to poorly drained, deep, non-calcareous, grey or brown sandy loams to sandy clays with strongly mottled and compact subsoil but with more sandy, more friable and darker topsoil. Moderate natural fertility; sodic subsoil possible.				
Length of Growing Period and Soil Moisture Properties :				
DGP varies with Physiography. For upland areas, one DGP per year with duration of 5-6 months depending on soil moisture storage capacity and crop rooting habits. However, in most of the zone, growing period condition determined by duration and depth of flooding				
Suitable crops:				
Rice and crops that withstand water-logging				

Stratification using the AEZ is therefore a possibility in Tanzania although there is little potential for testing different AEZs in multiple target areas (Table 7).

Table 7. Agro-ecological zones (and target districts) per legume crop

Common bean	N4 C Arumeru, N Moshi, NE Hai	N5 Arumeru	E12 Lushoto	
Groundnut	C2 Mtwara	E2 S Kiteto, Kongwa	P4 eastern Bukombe	P5 western Bukombe
Soybean	H1 E Iringa	P2 W Iringa		

2.3 Cropping systems

The biophysical relevance of a particular legume crop will be determined not just by the agro-ecological suitability or potential for a crop but also how well the crop fits into the dominant or prevalent cropping or farming system.

Crop production statistics are available for each district from 2007/8 for all regions. These are not in digital format and need to be compiled and linked to a map of the district boundaries. Two district boundary spatial datasets are available for Tanzania from 2002 and 2012, as well as the GADM boundary file. The data best fitting the districts of 2007-08 are the 2002 and GADM boundaries, with the GADM also providing division boundaries. For the purposes of linking the agricultural statistics the best boundary file is the 2002 district spatial dataset.

Data were available for new districts created between 2002 and 2007, which required the merging of data for a number of districts (Table 8).

Table 8. District changes in Tanzania between 2002 and 2007

2002 district	2007 districts
Arumeru	Meru and Arusha rural
Monduli	Monduli and Longido
Dodoma Rural	Chamwino and Bahi
Njombe	Njombe and Njombe Mji
Biharamulo	Biharamulo and Chato
Bukoba Rural	Bukoba Rural and Missenyi
Hai	Hai and Siha
Tarime	Tarime and Rorya
Masasi	Masasi and Nanyumbu
Muheza	Muheza and Mkinga

Very few districts were growing soybean in 2007/08, with most production concentrated in the southern highlands bordering Mozambique, as well as other districts on the borders of Zambia, Kenya, Uganda and some districts in the centre of the country (Figure 4). There was no record of soybean production in Iringa – the target area for soybeans in N2Africa.

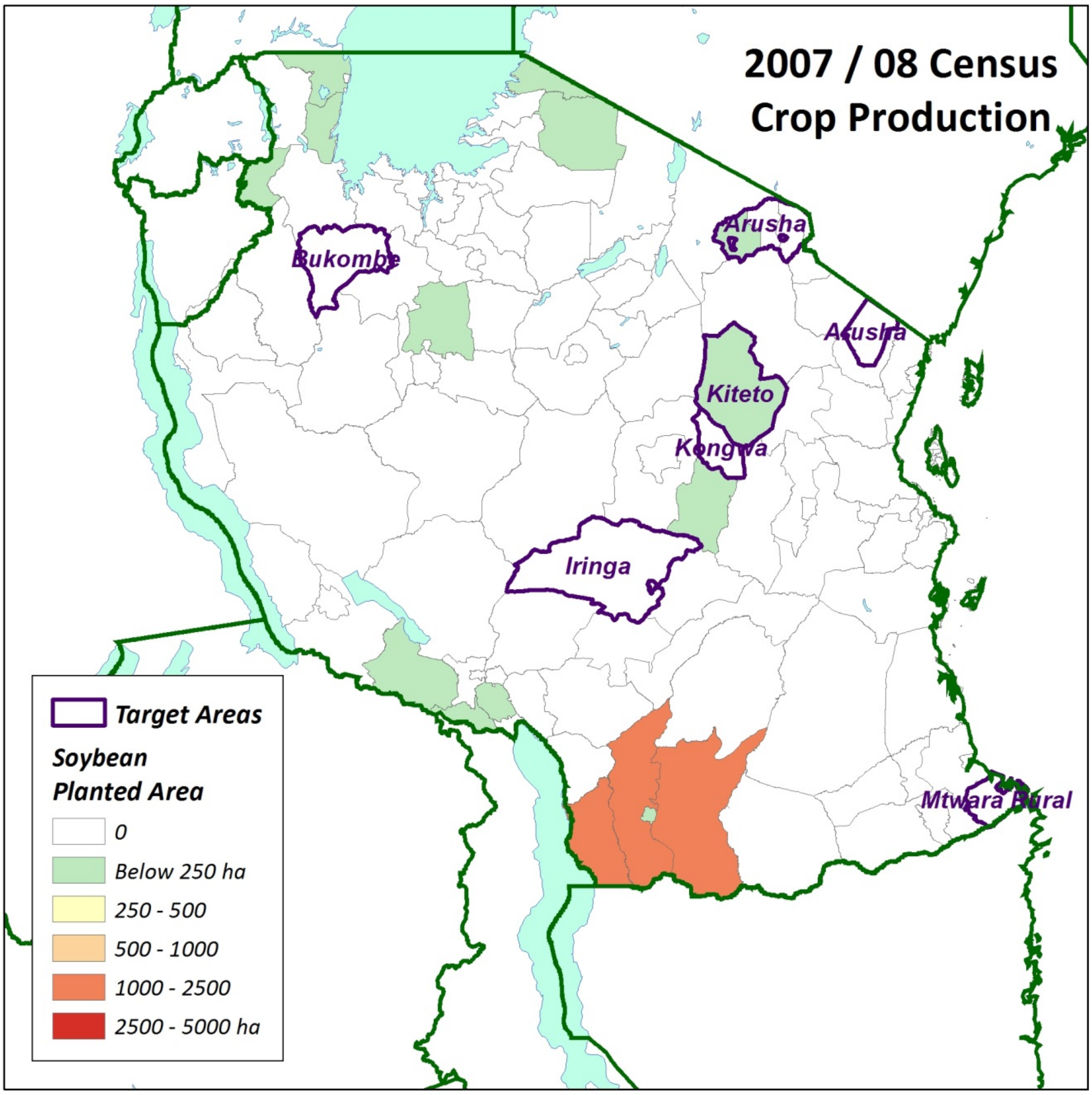

Figure 4. Soybean planted area in Tanzania per district. Source: MAFSC, et al., 2012.

The districts with the largest area dedicated to groundnut were in the central and west of Tanzania around Dodoma, Mpanda and Tabora (Figure 5). Of the target areas for groundnut only Kongwa registered more than 10,000 hectares, with no production at all in Bukombe.

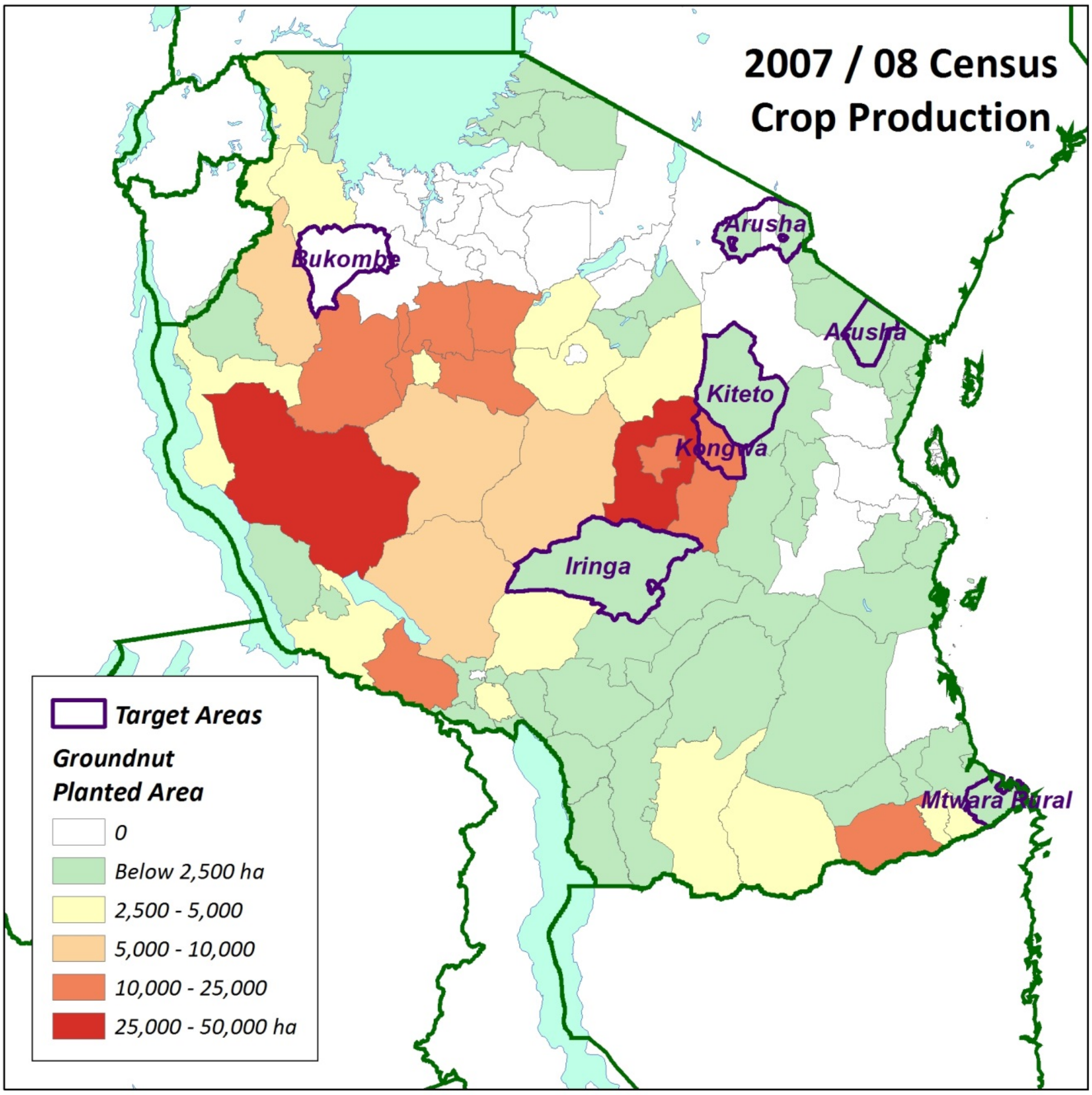

Figure 5. Groundnut planted area in Tanzania per district. Source: MAFSC, et al., 2012.

The target areas for common bean are districts that have large areas planted with common bean. However significant areas of common bean production (e.g. Kagera, Kigoma and Southern Highlands) have not been targeted in the project (Figure 6).

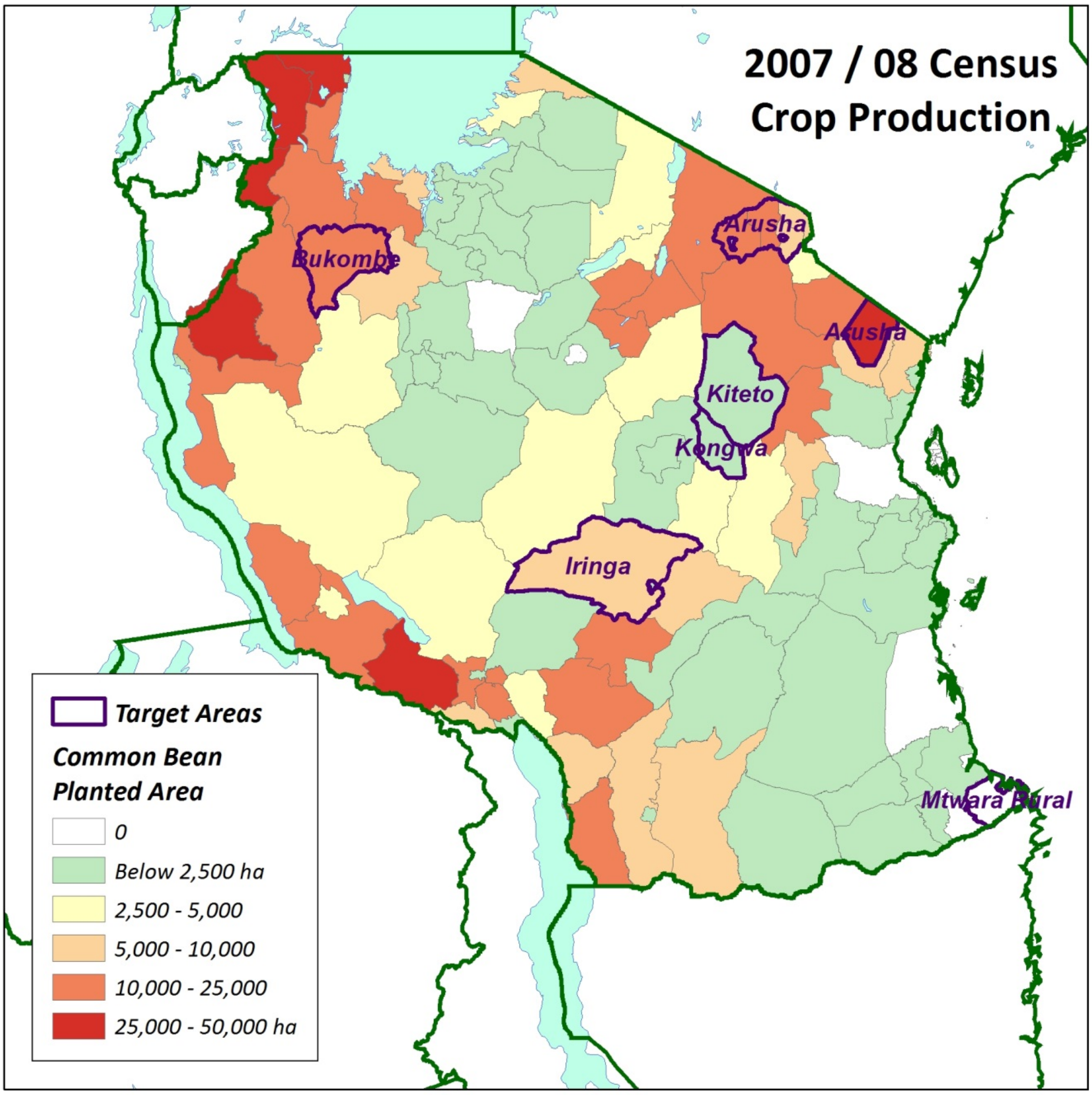

Figure 6. Common bean planted area in Tanzania per district. Source: MAFSC, et al., 2012.

Another source of data on cropping systems is available from the Atlas of common bean in Africa (CIAT, unpublished). This is a compilation of expert knowledge and refers to specific bean production areas in various countries. In Tanzania there are eleven different bean production areas, which cover the western, northern and southern highlands and mid altitude areas. Information was collected on the cropping systems of common beans, and the main intercrop (Table 9).

The most common cropping system for common beans in the target districts is as an interctop with maize, apart from the northern semi-arid highlands and in Lushoto where beans are grown as a sole crop. The bean-coffee-banana system is encountered around Arusha and is the most common system in Kagera.

Table 9. Cropping systems for common beans per district in each target area

Zone	Target districts	'Best bet' Legume crop	Common bean Cropping system
Northern	Arusha rural, Meru, Siha, Hai, and Moshi rural	Common bean	Maize intercrop, Coffee Banana intercrop
	Kiteto	Groundnut	Sole crop
	Lushoto	Common bean	Sole crop, Maize intercrop
Lake	Bukombe	Groundnut	Maize intercrop
Central	Kongwa	Groundnut	
Southern Highlands	Iringa	Soybean	Maize intercrop
Southern	Mtwara	Groundnut	

Livelihood zones incorporate not only the major environmental characteristics but also the exploitation of these resources for agriculture. A set of 14 livelihood zones were constructed in 2010 (Table 10) by a group of individuals (Perfect and Majule, 2010) representing various NGO, governmental and academic institutions, facilitated by FAO and IRA (Institute of Resource Assessment University of Dar es Salaam, Tanzania). The zones and accompanying profiles were developed as part of a water management project and therefore have a tendency to emphasise water management technologies, but are still valid because of the high dependence on agriculture in much of Tanzania.

Table 10. Livelihood zones in Tanzania

FAO Livelihood zone	Description
LZ 1	Highlands, humid, high rainfall, bi-modal coffee and banana zone
LZ 2	Cotton, paddy and cattle midlands
LZ 3	Tobacco-cotton zone
LZ 4	Unimodal, semi-arid, sorghum livestock zone
LZ 5	Pastoral zone
LZ 6	Coastal zone-tree crop(Cashew, coconut, fishing zone, spices, tourism)
LZ 7	Lake Tanganyika zone
LZ 8	Plantation zone (tree, pyrethrum and tea)
LZ 9	Maize, cassava, cashew, Simsim zone
LZ 10	Rice zone
LZ 11	Sisal, sugar cane and cattle
LZ 12	Maize-tobacco zone
LZ 13	Unimodal rainfall (Rice, maize, pulse, banana, tree, fishing, tourism, cotton, mining)
LZ 14	Bimodal rainfall (Rice, maize, banana, fishing, tourism, Cotton, mining)

Some of these zones seem to contradict other sources, for instance the bimodal rainfall zone of Iringa and Chunya is considered a unimodal area in most other sources, however the profiles for each of these zones appear more consistent with other sources. Using these zones for stratification is not easy because the construction of the zones was not based on a protocol, but a comparison shows that for groundnuts at least the choice of target districts allows for four different livelihood zones to be compared (Table 11).

