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

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N2Africa

Putting nitrogen fixation to work for smallholder farmers in Africa

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Table of contents

Table of tables

Table of figures

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).

Using expert knowledge three major regions have been identified in Uganda in which three grain legume crops are already a major component of the farming system or for which there is great potential (Table 2). These legume crops are subsequently referred to as the 'best bet' legumes for the particular target areas (Table 3).

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

Zone	Common bean	Soybean	Groundnut
Northern			
South-western			
Eastern			

The major partners of N2Africa in Uganda are Makerere University, World Vision Uganda, VECO East Africa (a regional program of Vredeseilanden Coopibo a Belgian International NGO) and Africa 2000 Network (A2N). The three NGOs have differing approaches, A2N favouring community based facilitation, VECO favouring cooperatives and World Vision specialising on community based seed multiplication as part of the Oyam Area Development Programme (Table 3). The

Table 3. N2Africa partners, areas of current operations and 'best bet' legume crops for these areas

Target Area	Partner	District	'Best bet' Legume crop
Northern	Makerere University / World Vision	Lira	Soybean
		Kole	
		Apac	
		Oyam	
South-western	Africa 2000 Network	Kabale	Common bean
		Kisoro	
Eastern	VECO	Kapchorwa	Common bean
		Pallisa	Groundnut
		Kibuku	

The characterisation and suggestions for stratification in this report are focussed on these districts which can be seen in Figure 1. The characterisation focusses 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.

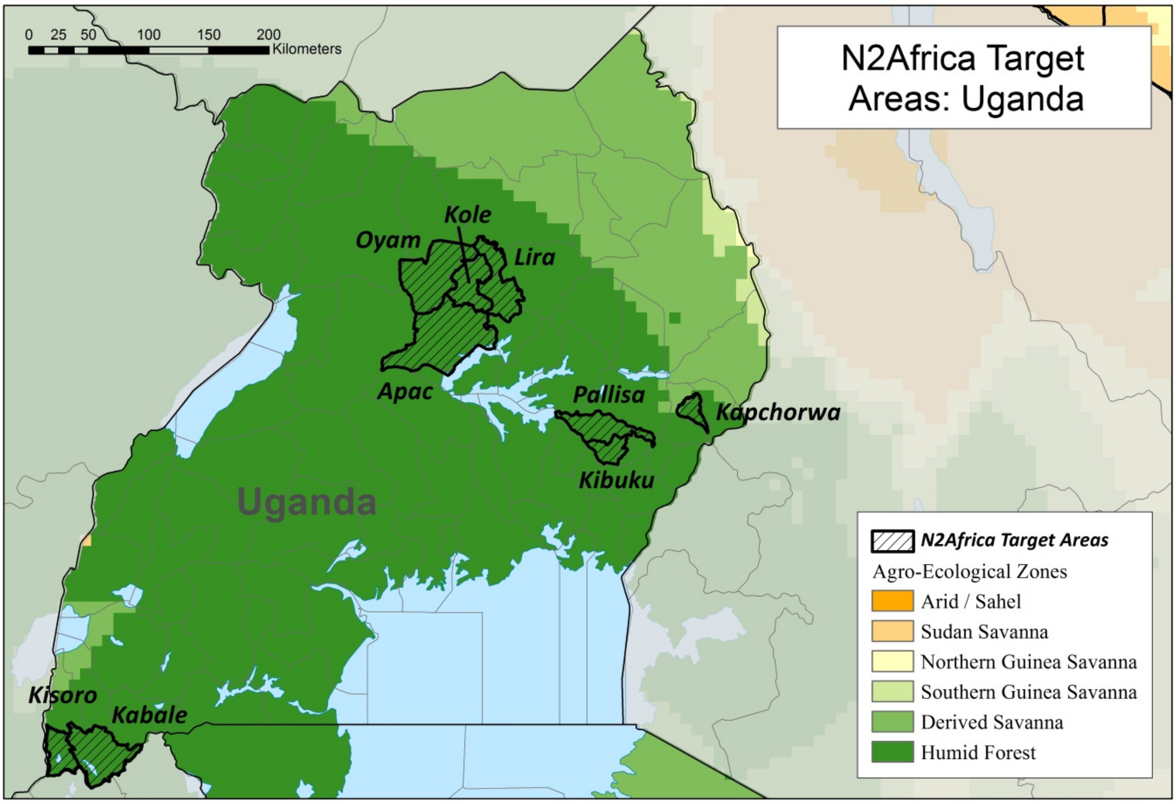


Figure 1. N2Africa Target Areas in Uganda

2 Biophysical relevance of technology

2.1 Length of the growing period

The length of growing period in the target areas varies from 255 days in the northern and eastern regions to 365 days in the south-western highlands (Figure 