Table 11. FAO Livelihood zones per district in each target area

Zone	Target districts	'Best bet' Legume crop	FAO LZ	Reference to legumes
Northern	Arusha rural, Meru, Siha, Hai, and Moshi rural	Common bean	1	Common beans noted as important food and cash crop
	Kiteto	Groundnut	5	Pigeon pea noted as important food crop
	Lushoto	Common bean	1	Common beans noted as important food and cash crop
Lake	Bukombe	Groundnut	2	No mention
Central	Kongwa	Groundnut	4	Groundnut and pigeon pea noted as important food crop
Southern Highlands	Iringa	Soybean	14	No mention
Southern	Mtwara	Groundnut	6	Pulses are mentioned as important food crop

An earlier alternative zoning was constructed by FEWS NET in 2008 in collaboration with the Tanzania Food Security Information Team (FSIT). The methodology applied by FEWS NET was similar to FAO but included four regional workshops rather than a national workshop. The number of zones created was also significantly larger with 78 zones identified. Each zone is accompanied with a livelihood profile highlighting the major food crops, sources of income, livestock and hazards. The description of the rainfall pattern reflects better other sources and this assessment is probably better than the IRA/FAO livelihood zones, although may be difficult to use for stratification (due to the large number of zones) but is useful in characterising the target areas.

There is greater diversity between rather than within the target areas and the best bet legumes fit well, however soybeans are not mentioned explicitly in the description of the livelihood zones, and the common legumes in the Southern highlands target area are instead common beans and groundnuts.

Table 12. FEWS NET Livelihood zones per district in each target area

Zone	Target districts	'Best bet' Legume crop	FEWS NET LZ	Reference to legumes
Northern	Arusha rural, Meru, Siha, Hai, and Moshi rural	Common bean	11 - Kilimanjaro-Meru Maize, Coffee, and Plantains 13 - Lower Arusha-Simanjiro Maize	11 – No mention 13 – Common beans noted as important food crop
	Kiteto	Groundnut	1 - Southern Maasai Pastoralist 17 - Kiteto-Kongwa-Mpwapwa-Mvomero Maize, Sorghum, and Pigeon Pea	1 – Common beans noted as important food crop 17 – Pigeonpea mentioned
	Lushoto	Common bean	5 - Usambara-Pare Highland 6 - Tanga Maize, Orange, and Jackfruit Midlands	5 – Common beans noted as important food crop 6 – No mention
Lake	Bukombe	Groundnut	29 - Mwanza-Shinyanga-Mara Cotton, Livestock, Cassava, and Maize 34 - Kahama-Tabora Midland Tobacco, Maize, Rice, and Livestock	29 - No mention 34 - No mention
Central	Kongwa	Groundnut	17 - Kiteto-Kongwa-Mpwapwa-Mvomero Maize, Sorghum, and Pigeon Pea 55 - Singida-Dodoma Sorghum, B/Millet, Sunflower, and Livestock	17 – Pigeonpea mentioned 55 - Groundnuts noted as important cash crop
Southern Highlands	Iringa	Soybean	40 - Ruaha Riverine Maize, Onion, Tomato, and Paddy Lowlands 74 – Njombe-Mufindi Maize, Irish Potato, and Bean 75 - Iringa-Mbarali Maize, Sunflower, Beans, and Groundnut Belt	40 - Common beans noted as important food crop 74 - Common beans noted as important food and cash crop 75 - Common beans noted as important food crop, Groundnuts noted as important cash crop
Southern	Mtwara	Groundnut	53 - Southeastern Plateau Cassava, Cashew, and Bambara Nuts	53 - Bambara Nuts noted as important food and cash crop

2.4 Stratification according to biophysical relevance of the legume technology

The characterisation of Tanzania according to the key biophysical variables suggests that stratification using agro-climatic variables is unlikely to change the broad target areas and the choice of legumes but remains a useful tool for communicating the rationale behind those decisions and allows the identification of areas with similar biophysical contexts.

The length of growing period is a common indicator of agro-ecological potential and in East Africa a threshold of 200 days has been used to differentiate areas with higher and lower agro-ecological potential (ASARECA, 2005). (Figure 7).

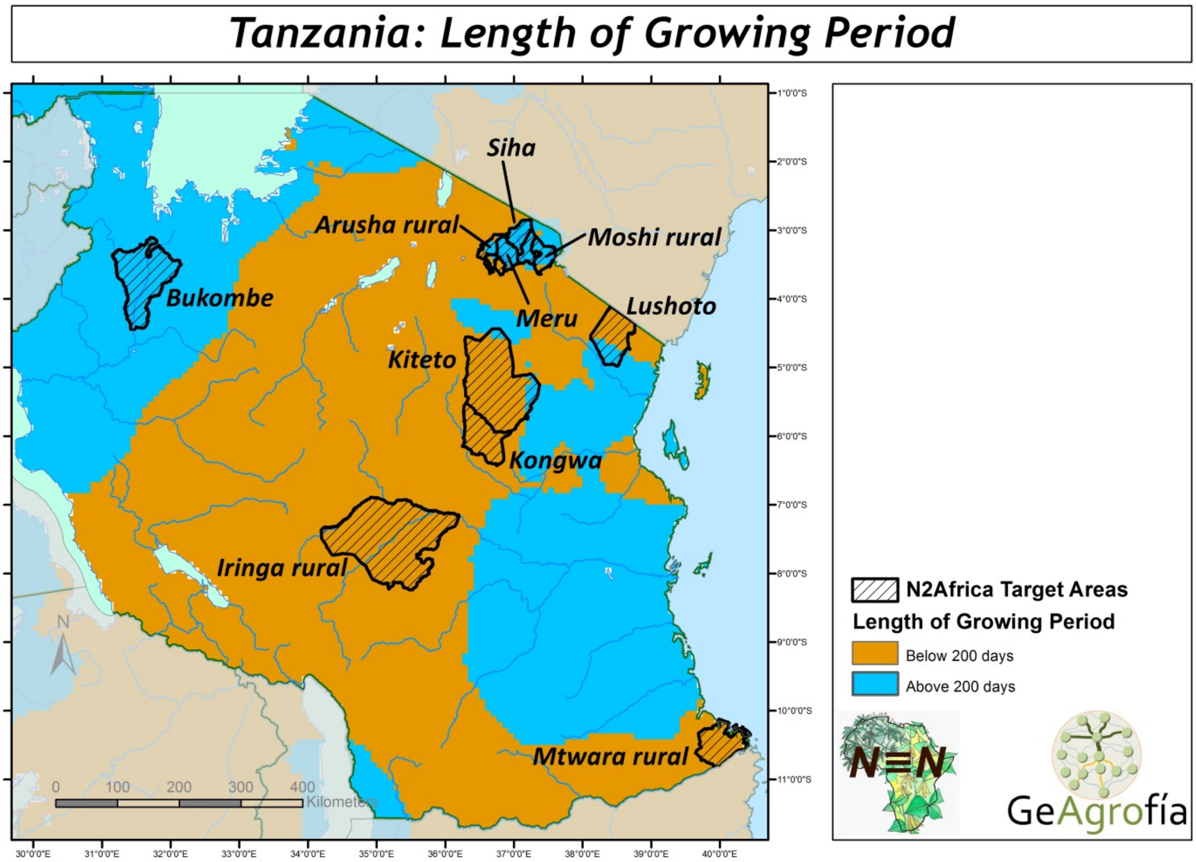

Figure 7. Spatial stratification of Tanzania based on Length of Growing Period. Source: van Velthuizen et al., 2007

The result of stratifying Tanzania based on the LGP is that the central districts of Iringa, Kongwa and Kiteto, as well as the southern district of Mtwara are classified as having a short growing period and the other districts as humid (Table 13).

Table 13. Stratification of target districts according to average mean temperature in the wettest quarter in Uganda

Short growing period	Long growing period
Kongwa, Iringa, N Lushoto, Mtwara and Kiteto	Arusha rural, Meru, Siha, Hai, Moshi rural, S Lushoto, and Bukombe

3 Land availability, quality or tenure

Availability of land, its quality and continued access to land was shown to be a major constraint to or a factor affecting the adoption of legumes in Africa (Farrow, 2014). Indicators of land availability include farm size summaries for districts or regions as well as proxy measures such as rural population density.

3.1 Farm size

Information on farm size has been captured in the 2007/08 agricultural census and summarised for each region in different size classes. Data are not presented for each district, but instead are shown for different types of agricultural households: crops only, livestock only, pastoralists, and crops and livestock (Figure 8, Figure 9, Figure 10, Figure 11, Figure 12, Figure 13, Figure 14, and Figure 15).

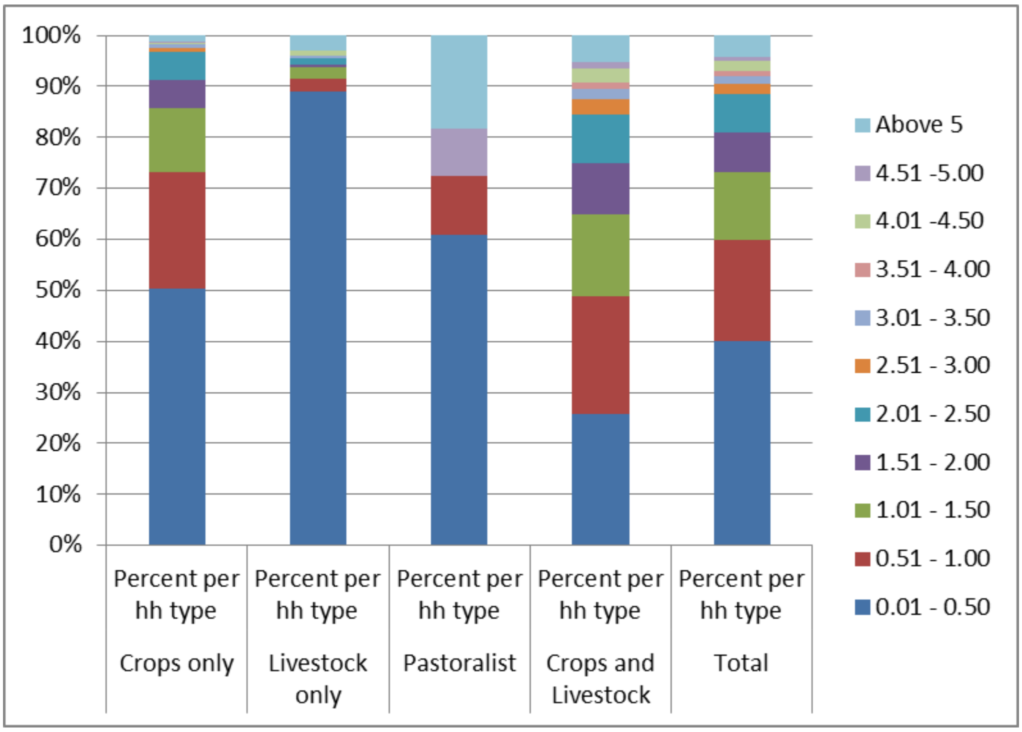

Figure 8. Farm size distributions in Arusha region. Source: MAFSC, et al., 2012

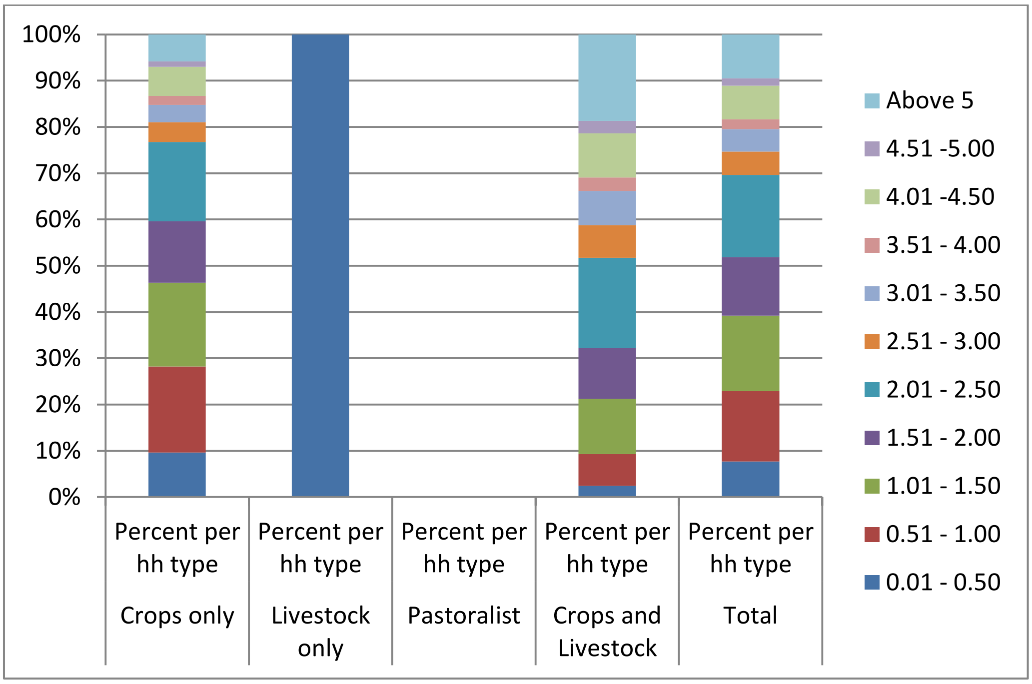

Figure 9. Farm size distributions in Dodoma region. Source: MAFSC, et al., 2012

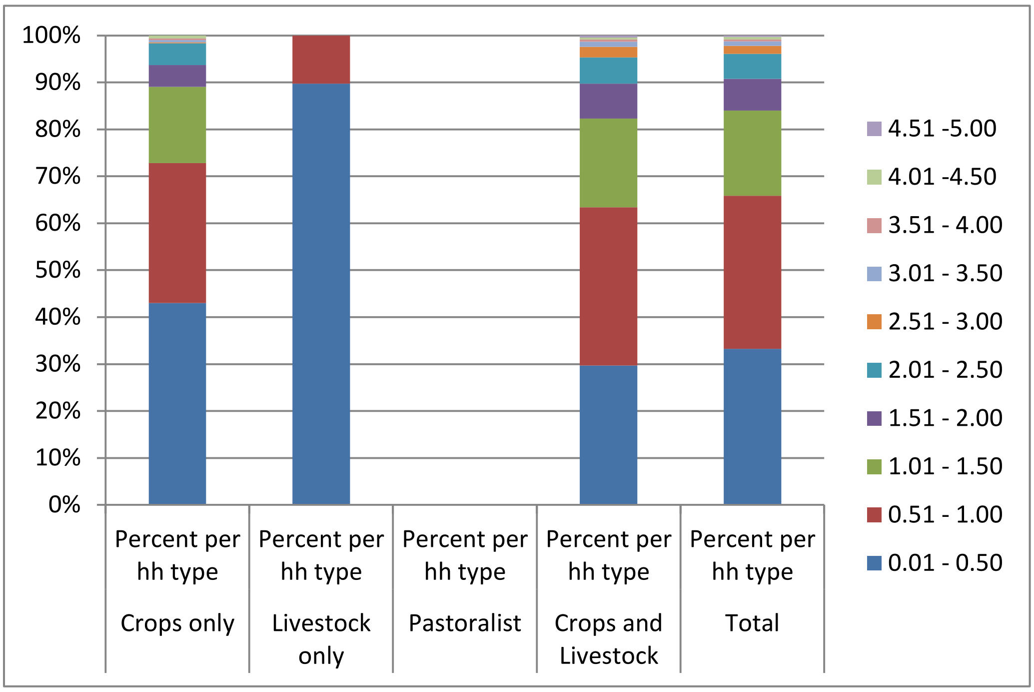

Figure 10. Farm size distributions in Kilimanjaro region. Source: MAFSC, et al., 2012

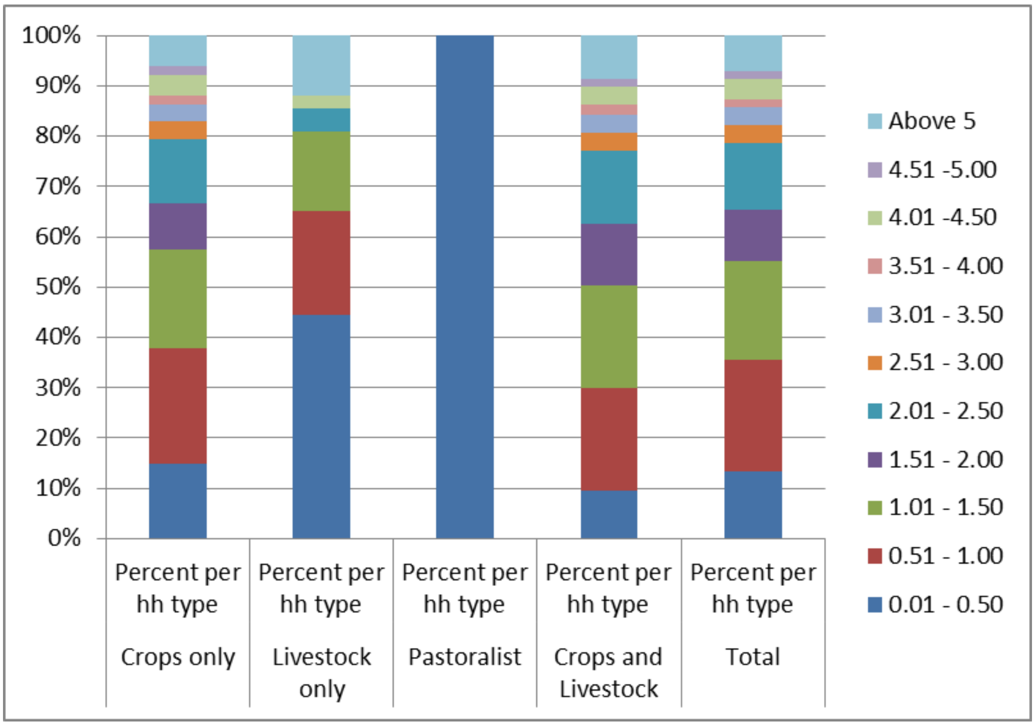

Figure 11. Farm size distributions in Tanga region. Source: MAFSC, et al., 2012

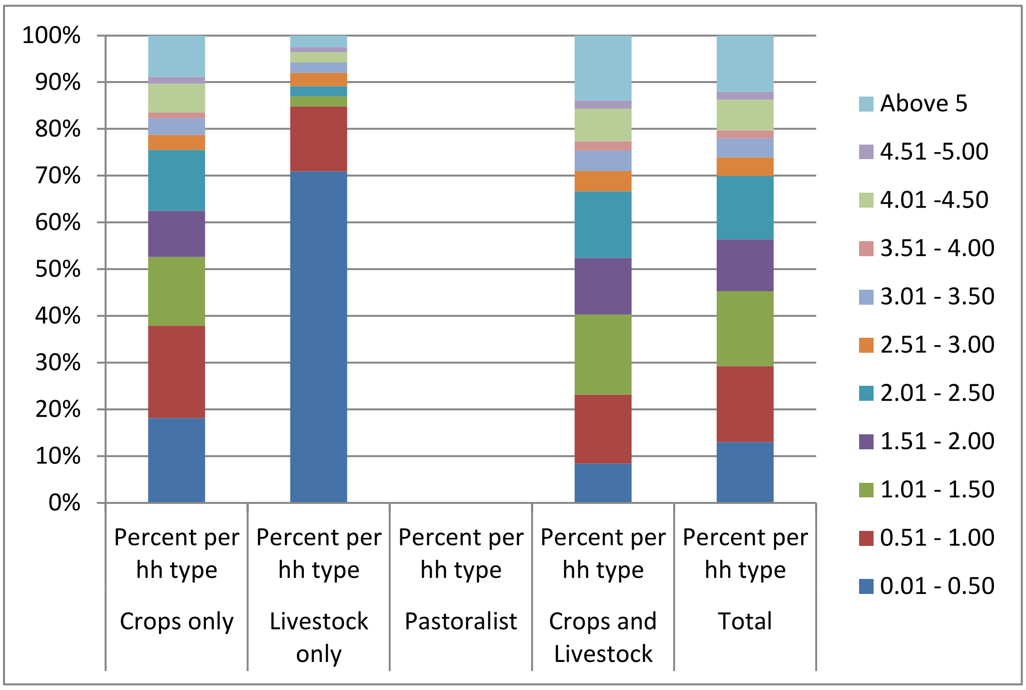

Figure 12. Farm size distributions in Manyara region. Source: MAFSC, et al., 2012

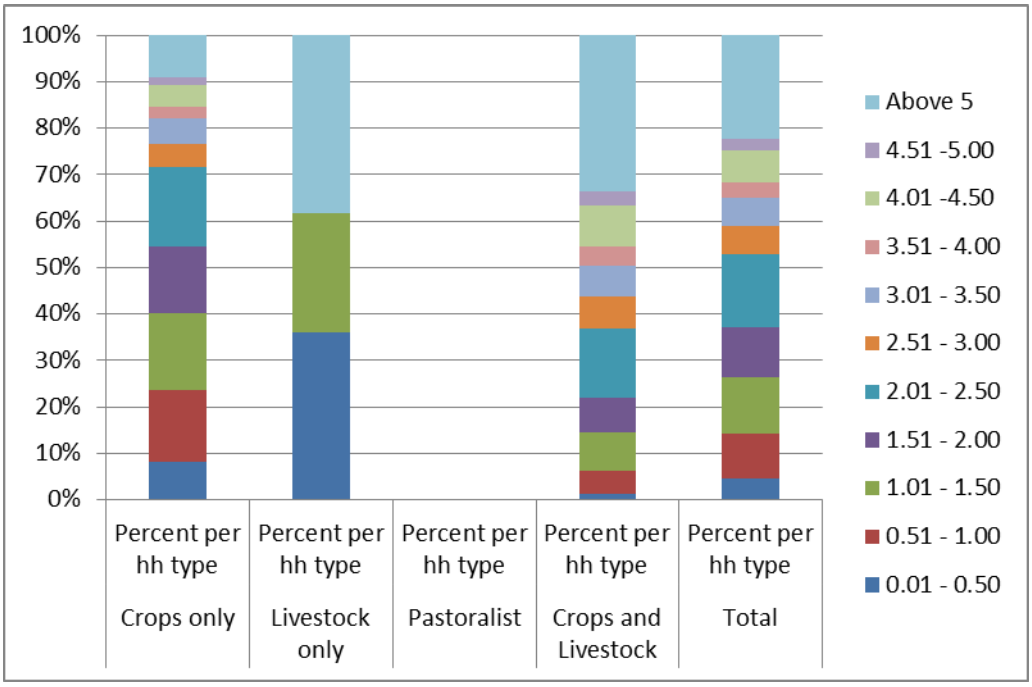

Figure 13. Farm size distributions in Shinyanga region. Source: MAFSC, et al., 2012

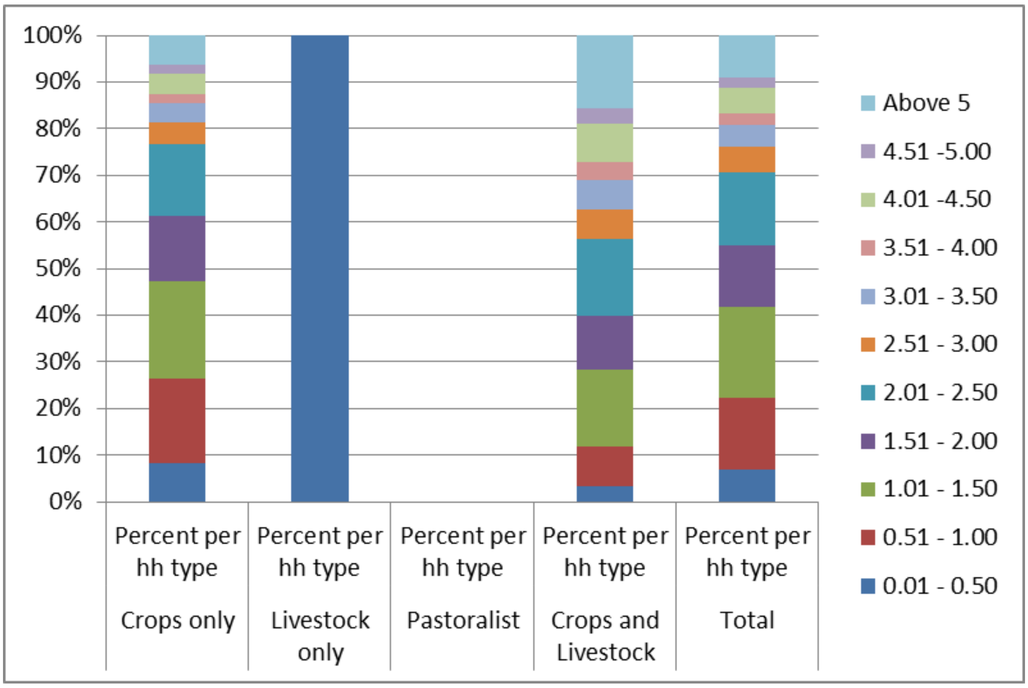

Figure 14. Farm size distributions in Iringa region. Source: MAFSC, et al., 2012

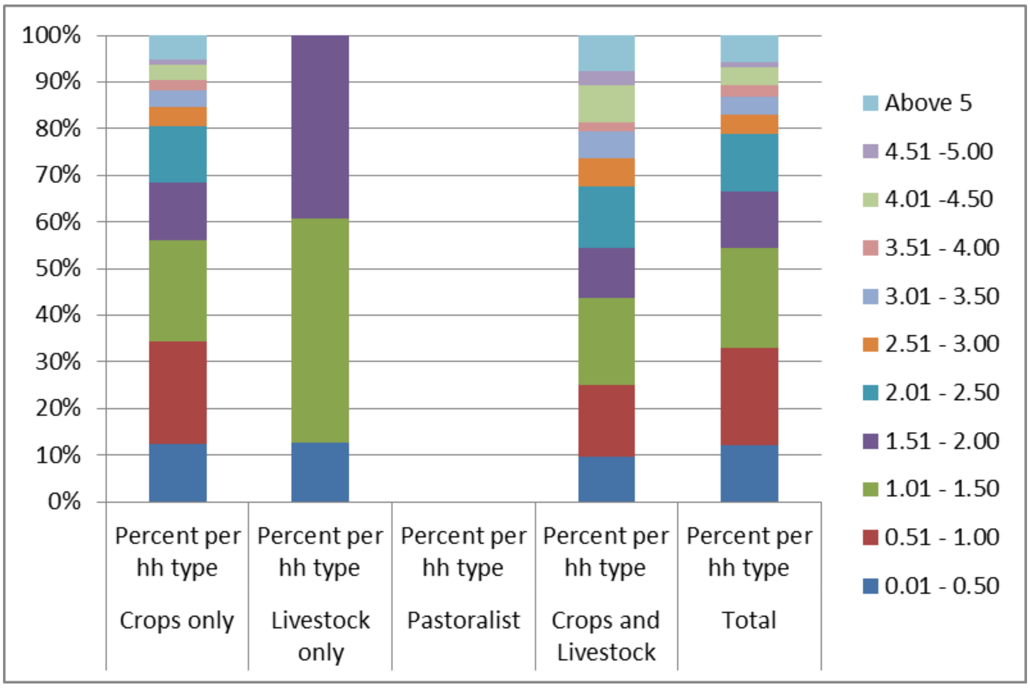

Figure 15. Farm size distributions in Mtwara region. Source: MAFSC, et al., 2012

Only in Arusha do farms with livestock-only contribute a significant portion of the farm households (15% of all farms), while pastoralists are either absent from the target regions or are too small to make difference to the total distribution of farm households. The aggregate figures for each region are therefore a good indication of the households who are likely to use and benefit from N2Africa and if some assumptions are made the average farm size can be calculated for each region.

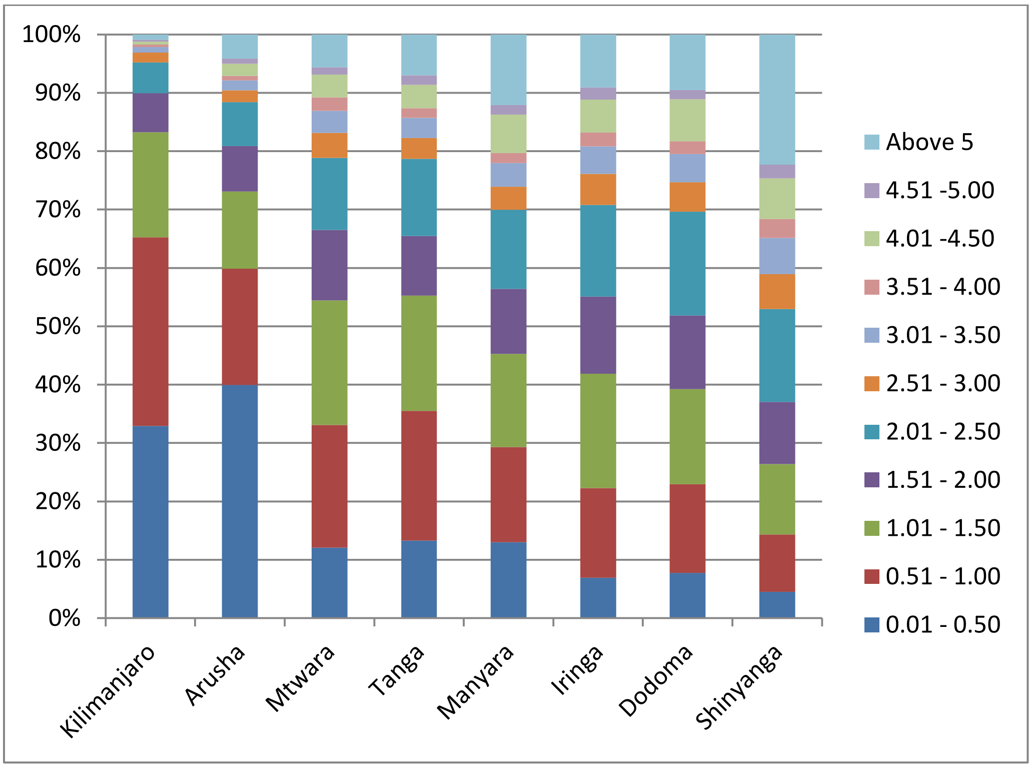

Figure 16. Farm size distributions in selected regions of Tanzania. Source: MAFSC, et al., 2012

When the distributions of farm size are compared among the target regions (Figure 16) there are clear differences, with Arusha characterised by many small farms whereas regions like Shinyanga have more big farms, Kilimanjaro has a similar pattern to Arusha but has more intermediate size farms and fewer large farms than Arusha.

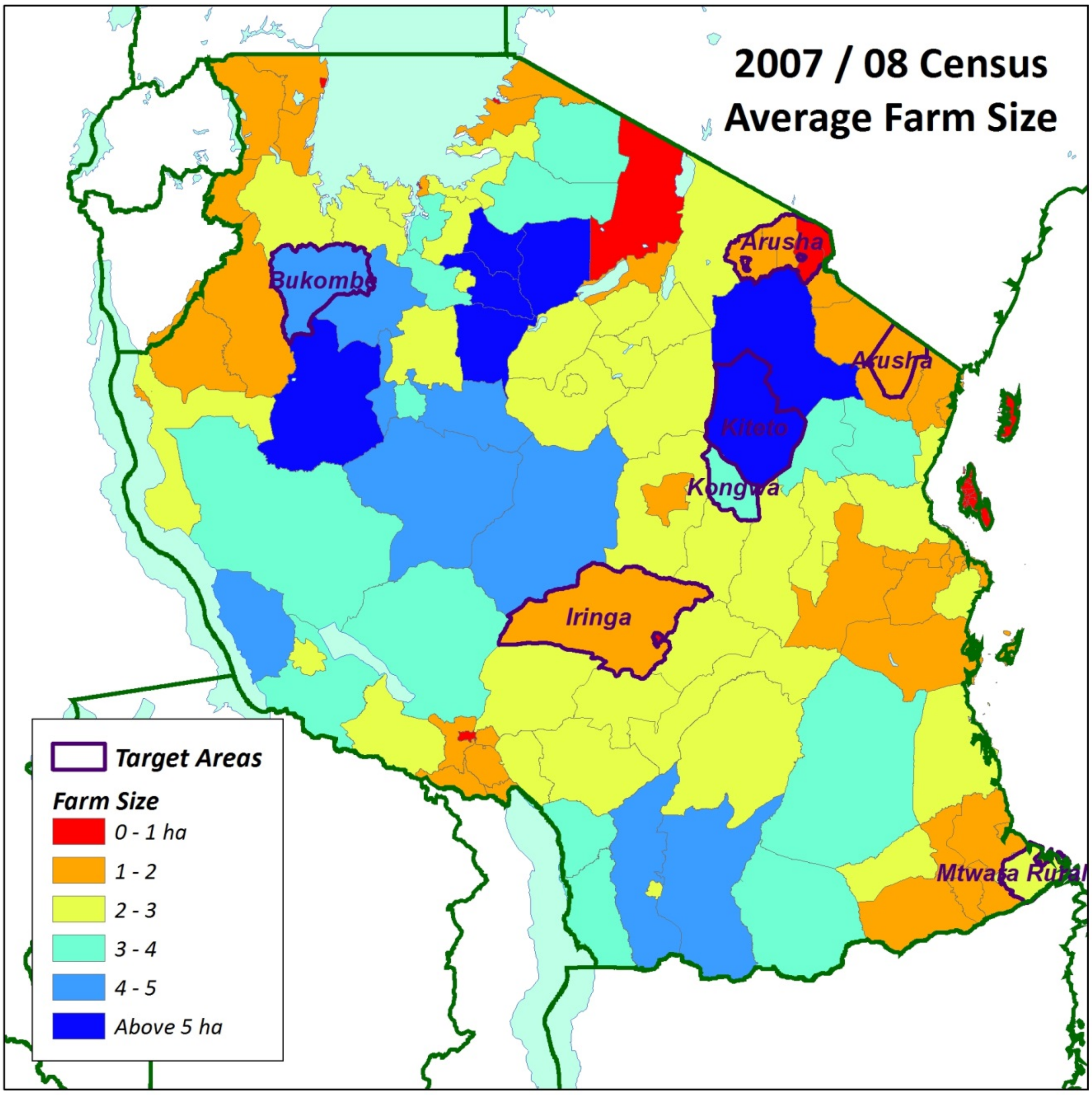

Figure 17. Average farm size per district (authors calculation). Source: MAFSC, et al., 2012

While there are no district-level data regarding the distribution of farm sizes for the 2007/08 census there is information on the number of farm households per district and the total area that is dedicated to agriculture. This allows a calculation of the average area per agricultural household in each district (Figure 17).

What is clear from these figures is that the *a priori* best fit legume crops are highly associated with the amount of land available to an agricultural household. The difference between the regional and district estimates of average farm sizes are only large in the cases of Kongwa, Bukombe and Kiteto (Table 14).

Table 14. Farm size averages per region and district

Zone	Region	Regional mean (estimated from farm size classes)	Target districts	'Best bet' Legume crop	Mean farm size (from number of households and agricultural area)
Northern	Kilimanjaro	1.0	Moshi	Common bean	0.87
Northern	Tanga	1.8	Lushoto	Common bean	1.06
Northern	Arusha	1.2	Arumeru	Common bean	1.07
Northern	Kilimanjaro	1.0	Hai	Common bean	1.13
Southern Highlands	Iringa	2.2	Iringa	Soybean	1.95
Southern	Mtwara	1.8	Mtwara	Groundnut	2.29
Central	Dodoma	2.2	Kongwa	Groundnut	3.93
Lake	Shinyanga	2.8	Bukombe	Groundnut	4.47
Northern	Manyara	2.2	Kiteto	Groundnut	5.07

3.2 Population density

The biggest problem with the farm size data is the lack of district-level figures. A crude proxy for farm size is the population density where a greater proportion of small farm sizes is associated with high population density areas. The most recent data for population are from the 2012 population and housing census (Figure 18).

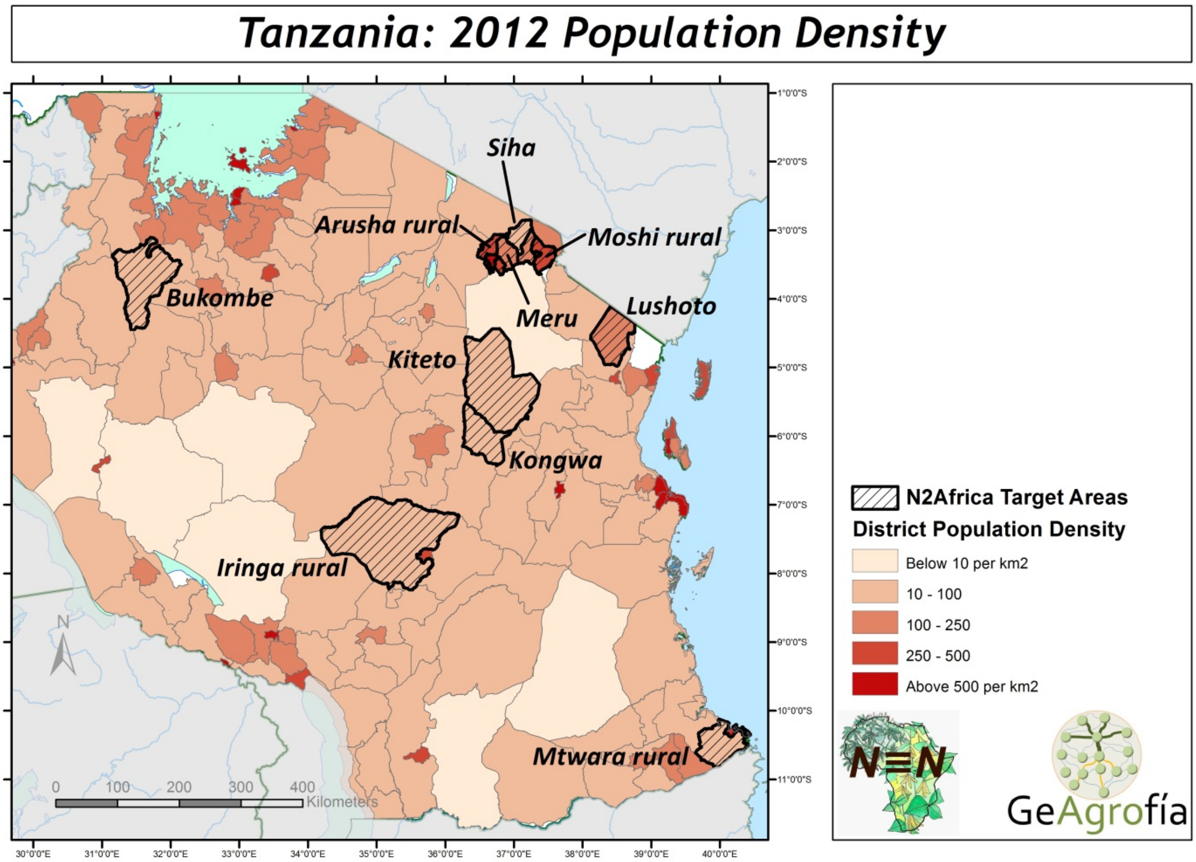

Figure 18. Population density per district (2012). Source: van National Bureau of Statistics and Office of Chief Government Statistician, 2013; authors calculation

These recent figures show that population density is highest in the Arusha and Kilimanjaro regions and most especially in the districts of Moshi rural and Arusha rural (Table 15). These are more or less consistent with the average farm sizes.

Table 15. Population density per target district (2012). Source: van National Bureau of Statistics and Office of Chief Government Statistician, 2013; authors calculation.

Zone	Region	Target districts	'Best bet' Legume crop	Population density (per km^2)
Northern	Arusha	Arusha rural	Common bean	335
		Meru	Common bean	210
	Kilimanjaro	Moshi rural	Common bean	357
		Hai	Common bean	232
		Siha	Common bean	95
	Tanga	Lushoto	Common bean	119
	Manyara	Kiteto	Groundnut	18
Lake	Shinyanga	Bukombe	Groundnut	28
Central	Dodoma	Kongwa	Groundnut	78
Southern Highlands	Iringa	Iringa	Soybean	14
Southern	Mtwara	Mtwara	Groundnut	61

Two different sources of spatially explicit data for population density from the 2006 and 2010 are also available and display the intra-district differences in population density. These maps show generally similar patterns of population density in the target districts in Tanzania, although differences between the datasets are apparent due to the methodologies used in their creation (Figure 19 and Figure 20).

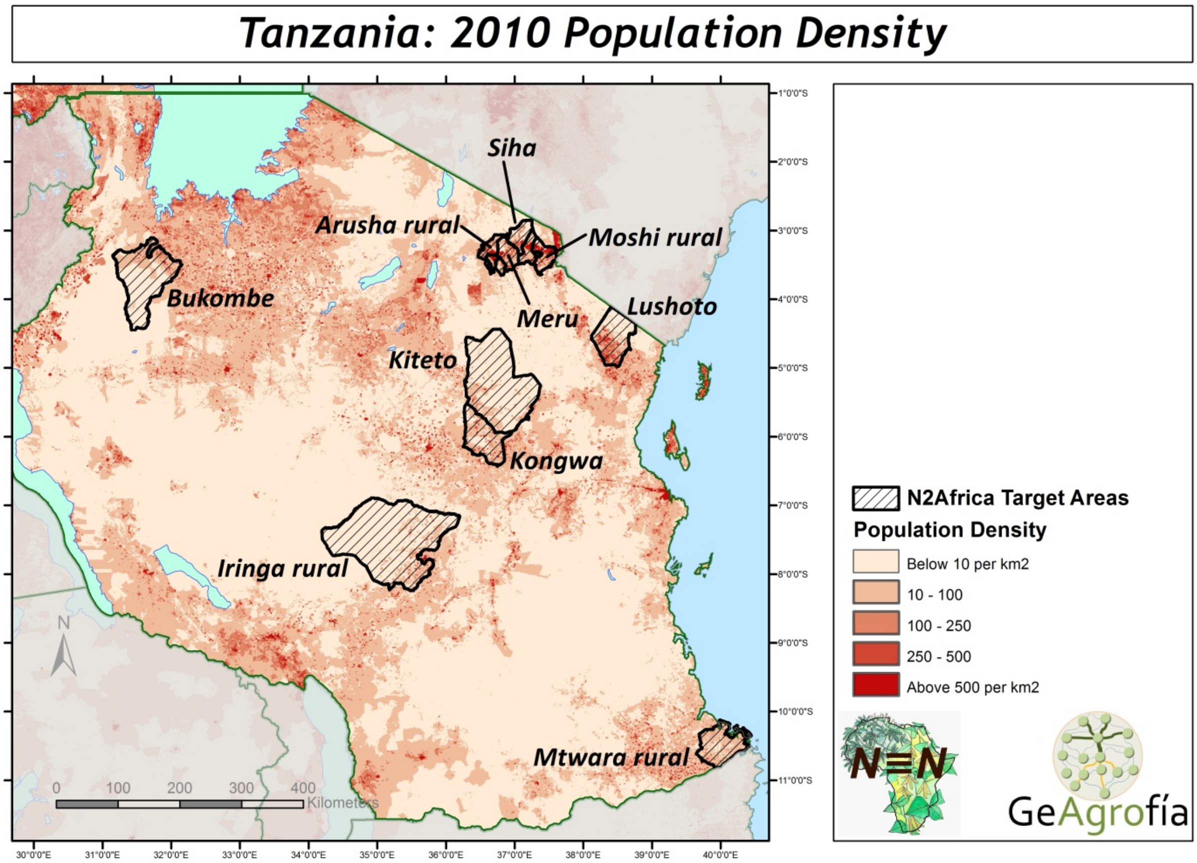

Figure 19. 2010 Population density in Tanzania. Source: AfriPop 2010 (Linard et al., 2010)

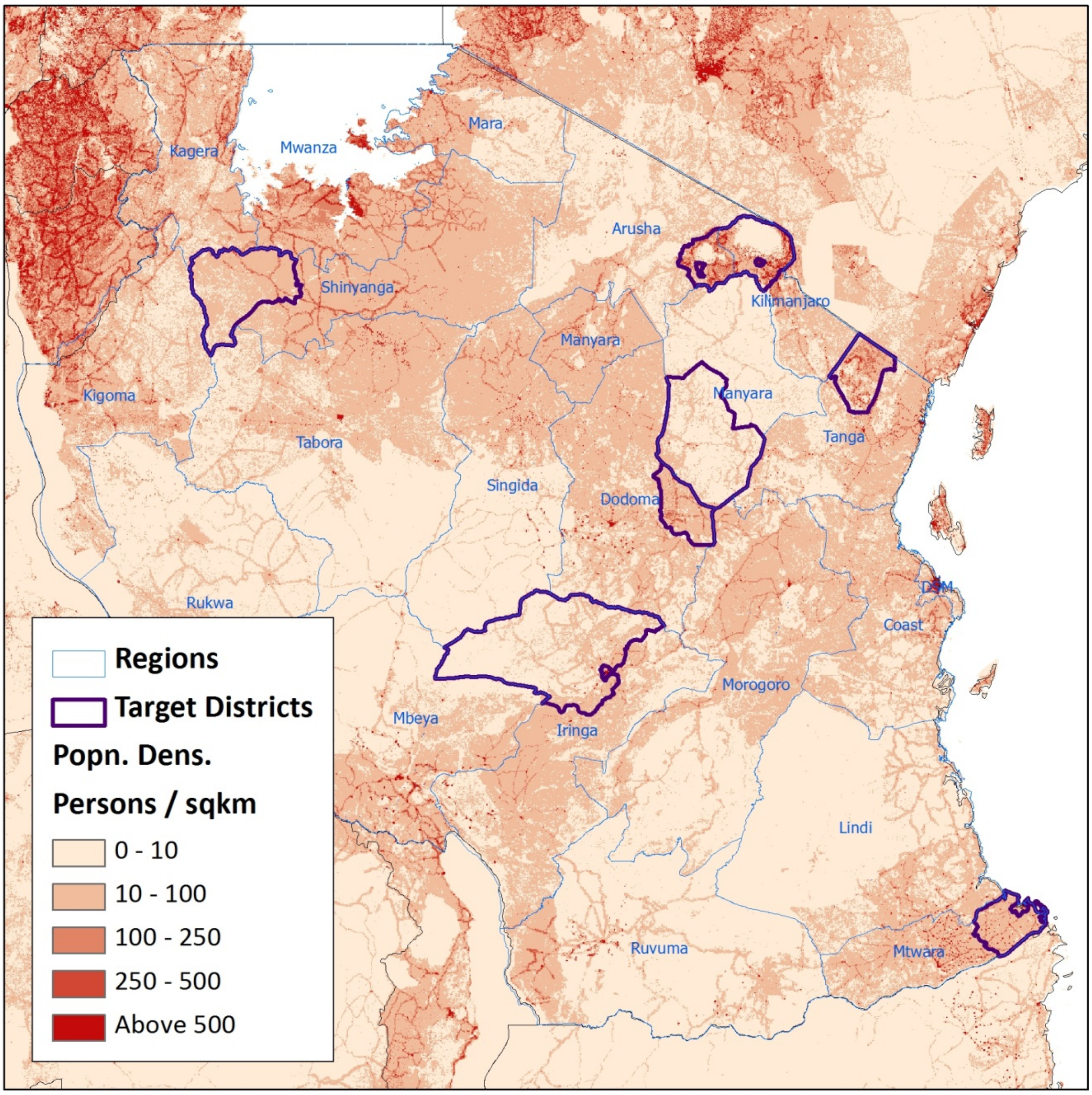

Figure 20. 2010 Population density in Tanzania. Source: LandScan2006 (Bright et al., 2007)

3.3 Land tenure

Land tenure systems can have effects on the adoption of agricultural technologies (Gavian and Ehui 1999; Gavian and Fafchamps 1996) and lack of security can hinder investment in legumes (Thomas and Sumberg, 1995). Land tenure systems are recorded for farms in Tanzania and are reported at the district level (Figure 21).

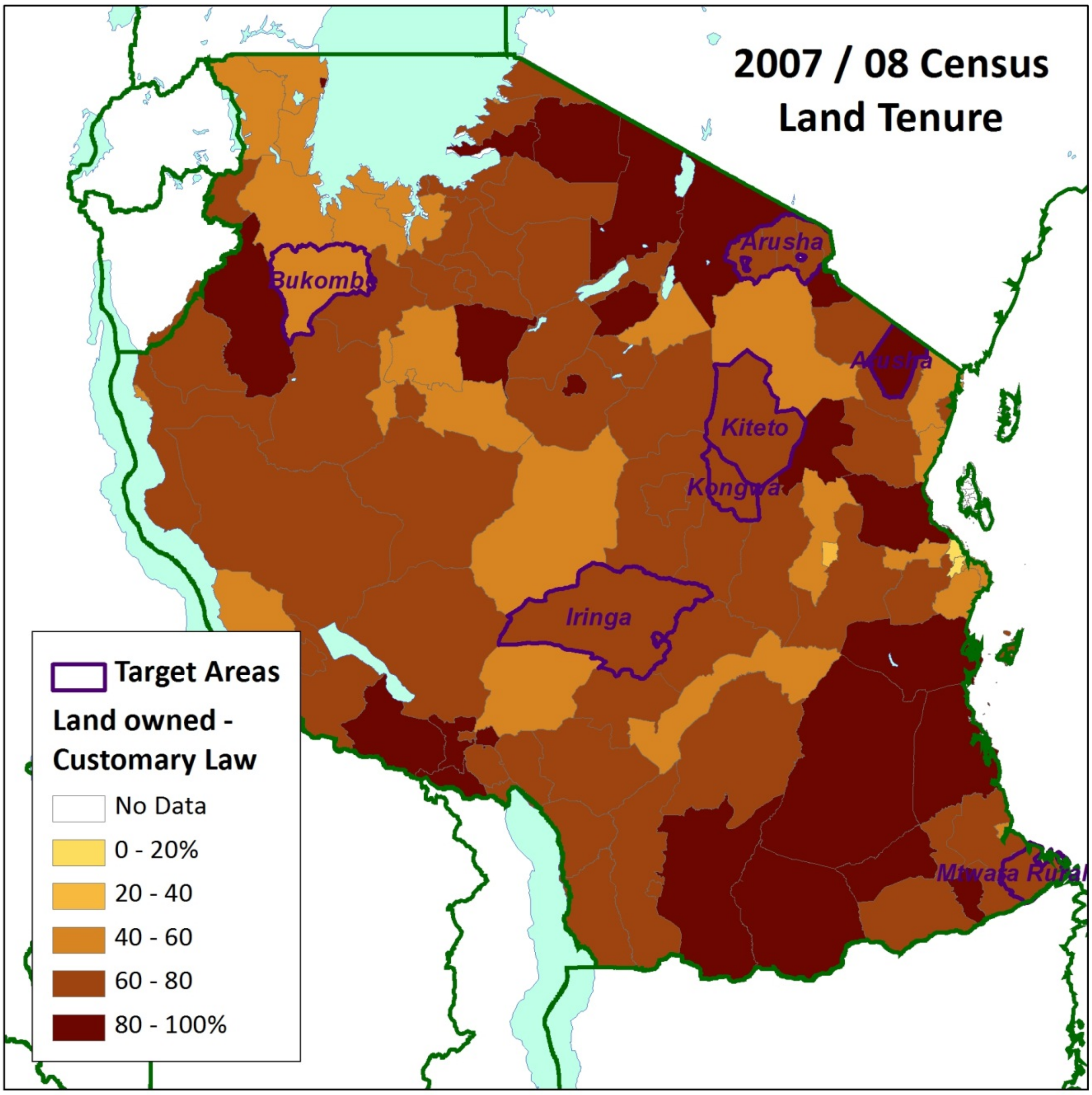

Figure 21. Percentage of land owned under customary law 2007/08. Source: MAFSC, et al., 2012.

The percentage of land that lacks security (i.e. is rented, borrowed or shared) is not more than 20% in any of the target districts (Table 16). There is also little correlation with average farm sizes and it is difficult to use tenure as a variable for stratification at the level of the country, but it might be become more apparent at the community and household levels.

Table 16. Percentage of land rented, borrowed or shared (2007/08) per target district

Zone	Region	Target districts	'Best bet' Legume crop	% of land rented, borrowed or shared
Northern	Kilimanjaro	Moshi	Common bean	13
Northern	Tanga	Lushoto	Common bean	3
Northern	Arusha	Arumeru	Common bean	10
Northern	Kilimanjaro	Hai	Common bean	15
Southern Highlands	Iringa	Iringa	Soybean	8
Southern	Mtwara	Mtwara	Groundnut	2
Central	Dodoma	Kongwa	Groundnut	18
Lake	Shinyanga	Bukombe	Groundnut	9
Northern	Manyara	Kiteto	Groundnut	15

3.4 Stratification according to land availability, quality or tenure

Ruecker et al., (2003) use a density of 100persons per km^2 which allows discrimination between and within districts in the target area and shows clearly those areas where land availability is an issue (Figure 22).

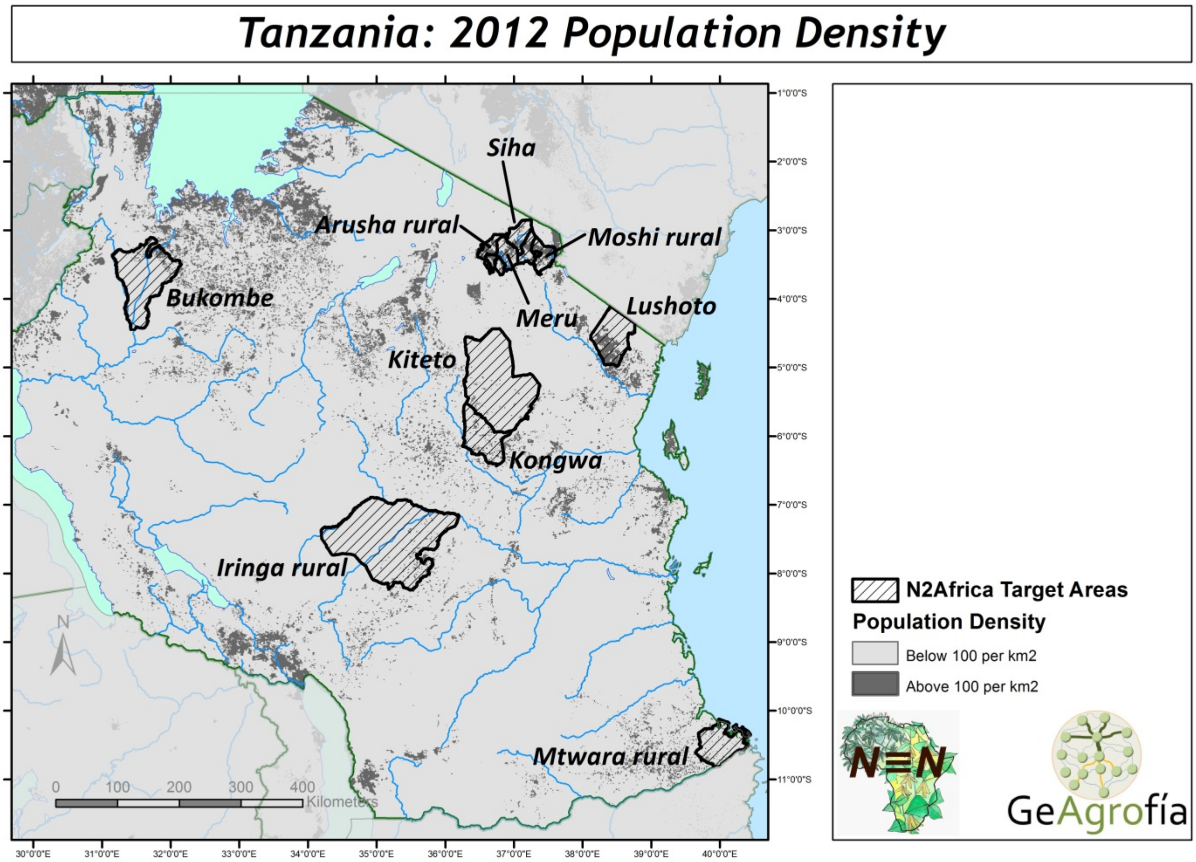

Figure 22. Population density threshold applied in Tanzania

The result of stratifying Tanzania based on population density and farm size is that the northern highland districts (except Siha) are classified as high density whereas all other districts are classified as low density (Table 17).

Table 17. Stratification of target districts according to average mean temperature in the wettest quarter in Uganda

High Population density /Small farm sizes	Lower Population density / larger farm sizes
Arusha rural, Meru, Hai, Moshi rural and Lushoto	Kiteto, Bukombe, Kongwa, Siha, Iringa and Mtwara

4 Output market for agricultural (legume) products

Access to markets for grain legumes is seen as a pre-requisite for increasing the adoption of improved legume varieties, inputs and practices that can increase productivity. Successful engagement with markets has many components including access to information, and the ability to meet market demands for quality and quantity. Some of these factors are dynamic, or are not dependent on location and are therefore difficult to incorporate into a stratification scheme, however physical access to markets is an important pre-requisite for successful engagement with output markets and can be mapped or modeled (e.g. Deichmann, 1997; Geurs et al., 2001) and used to stratify regions into areas with poor and good access (Ruecker et al., 2003; ASARECA, 2005).

The general method for modelling access to markets follows Farrow et al. (2011; 2013) in a raster environment using a 'costdistance' algorithm (Esri, 2012) that calculates the shortest weighted distance to the nearest market across a friction surface; the surface is composed of roads, land cover and barriers to movement (Appendix 1) and is modified by slope which is treated in the same way as in Nelson (2008).

Market access is assumed to be determined by the time required to reach a market location with thresholds representing the limits of acceptable proximity (Church and ReVelle, 1974). Different time thresholds are applied (Table 18) according to the attractiveness or importance of the market (Reilly, 1931). Each market type was modelled separately and the results combined to give a binary map showing good and poor market access areas (Figure 23, Figure 24, and Figure 25).

Table 18. Time threshold to reach different market types

Market importance	**Threshold (hours)**
Most important market	8
Next important market	6
Less important market	4
Least important market	1

The importance of markets for the three grain legume crops being tested in Tanzania can be indicated by the volume of trade at different market centres, but these data are not available for all crops and instead expert knowledge has been used (Baijukya, personal communication 13th February 2014). The market centres for common beans were extracted from information from the Atlas of Common bean in Africa (CIAT, unpublished) but were modified by partners from N2Africa (Table 19).

Table 19. Markets per crop according to different market types in Tanzania

Market importance	Common bean	Soybean	Groundnut
Most important markets	Arusha, Dar es Salaam, Iringa, Mbeya, Mpanda, Musoma, Mwanza, Njombe and Shinyanga	Dar es Salaam, Mbeya and Njombe	Arusha and Dar es Salaam
Next important markets	Kigoma, Makambako, Tabora and Uganda (Kagera)	Kenya and Makambako	Dodoma, Moshi, Mtwara and Tabora
Less important markets	Mafinga, Sumbawanga, Tanga and Tunduma	Arusha, Iringa, Morogoro, Moshi and Sumbawanga	Mwanza
Least important markets	Dodoma, Kenya, Singida, Zambia/DRC/Malawi and Zanzibar		Bukoba, Kenya, Lindi, Morogoro, Mpanda and Shinyanga

The model outputs show that coastal Tanzania has generally good access to markets for all three crops, due in part to the proximity to Dar es Salaam or to the main trading corridor towards the border with Kenya. Differences between the districts in target areas are noticeable for common bean where Lushoto has poorer market access than the districts around Arusha and Moshi (Figure 23). For the soybean target area there is a big difference within the district of Iringa with only eastern areas experiencing good market access (Figure 24). The situation for ground nut shows that Kongwa and Mtwara have good access to markets while Bukombe and Kiteto have poor access (Figure 25). Stratification based on market access (Table 20) can therefore help in both differentiating among districts and can be used to orient the location of some N2Africa activities, such as the baseline survey which will provide further information on market integration of smallholder farmers.

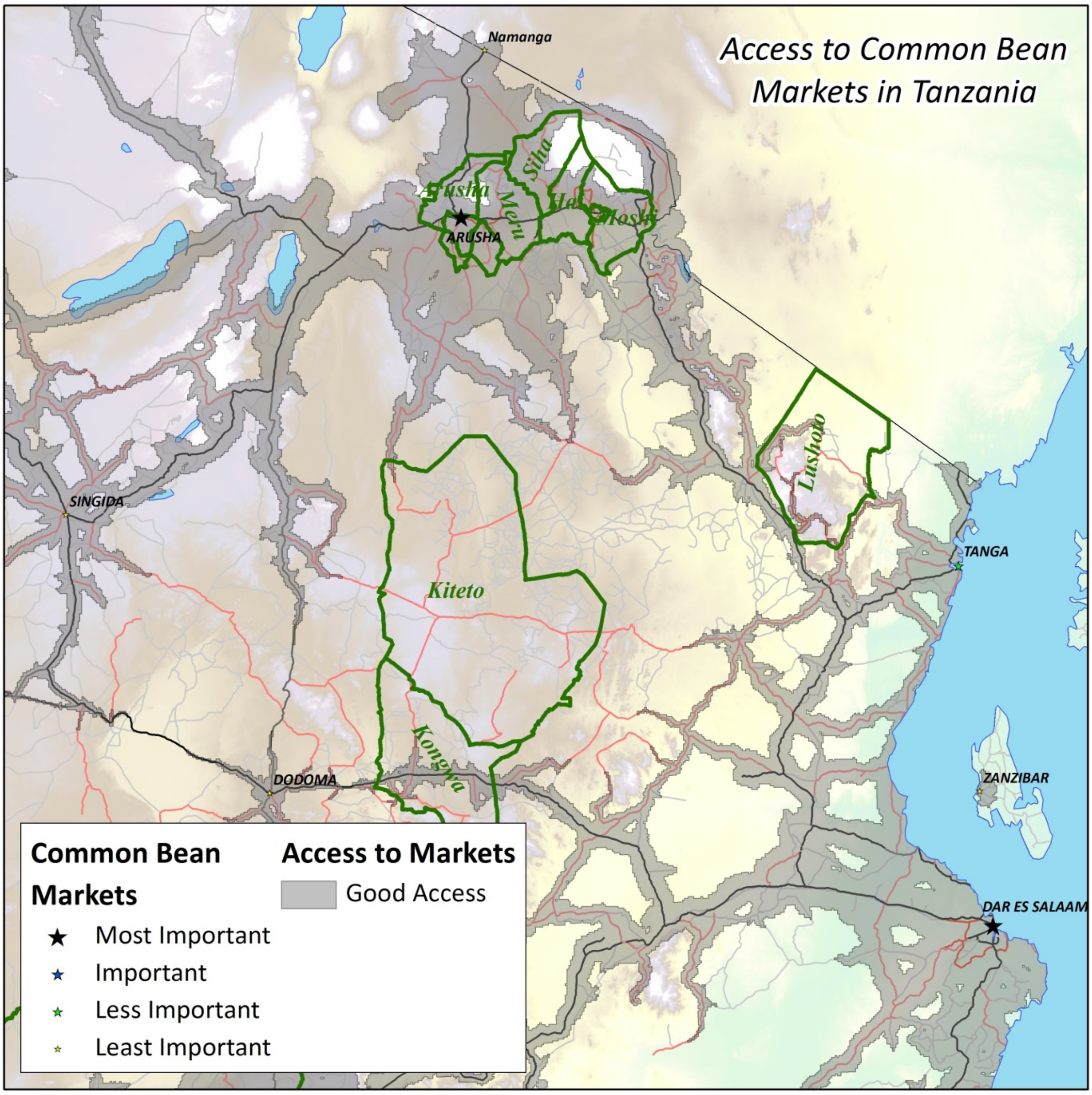

Figure 23. Access to common bean markets in Tanzania

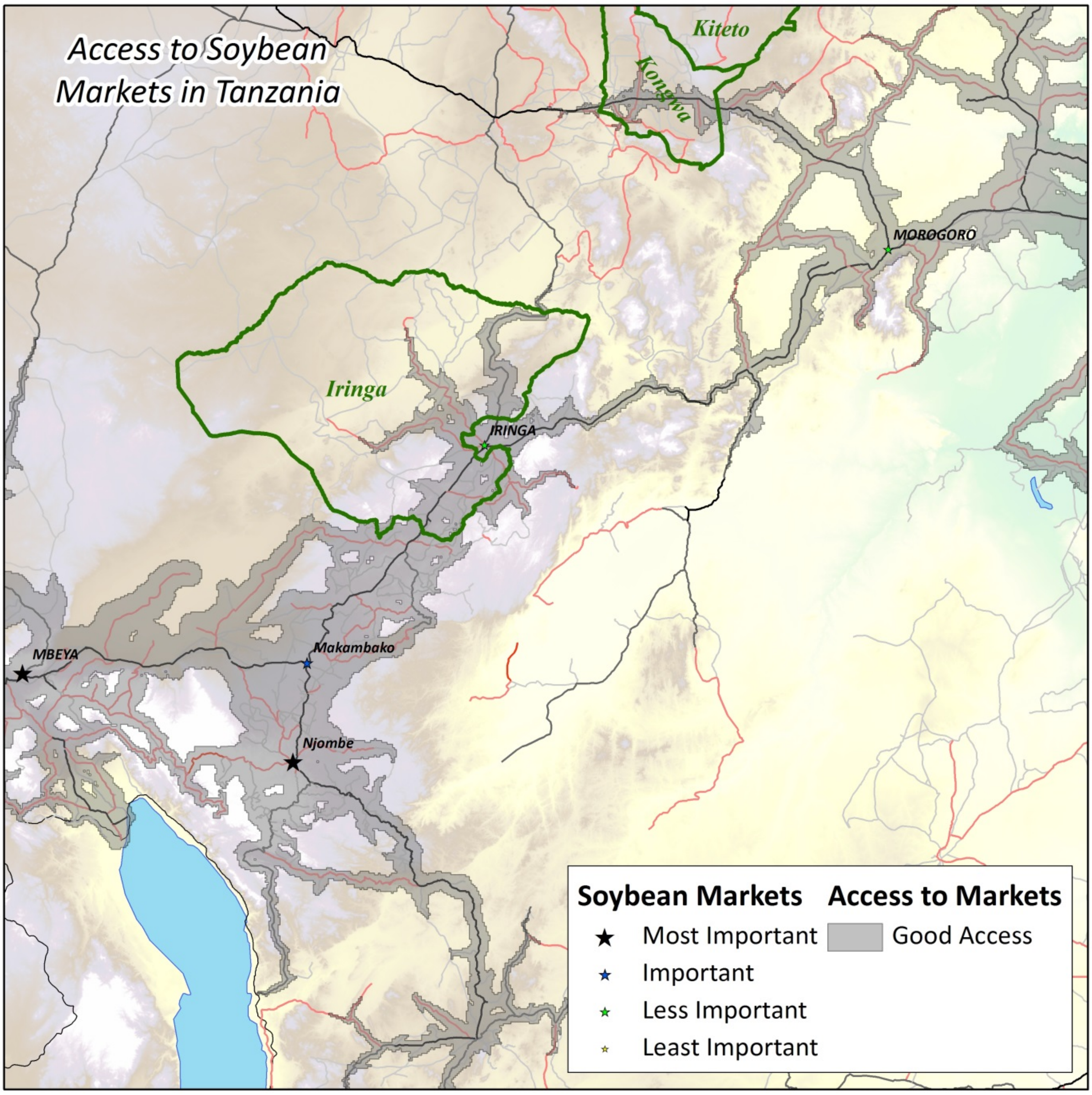

Figure 24. Access to soybean markets in Tanzania

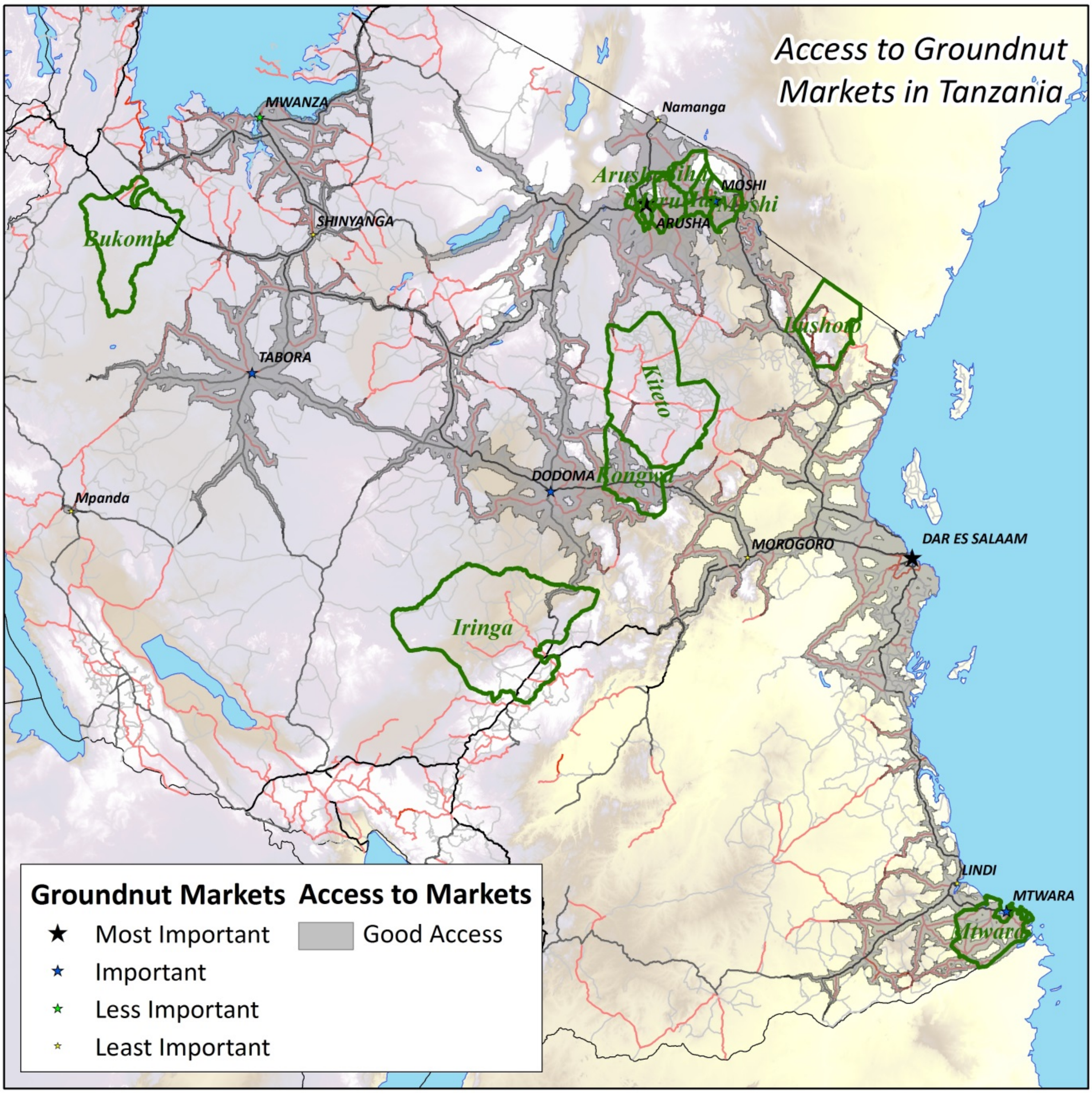

Figure 25. Access to groundnut markets in Tanzania

Table 20. Stratification of target districts according to market access in Tanzania

Good market access	Poor market access
Moshi rural, Arusha rural, Meru, Hai, Siha, Mtwara, Kongwa and parts of Iringa	Bukombe, Lushoto, Kiteto and parts of Iringa

5 Adoption domains

I construct domains based on the binary stratification of temperature (Table 13), population density/farm size (Table 17) and market access (Table 20). These three variables are considered as factors rather than constraints (Conchedda et al., 2001) and I do not describe suitability of any particular technology *per se*. Instead I combine the variables and create domains (Weber et al., 1996; Okike et al., 2000; ASARECA, 2005; Notenbaert et al., 2013; Homann-Kee Tui, et al., 2013) that have implications on the treatments and interventions (Kristjanson, et al., 2002) that will lead to the adoption of grain legumes.

When the three variables are combined there are eight possible domains (Table 21), these domains are unlikely to be equally representative of either the rural population or the land area due to the deliberate choice of thresholds for the three variables, but instead represent niches in which the legume technologies need to fit.

Table 21. Possible adoption domains based on binary stratification of key variables

		Short growing period	Long growing period
Good Market Access	High Population Density	**1**	**2**
	Low Population Density	**3**	**4**
Poor Market Access	High Population Density	**5**	**6**
	Low Population Density	**7**	**8**

Domains are constructed separately for each crop due (Figure 26, Figure 27, and Figure 28) to the different market access maps and the target districts are characterised using the adoption domain for the appropriate legume crop (e.g. Iringa is characterised using the soybean adoption domain).

The results (Figure 29) show that all of the domains are encountered in the target districts. The districts with the most diversity of domains are Arusha rural and Lushoto, which implies that site selection within these districts must be undertaken with great care, but that these districts offer opportunities for multiple niches to be considered. In contrast Kiteto and Bukombe are characterised by a single domain which implies that site selection within these districts is less important.

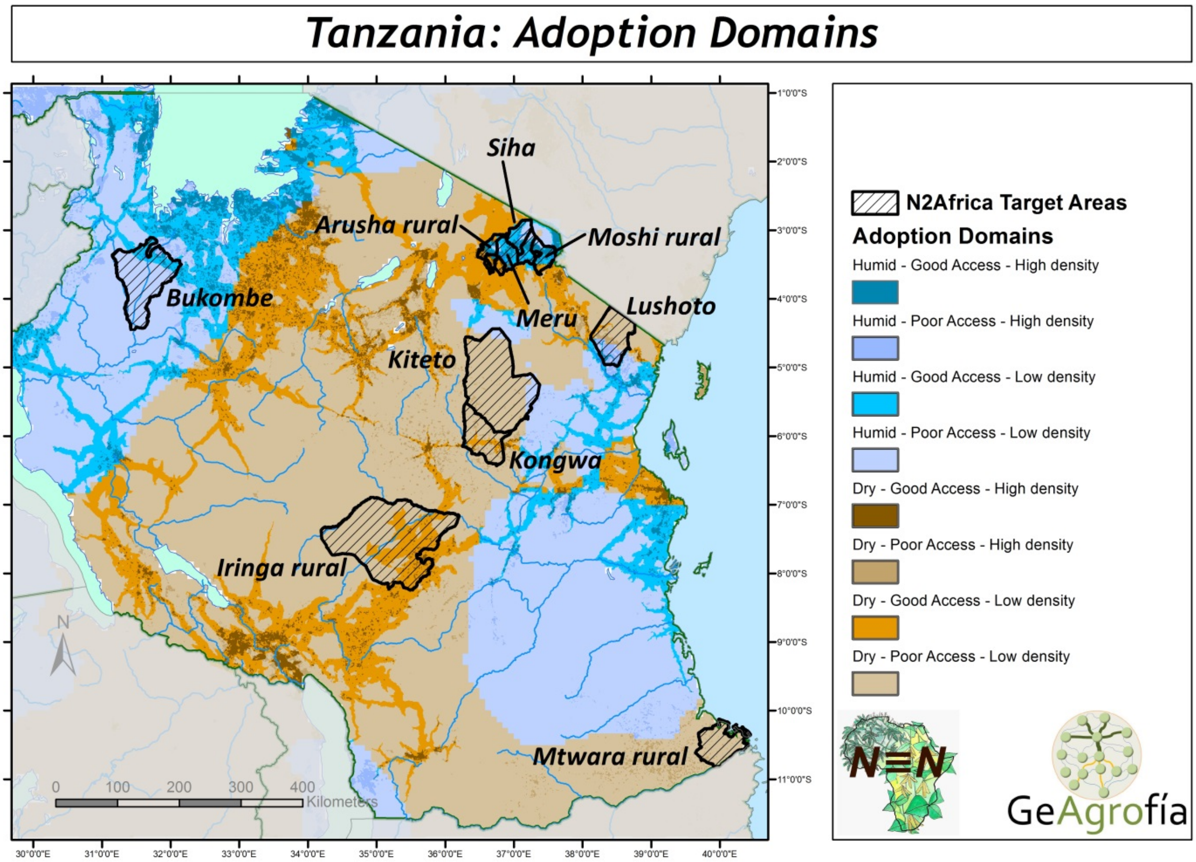

Figure 26. Common bean adoption domains

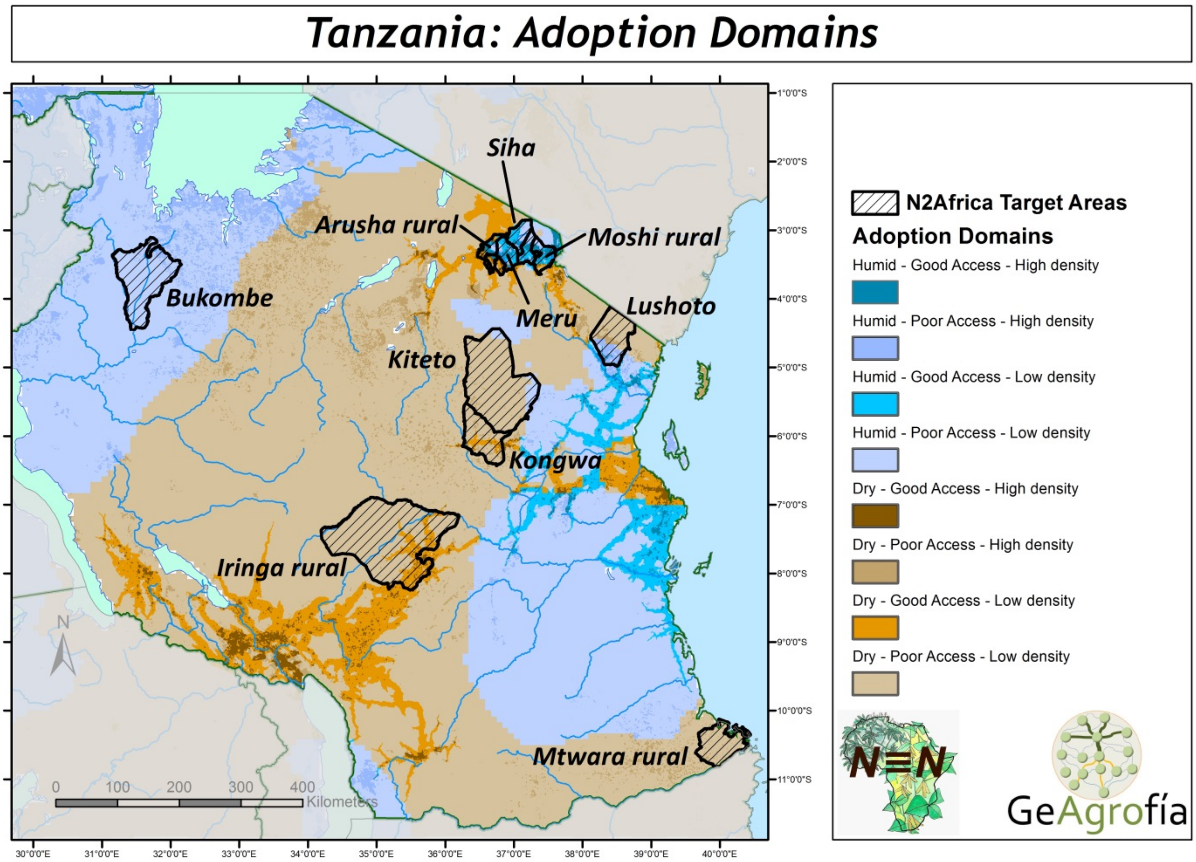

Figure 27. Soybean adoption domains

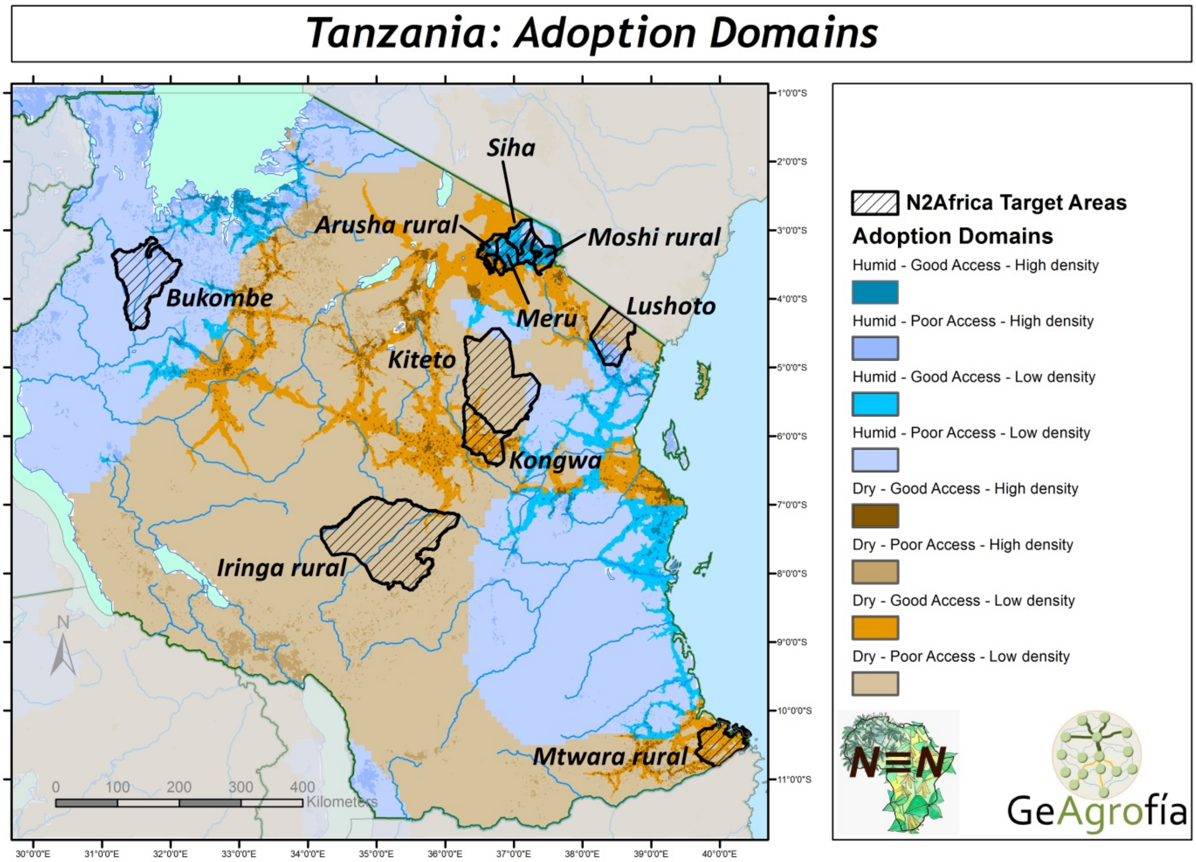

Figure 28. Groundnut adoption domains

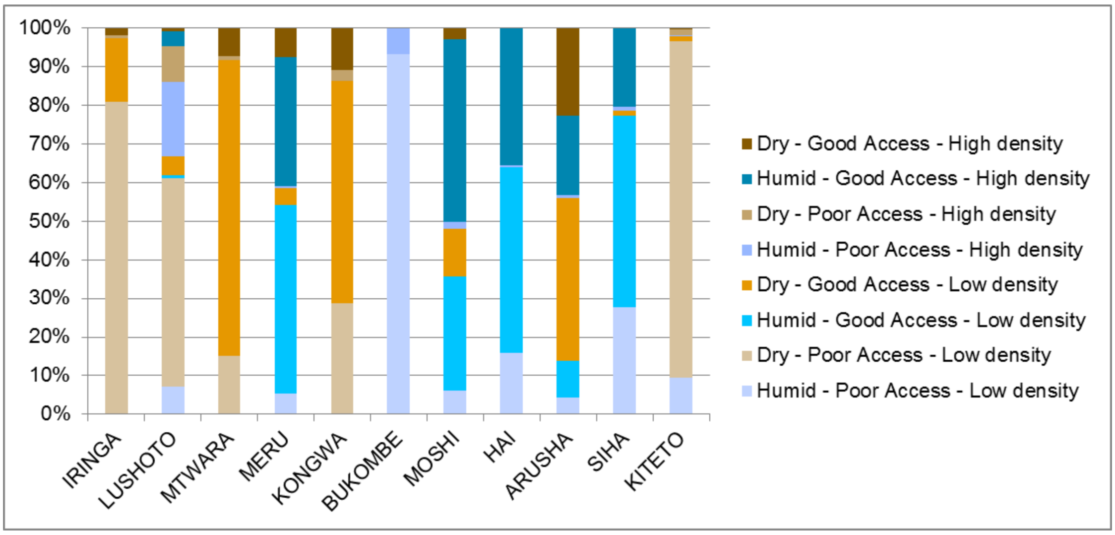

Figure 29. Characterisation of target districts using adoption domains

6 Conclusions

The adoption domains created for the different N2Africa best bet legume crops in Tanzania provide a broad structure for implementing research and development activities, and for evaluating the impact of the outcomes of those activities. The hypothesis implicitly proposed here is that adoption of a particular technology package – a legume variety with rhizobium, fertiliser and management practices – would be more likely to be adopted in one domain than another one. This hypothesis can be tested as part of the N2Africa objective on learning and assessing impact (cf. Nkonya et al., 2013). Perhaps more importantly (but with implications for hypothesis testing), the domains should be used to better target the individual components of the technology package.

The domains presented here are composed of variables that vary considerably across Tanzania, but present less variability within the individual domains. There are a number of other variables, however, that display large variation over relatively short distances within domains. These include socio-economic variables identified during the review of constraints to adoption (Table 1), but also comprise terrain, soil fertility and micro-climates. Further stratification is therefore required to control for the variability of these factors within the same domain of a target district.

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Appendix 1: Accessibility modelling

This annex includes information on the modelling environment within the ArcGIS software, the spatial dataset used, values used, and the python commands.

Modelling environment: projection

Tz_lam_Az_Eqarea

Projection: Lambert_Azimuthal_Equal_Area

False_Easting: 1000000.000000

False_Northing: 1000000.000000

Central_Meridian: 34.000000

Latitude_Of_Origin: -6.000000

Linear Unit: Meter

GCS_WGS_1984

Datum: D_WGS_1984

Creation of a Friction surface

Resolution 1km (995m – same as GLC2000)

Roads

gRoads v1

There is not enough information in the gRoads database for Tanzania to provide a road speed for every length of road, nor to correlate the Class the road with the speed or seasonality. The road class appears to be based on surface type although there are lots of missing values.

ILRI

The dataset is the same as the gRoads although with far fewer roads.

Michelin

Speed indicated for all roads, but some important roads missing (e.g. Ifakara-Songea), poor accuracy elsewhere and other roads not updated with new surface (e.g. Serengeti)

African Development Bank

“Data on road surface type, condition and traffic volume were compiled by Africon Limited for the AICD study led by the World Bank. Data from the Roads Agency Formation Unit (RAFU) were reviewed and transport experts were consulted in an effort to derive estimates for all of the primary and secondary road network."

A very limited set of roads with differences to both the Michelin and gRoads datasets.

Tanroads.org

The Tanzania National Roads Agency (TANROADS) provides maps for each region showing the trunk, regional and district roads with information on road surface (paved, non-paved). These maps can be used in conjunction with the gRoads dataset to select the roads and assign surface and times.

The best single source is from gRoads, but this can be augmented with additions to the network (e.g. Kilosa - Mbunga).

Source	**Road Link**
Tanroads	Lake Eyasi – unpaved trunk road Arusha
Tanroads	Kilosa Kwa Mpepo-Mbunga unpaved trunk road Morogoro
Tanroads	Uvinza – Nguruka unpaved trunk road Kigoma

Type	**Speed**	**Time to travel 1 km (secs)**
Paved trunk road	60 kph	60
Paved regional road	45 kph	80
Unpaved trunk road	36 kph	100
Unpaved regional road	24 kph	150
Unpaved district road	5 kph	720

arcpy.PolylineToRaster_conversion("tz_roads_trunk_paved_lam","FID","SPATAL DATA PATH/Africa/africa/N2Africa/tz_rd_trpv","MAXIMUM_LENGTH","NONE","993.45800491098")

arcpy.gp.Reclassify_sa("tz_rd_trpv","VALUE","0 596 60;NODATA 3600","SPATAL DATA PATH/Africa/africa/N2Africa/tz_rd_60","DATA")

arcpy.PolylineToRaster_conversion("tz_roads_regional_paved_lam","FID","SPATAL DATA PATH/Africa/africa/N2Africa/tz_rd_rgpv","MAXIMUM_LENGTH","NONE","993.45800491098")

arcpy.gp.Reclassify_sa("tz_rd_rgpv","VALUE","0 65 80;NODATA 3600","SPATAL DATA PATH/Africa/africa/N2Africa/tz_rd_80","DATA")

arcpy.PolylineToRaster_conversion("tz_roads_trunk_unpaved_lam","FID","SPATAL DATA PATH/Africa/africa/N2Africa/tz_rd_trupv","MAXIMUM_LENGTH","NONE","993.45800491098")

arcpy.gp.Reclassify_sa("tz_rd_trupv","VALUE","0 470 100;NODATA 3600","SPATAL DATA PATH/Africa/africa/N2Africa/tz_rd_100","DATA")

arcpy.PolylineToRaster_conversion("tz_roads_regional_unpaved_lam","FID","SPATAL DATA PATH/Africa/africa/N2Africa/tz_rd_rgupv","MAXIMUM_LENGTH","NONE","993.45800491098") arcpy.gp.Reclassify_sa("tz_rd_rgupv","VALUE","0 1312 150;NODATA 3600","SPATAL DATA PATH/Africa/africa/N2Africa/tz_rd_150","DATA")

arcpy.PolylineToRaster_conversion("tz_roads_district_unpaved_lam","FID","SPATAL DATA PATH/Africa/africa/N2Africa/tz_rd_dsupv","MAXIMUM_LENGTH","NONE","993.45800491098")

arcpy.gp.Reclassify_sa("tz_rd_dsupv","VALUE","0 4583 720;NODATA 3600","SPATAL DATA PATH/Africa/africa/N2Africa/tz_rd_720","DATA")

arcpy.gp.RasterCalculator_sa("""Con("tz_rd_60" == 60, 60,Con("tz_rd_80" == 80, 80, Con("tz_rd_100" == 100, 100, Con("tz_rd_150" == 150,150 , "tz_rd_720"))))""","SPATAL DATA PATH/Africa/africa/N2Africa/tz_rd_rcl")

Land use

Africover

Very high resolution imagery converted to vector format. Separate datasets for grasslands, crops and woodlands and another dataset with categories outside those three. Overlap between the datasets is common where areas have been classified as a mixture of different land cover.

Within the three datasets classes are limited to herbaceous crops, tree and shrub crops, closed to open grassland, closed to open shrubs and closed to open trees. The 'spatial agg' dataset has a further 29 classes including urban areas and flooded lands. Wetlands, which are an important feature of Uganda, are classed mainly as grasslands, which would have implications on the accessibility mapping given the difficulty of crossing these features.

GLC2000v5 (African regional dataset)

This dataset has a poorer resolution than Globcover and does not discriminate well the urban areas, and classes many wetlands as croplands. In contrast many croplands are classified as deciduous woodland.

Globcover

Globcover has a resolution of 300m with 22 classes, including croplands, grasslands, forests and urban areas. Despite a validation exercise the Globcover land cover map classifies many papyrus wetlands as a mosaic of vegetation and croplands. In general the dataset is suitable for defining background speeds for the friction surface.

To be consistent with the other N2Africa accessibility models the Globcover dataset needs to be resampled to the same (1km) resolution, this is best achieved using points to ensure that the resampling uses the most frequent value.

arcpy.RasterToOtherFormat_conversion("SPATAL DATA PATH/Global/Biofisico/Globcover/GLOBCOVER_L4_200901_200912_V2.3.tif'","SPATAL DATA PATH/Globcover","GRID")

arcpy.RasterToPoint_conversion("globcove","SPATAL DATA PATH/Globcover/tz_glob_pt.shp","VALUE")

arcpy.PointToRaster_conversion("tz_glob_pt","GRID_CODE","SPATAL DATA PATH/Africa/africa/N2Africa/tz_glob","MOST_FREQUENT","NONE","0.00892857")

```
arcpy.ProjectRaster_management("tz_glob","SPATAL DATA PATH/Africa/africa/N2Africa/tz_glob_lam","PROJCS['Tz_lam_Az_Eqarea',GEOGCS['GCS_WGS_1984',DATUM['D_WGS_1984',SPHEROID['WGS_1984',6378137.0,298.257223563]],PRIMEM['Greenwich',0.0],UNIT['Degree',0.0174532925199433]],PROJECTION['Lambert_Azimuthal_Equal_Area'],PARAMETER['False_Easting',1000000.0],PARAMETER['False_Northing',1000000.0],PARAMETER['Central_Meridian',34.0],PARAMETER['Latitude_Of_Origin',-6.0],UNIT['Meter',1.0]]","NEAREST","993.45800491098","#","#","GEOGCS['GCS_WGS_1984',DATUM['D_WGS_1984',SPHEROID['WGS_1984',6378137.0,298.257223563]],PRIMEM['Greenwich',0.0],UNIT['Degree',0.0174532925199433]]")
```

Name	Code	Time
Post-flooding or irrigated croplands	11	36 mins per km
Rainfed croplands	14	36 mins per km
Mosaic Cropland (50-70%) / Vegetation (grassland, shrubland, forest) (20-50%)	20	36 mins per km
Mosaic Vegetation (grassland, shrubland, forest) (50-70%) / Cropland (20-50%)	30	36 mins per km
Closed to open (>15%) broadleaved evergreen and/or semi-deciduous forest (>5m)	40	48 mins per km
Closed (>40%) broadleaved deciduous forest (>5m)	50	60 mins per km
Open (15-40%) broadleaved deciduous forest (>5m)	60	48 mins per km
Closed (>40%) needleleaved evergreen forest (>5m)	70	60 mins per km
Open (15-40%) needleleaved deciduous or evergreen forest (>5m)	90	48 mins per km
Closed to open (>15%) mixed broadleaved and needleleaved forest (>5m)	100	48 mins per km
Mosaic Forest/Shrubland (50-70%) / Grassland (20-50%)	110	48 mins per km
Mosaic Grassland (50-70%) / Forest/Shrubland (20-50%)	120	36 mins per km
Closed to open (>15%) shrubland (<5m)	130	36 mins per km
Closed to open (>15%) grassland	140	36 mins per km
Sparse (>15%) vegetation (woody vegetation, shrubs, grassland)	150	24 mins per km
Closed (>40%) broadleaved forest regularly flooded - Fresh water	160	60 mins per km
Closed (>40%) broadleaved semi-deciduous and/or evergreen forest regularly flooded - Saline water	170	60 mins per km
Closed to open (>15%) vegetation (grassland, shrubland, woody vegetation) on regularly flooded or waterlogged soil - Fresh, brackish or saline water	180	60 mins per km
Artificial surfaces and associated areas (urban areas >50%)	190	Replaced by Urban areas
Bare areas	200	24 mins per km
Water bodies	210	83 minutes per

		km
Permanent snow and ice	220	60 mins per km

arcpy.Reclassify_sa("tz_glob_lam","VALUE","11 2160; 14 2160;20 2160;30 2160;40 2880;50 3600;60 2880;70 3600;90 2880;100 2880;110 2880;120 2160;130 2160;140 2160;150 1440;160 3600;170 3600;180 3600;190 3600;200 1440;210 5000;NODATA 5000","SPATAL DATA PATH/Africa/africa/N2Africa/tz_glob_rcl","DATA")

Urban areas

There are some small errors in the urban extents spatial dataset (CIESIN et al., 2011) but despite this the coverage of urban areas is more widespread than the urban areas in the Globcover dataset.

The global urban areas layer was restricted to Tanzania

arcpy.RasterCalculator_sa("/\glurmask/\ * 1","SPATAL DATA PATH/Africa/africa/N2Africa/tz_glurmask")

and projected to the equal area projection

arcpy.ProjectRaster_management("tz_glurmask","SPATAL DATA PATH/Africa/africa/N2Africa/tz_glur_lam","PROJCS['Tz_lam_Az_Eqarea',GEOGCS['GCS_WGS_1984',DATUM['D_WGS_1984',SPHEROID['WGS_1984',6378137.0,298.257223563]],PRIMEM['Greenwich',0.0],UNIT['Degree',0.0174532925199433]],PROJECTION['Lambert_Azimuthal_Equal_Area'],PARAMETER['False_Easting',1000000.0],PARAMETER['False_Northing',1000000.0],PARAMETER['Central_Meridian',34.0],PARAMETER['Latitude_Of_Origin',-6.0],UNIT['Meter',1.0]]","NEAREST","927.229933046197","#","#","GEOGCS['GCS_WGS_1984',DATUM['D_WGS_1984',SPHEROID['WGS_1984',6378137.0,298.257223563]],PRIMEM['Greenwich',0.0],UNIT['Degree',0.0174532925199433]]")

and reclassified using the cellsize of the land cover dataset

Name	Time
Urban extent	2 mins per km

arcpy.Reclassify_sa("tz_glur_lam","VALUE","1 3600;2 120;NODATA 3600","SPATAL DATA PATH/Africa/africa/N2Africa/tz_glur_rcl","DATA")

Base times

The order of the inputs into the base times is:

Landcover

Urban

Roads

arcpy.RasterCalculator_sa("Con(/\Roads/tz_rd_rcl/\ < 3600, /\Roads/tz_rd_rcl/\, Con(/\tz_glur_rcl/\ == 120 , 120 , /\Land Cover/tz_glob_rcl/\))","SPATAL DATA PATH/Africa/africa/N2Africa/tz_base_1")

Slope

Slope was calculated in ArcMap from SRTM elevation grid

arcpy.Slope_sa("tz_srtm_lam","G:/Lenovo backup/DatosProyecto/SpatialDataC/tz_srtm/tz_slp_lam","DEGREE","1")

Slope grid split into 9 smaller raster grids

arcpy.SplitRaster_management("tz_slp_lam","G:/Lenovo backup/DatosProyecto/SpatialDataC/tz_srtm","tz_slp_lam","NUMBER_OF_TILES","GRID","NEAREST","3 3","2048 2048","0","PIXELS","#","#")

Slope grids were converted to points

tz_slp_pt0 to tz_slp_pt8

The point file was converted back into a grid albeit with a larger cellsize, and point values were averaged for each grid cell

Example

arcpy.PointToRaster_conversion("tz_slp_pt8","GRID_CODE","C:/SpatialDataC/Africa/tz_srtm/tz_slp_1k8","MEAN","GRID_CODE","993.45800491098")

Resulting grids were mosaiced and average values were calculated for any overlaps among the grids

arcpy.MosaicToNewRaster_management("tz_slp_1k8;tz_slp_1k7;tz_slp_1k6;tz_slp_1k5;tz_slp_1k4;tz_slp_1k3;tz_slp_1k2;tz_slp_1k1;tz_slp_1k0","C:/SpatialDataC/Africa/tz_srtm","tz_slp_1k","#","16_BIT_SIGNED","#","1","MEAN","FIRST")

Slope was converted from degrees to vertical metres per horizontal metre

arcpy.RasterCalculator_sa("Tan((/\tz_slp_1k/\ * (math.pi / 180)))","G:/Lenovo backup/DatosProyecto/SpatialDataC/tz_srtm/tz_slp_m")

Metres-in-metre slope grid was multiplied by -3 and used as the power of the exponential function and the inverse was used as the friction factor.

arcpy.RasterCalculator_sa("1 / (Exp(/\tz_slp_m/\ * - 3))","G:/Lenovo backup/DatosProyecto/SpatialDataC/tz_srtm/tz_slp_ff")

The resulting friction factor grid had values between 1 and 14.

Elevation

We consider that inhabitants are well adapted to their elevation zone, and that elevation will not have an effect on speed.

Friction grid

arcpy.RasterCalculator_sa("/\tz_base_1/\ * /\Slope/tz_slp_ff/\","SPATAL DATA PATH/Africa/africa/N2Africa/tz_friction")

Costdistance modelling

Common bean

Most important markets

arcpy.PointToRaster_conversion("tz_markets_lam_merge","Name","SPATAL DATA PATH/Africa/africa/N2Africa/tz_comb_5","MOST_FREQUENT","NONE","993.45800491098")

arcpy.CostAllocation_sa("tz_comb_5","tz_friction","SPATAL DATA PATH/Africa/africa/N2Africa/tz_comb5all","#","tz_comb_5","NAME","SPATAL DATA PATH/Africa/africa/N2Africa/tz_comb5acc","SPATAL DATA PATH/Africa/africa/N2Africa/tz_comb5dir")

arcpy.RasterCalculator_sa("Int(/\tz_comb5acc/\ / 993.45800491098)","SPATAL DATA PATH/Africa/africa/N2Africa/tz_comb5int")

Next important markets

arcpy.PointToRaster_conversion("tz_markets_lam_merge","Name","SPATAL DATA PATH/Africa/africa/N2Africa/tz_comb_4","MOST_FREQUENT","NONE","993.45800491098")

arcpy.CostAllocation_sa("tz_comb_4","tz_friction","SPATAL DATA PATH/Africa/africa/N2Africa/tz_comb4all","#","tz_comb_4","NAME","SPATAL DATA PATH/Africa/africa/N2Africa/tz_comb4acc","SPATAL DATA PATH/Africa/africa/N2Africa/tz_comb4dir")

arcpy.RasterCalculator_sa("Int(/\tz_comb4acc/\ / 993.45800491098)","SPATAL DATA PATH/Africa/africa/N2Africa/tz_comb4int")

Less important markets

arcpy.PointToRaster_conversion("tz_markets_lam_merge","Name","SPATAL DATA PATH/Africa/africa/N2Africa/tz_comb_3","MOST_FREQUENT","NONE","993.45800491098")

arcpy.CostAllocation_sa("tz_comb_3","tz_friction","SPATAL DATA PATH/Africa/africa/N2Africa/tz_comb3all","#","tz_comb_3","NAME","SPATAL DATA PATH/Africa/africa/N2Africa/tz_comb3acc","SPATAL DATA PATH/Africa/africa/N2Africa/tz_comb3dir")

arcpy.RasterCalculator_sa("Int(/\tz_comb3acc/\ / 993.45800491098)","SPATAL DATA PATH/Africa/africa/N2Africa/tz_comb3int")

Least important markets

arcpy.PointToRaster_conversion("tz_markets_lam_merge","Name","SPATAL DATA PATH/Africa/africa/N2Africa/tz_comb_2","MOST_FREQUENT","NONE","993.45800491098")

arcpy.CostAllocation_sa("tz_comb_2","tz_friction","SPATAL DATA PATH/Africa/africa/N2Africa/tz_comb2all","#","tz_comb_2","NAME","SPATAL DATA PATH/Africa/africa/N2Africa/tz_comb2acc","SPATAL DATA PATH/Africa/africa/N2Africa/tz_comb2dir")

arcpy.RasterCalculator_sa("Int(/\tz_comb2acc/\ / 993.45800491098)","SPATAL DATA PATH/Africa/africa/N2Africa/tz_comb2int")

Combination of markets

arcpy.RasterCalculator_sa("Con(/\tz_comb5int/\ > 28800, Con(/\tz_comb4int/\ > 21600, Con(/\tz_comb3int/\ > 14400, Con(/\tz_comb2int/\ > 3600, 0, 1), 1) , 1), 1)","SPATAL DATA PATH/Africa/africa/N2Africa/tz_comb_bin")

arcpy.RasterToPolygon_conversion("tz_comb_bin","SPATAL DATA PATH/Africa/africa/N2Africa/tz_comb_bin_lam.shp","NO_SIMPLIFY","VALUE")

arcpy.Project_management("tz_comb_bin_lam","SPATAL DATA PATH/Africa/africa/N2Africa/tz_comb_bin.shp","GEOGCS['GCS_WGS_1984',DATUM['D_WGS_1984',SPHEROID['WGS_1984',6378137.0,298.257223563]],PRIMEM['Greenwich',0.0],UNIT['Degree',0.0174532925199433]]","#","PROJCS['Tz_lam_Az_Eqarea',GEOGCS['GCS_WGS_1984',DATUM['D_WGS_1984',SPHEROID['WGS_1984',6378137.0,298.257223563]],PRIMEM['Greenwich',0.0],UNIT['Degree',0.0174532925199433]],PROJECTION['Lambert_Azimuthal_Equal_Area'],PARAMETER['False_Easting',1000000.0],PARAMETER['False_Northing',1000000.0],PARAMETER['Central_Meridian',34.0],PARAMETER['Latitude_Of_Origin',-6.0],UNIT['Meter',1.0]]")

Soybean

Most important markets

arcpy.PointToRaster_conversion("tz_markets_lam_merge","Name","SPATAL DATA PATH/Africa/africa/N2Africa/tz_soyb_5","MOST_FREQUENT","NONE","993.45800491098")

arcpy.CostAllocation_sa("tz_soyb_5","tz_friction","SPATAL DATA PATH/Africa/africa/N2Africa/tz_soyb5all","#","tz_soyb_5","NAME","SPATAL DATA PATH/Africa/africa/N2Africa/tz_soyb5acc","SPATAL DATA PATH/Africa/africa/N2Africa/tz_soyb5dir")

arcpy.RasterCalculator_sa("Int(/\tz_soyb5acc/\ / 993.45800491098)","SPATAL DATA PATH/Africa/africa/N2Africa/tz_soyb5int")

Next important markets

arcpy.PointToRaster_conversion("tz_markets_lam_merge","Name","SPATAL DATA PATH/Africa/africa/N2Africa/tz_soyb_4","MOST_FREQUENT","NONE","993.45800491098")

arcpy.CostAllocation_sa("tz_soyb_4","tz_friction","SPATAL DATA PATH/Africa/africa/N2Africa/tz_soyb4all","#","tz_soyb_4","NAME","SPATAL DATA PATH/Africa/africa/N2Africa/tz_soyb4acc","SPATAL DATA PATH/Africa/africa/N2Africa/tz_soyb4dir") arcpy.RasterCalculator_sa("Int(/\tz_soyb4acc/\ / 993.45800491098)","SPATAL DATA PATH/Africa/africa/N2Africa/tz_soyb4int")

Less important markets

arcpy.PointToRaster_conversion("tz_markets_lam_merge","Name","SPATAL DATA PATH/Africa/africa/N2Africa/tz_soyb_3","MOST_FREQUENT","NONE","993.45800491098")

arcpy.CostAllocation_sa("tz_soyb_3","tz_friction","SPATAL DATA PATH/Africa/africa/N2Africa/tz_soyb3all","#","tz_soyb_3","NAME","SPATAL DATA PATH/Africa/africa/N2Africa/tz_soyb3acc","SPATAL DATA PATH/Africa/africa/N2Africa/tz_soyb3dir")

arcpy.RasterCalculator_sa("Int(/\tz_soyb3acc/\ / 993.45800491098)","SPATAL DATA PATH/Africa/africa/N2Africa/tz_soyb3int")

Least important markets

Combination of markets

arcpy.RasterCalculator_sa("Con(/\tz_soyb5int/\ > 28800, Con(/\tz_soyb4int/\ > 21600, Con(/\tz_soyb3int/\ > 14400, 0, 1), 1) , 1)","SPATAL DATA PATH/Africa/africa/N2Africa/tz_soyb_bin")

arcpy.RasterToPolygon_conversion("tz_soyb_bin","SPATAL DATA PATH/Africa/africa/N2Africa/tz_soyb_bin_lam.shp","NO_SIMPLIFY","VALUE")

arcpy.Project_management("tz_soyb_bin_lam","SPATAL DATA PATH/Africa/africa/N2Africa/tz_soyb_bin.shp","GEOGCS['GCS_WGS_1984',DATUM['D_WGS_1984', SPHEROID['WGS_1984',6378137.0,298.257223563]],PRIMEM['Greenwich',0.0],UNIT['Degree',0.0174532925199433]]","#","PROJCS['Tz_lam_Az_Eqarea',GEOGCS['GCS_WGS_1984',DATUM['D_WGS_1984',SPHEROID['WGS_1984',6378137.0,298.257223563]],PRIMEM['Greenwich',0.0],UNIT['Degree',0.0174532925199433]],PROJECTION['Lambert_Azimuthal_Equal_Area'],PARAMETER['False_Easting',1000000.0],PARAMETER['False_Northing',1000000.0],PARAMETER['Central_Meridian',34.0],PARAMETER['Latitude_Of_Origin',-6.0],UNIT['Meter',1.0]]")

Groundnut

Most important markets

arcpy.PointToRaster_conversion("tz_markets_lam_merge","Name","SPATAL DATA PATH/Africa/africa/N2Africa/tz_gnut_5","MOST_FREQUENT","NONE","993.45800491098")

arcpy.gp.CostAllocation_sa("tz_gnut_5","tz_friction","SPATAL DATA PATH/Africa/africa/N2Africa/tz_gnut5all","#","tz_gnut_5","NAME","SPATAL DATA PATH/Africa/africa/N2Africa/tz_gnut5acc","SPATAL DATA PATH/Africa/africa/N2Africa/tz_gnut5dir")

arcpy.gp.RasterCalculator_sa("""Int("tz_gnut5acc" / 993.45800491098)""","SPATAL DATA PATH/Africa/africa/N2Africa/tz_gnut5int")

Next important markets

arcpy.PointToRaster_conversion("tz_markets_lam_merge","Name","SPATAL DATA PATH/Africa/africa/N2Africa/tz_gnut_4","MOST_FREQUENT","NONE","993.45800491098")

arcpy.gp.CostAllocation_sa("tz_gnut_4","tz_friction","SPATAL DATA PATH/Africa/africa/N2Africa/tz_gnut4all","#","tz_gnut_4","NAME","SPATAL DATA PATH/Africa/africa/N2Africa/tz_gnut4acc","SPATAL DATA PATH/Africa/africa/N2Africa/tz_gnut4dir")

arcpy.gp.RasterCalculator_sa("""Int("tz_gnut4acc" / 993.45800491098)""","SPATAL DATA PATH/Africa/africa/N2Africa/tz_gnut4int")

Less important markets

arcpy.PointToRaster_conversion("tz_markets_lam_merge","Name","SPATAL DATA PATH/Africa/africa/N2Africa/tz_gnut_3","MOST_FREQUENT","NONE","993.45800491098")

arcpy.gp.CostAllocation_sa("tz_gnut_3","tz_friction","SPATAL DATA PATH/Africa/africa/N2Africa/tz_gnut3all","#","tz_gnut_3","NAME","SPATAL DATA PATH/Africa/africa/N2Africa/tz_gnut3acc","SPATAL DATA PATH/Africa/africa/N2Africa/tz_gnut3dir")

arcpy.gp.RasterCalculator_sa("""Int("tz_gnut3acc" / 993.45800491098)""","SPATAL DATA PATH/Africa/africa/N2Africa/tz_gnut3int")

Least important markets

arcpy.PointToRaster_conversion("tz_markets_lam_merge","Name","SPATAL DATA PATH/Africa/africa/N2Africa/tz_gnut_2","MOST_FREQUENT","NONE","993.45800491098")

arcpy.gp.CostAllocation_sa("tz_gnut_2","tz_friction","SPATAL DATA PATH/Africa/africa/N2Africa/tz_gnut2all","#","tz_gnut_2","NAME","SPATAL DATA PATH/Africa/africa/N2Africa/tz_gnut2acc","SPATAL DATA PATH/Africa/africa/N2Africa/tz_gnut2dir")

arcpy.gp.RasterCalculator_sa("""Int("tz_gnut2acc" / 993.45800491098)""","SPATAL DATA PATH/Africa/africa/N2Africa/tz_gnut2int")

Combination of markets

arcpy.gp.RasterCalculator_sa("""Con("tz_gnut5int" > 28800, Con("tz_gnut4int" > 21600, Con("tz_gnut3int" > 14400, Con("tz_gnut2int"> 3600, 0, 1), 1) , 1), 1)""","SPATAL DATA PATH/Africa/africa/N2Africa/tz_gnut_bin")

arcpy.RasterToPolygon_conversion("tz_gnut_bin","SPATAL DATA PATH/Africa/africa/N2Africa/tz_gnut_bin_lam.shp","NO_SIMPLIFY","VALUE")

arcpy.Project_management("tz_gnut_bin_lam","SPATAL DATA PATH/Africa/africa/N2Africa/tz_gnut_bin.shp","PROJCS['Tz_lam_Az_Eqarea',GEOGCS['GCS_WGS_1984',DATUM['D_WGS_1984',SPHEROID['WGS_1984',6378137.0,298.257223563]],PRIMEM['Greenwich',0.0],UNIT['Degree',0.0174532925199433]],PROJECTION['Lambert_Azimuthal_Equal_Area'],PARAMETER['False_Easting',1000000.0],PARAMETER['False_Northing',1000000.0],PARAMETER['Central_Meridian',34.0],PARAMETER['Latitude_Of_Origin',-6.0],UNIT['Meter',1.0]]","#","PROJCS['Tz_lam_Az_Eqarea',GEOGCS['GCS_WGS_1984',DATUM['D_WGS_1984',SPHEROID['WGS_1984',6378137.0,298.257223563]],PRIMEM['Greenwich',0.0],UNIT['D

egree',0.0174532925199433]],PROJECTION['Lambert_Azimuthal_Equal_Area'],PARAMETER['False_Easting',1000000.0],PARAMETER['False_Northing',1000000.0],PARAMETER['Central_Meridian',34.0],PARAMETER['Latitude_Of_Origin',-6.0],UNIT['Meter',1.0]]")

List of project reports

1. N2Africa Steering Committee Terms of Reference
2. Policy on advanced training grants
3. Rhizobia Strain Isolation and Characterisation Protocol
4. Detailed country-by-country access plan for P and other agro-minerals
5. Workshop Report: Training of Master Trainers on Legume and Inoculant Technologies (Kisumu Hotel, Kisumu, Kenya-24-28 May 2010)
6. Plans for interaction with the Tropical Legumes II project (TLII) and for seed increase on a country-by-country basis
7. Implementation Plan for collaboration between N2Africa and the Soil Health and Market Access Programs of the Alliance for a Green Revolution in Africa (AGRA) plan
8. General approaches and country specific dissemination plans
9. Selected soyabeans, common beans, cowpeas and groundnuts varieties with proven high BNF potential and sufficient seed availability in target impact zones of N2Africa Project
10. Project launch and workshop report
11. Advancing technical skills in rhizobiology: training report
12. Characterisation of the impact zones and mandate areas in the N2Africa project
13. Production and use of rhizobial inoculants in Africa
18. Adaptive research in N2Africa impact zones: Principles, guidelines and implemented research campaigns
19. Quality assurance (QA) protocols based on African capacities and international existing standards developed
20. Collection and maintenance of elite rhizobial strains
21. MSc and PhD status report
22. Production of seed for local distribution by farming communities engaged in the project
23. A report documenting the involvement of women in at least 50% of all farmer-related activities
24. Participatory development of indicators for monitoring and evaluating progress with project activities and their impact
25. Suitable multi-purpose forage and tree legumes for intensive smallholder meat and dairy industries in East and Central Africa N2Africa mandate areas
26. A revised manual for rhizobium methods and standard protocols available on the project website
27. Update on Inoculant production by cooperating laboratories
28. Legume Seed Acquired for Dissemination in the Project Impact Zones
29. Advanced technical skills in rhizobiology: East and Central African, West African and South African Hub
30. Memoranda of Understanding are formalized with key partners along the legume value chains in the impact zones
31. Existing rhizobiology laboratories upgraded
32. N2Africa Baseline report
33. N2Africa Annual country reports 2011
34. Facilitating large-scale dissemination of Biological Nitrogen Fixation

35. Dissemination tools produced
36. Linking legume farmers to markets
37. The role of AGRA and other partners in the project defined and co-funding/financing options for scale-up of inoculum (banks, AGRA, industry) identified
38. Progress Towards Achieving the Vision of Success of N2Africa
39. Quantifying the impact of the N2Africa project on Biological Nitrogen Fixation
40. Training agro-dealers in accessing, managing and distributing information on inoculant use
41. Opportunities for N2Africa in Ethiopia
42. N2Africa Project Progress Report Month 30
43. Review & Planning meeting Zimbabwe
44. Howard G. Buffett Foundation – N2Africa June 2012 Interim Report
45. Number of Extension Events Organized per Season per Country
46. N2Africa narrative reports Month 30
47. Background information on agronomy, farming systems and ongoing projects on grain legumes in Uganda
48. Opportunities for N2Africa in Tanzania
49. Background information on agronomy, farming systems and ongoing projects on grain legumes in Ethiopia
50. Special Events on the Role of Legumes in Household Nutrition and Value-Added Processing
51. Value chain analyses of grain legumes in N2Africa: Kenya, Rwanda, eastern DRC, Ghana, Nigeria, Mozambique, Malawi and Zimbabwe
52. Background information on agronomy, farming systems and ongoing projects on grain legumes in Tanzania
53. Nutritional benefits of legume consumption at household level in rural sub-Saharan Africa: Literature study
54. N2Africa Project Progress Report Month 42
55. Market Analysis of Inoculant Production and Use
56. Identified soyabean, common bean, cowpea and groundnut varieties with high Biological Nitrogen Fixation potential identified in N2Africa impact zones
57. A N2Africa universal logo representing inoculant quality assurance
58. M&E Workstream report
59. Improving legume inoculants and developing strategic alliances for their advancement
60. Rhizobium collection, testing and the identification of candidate elite strains
61. Evaluation of the progress made towards achieving the Vision of Success in N2Africa
62. Policy recommendation related to inoculant regulation and cross border trade
63. Satellite sites and activities in the impact zones of the N2Africa project
64. Linking communities to legume processing initiatives
65. Special events on the role of legumes in household nutrition and value-added processing
66. Media Events in the N2Africa project
67. Launch N2Africa Phase II – Report Uganda

68. Review of conditioning factors and constraints to legume adoption and their management in Phase II of N2Africa
69. Report on the milestones in the Supplementary N2Africa grant
70. N2Africa Phase II Launch in Tanzania
71. N2Africa Phase II 6 months report
72. Involvement of women in at least 50% of all farmer related activities
73. N2Africa Final Report of the First Phase: 2009-2013
74. Managing factors that affect the adoption of grain legumes in Uganda in the N2Africa project
75. Managing factors that affect the adoption of grain legumes in Ethiopia in the N2Africa project
76. Managing factors that affect the adoption of grain legumes in Tanzania in the N2Africa project

Partners involved in the N2Africa project

A2N

Bayero University Kano (BUK)

Caritas Rwanda

)

Diobass

Eglise Presbyterienne Rwanda

Kwame Nkrumah University of science and Technology

Resource Projects-Kenya

SARI

Sasakawa Global; 2000

Université Catholique de Bukavu

MIRCEN
University of Nairobi MIRCEN

University of Zimbabwe

Urbanet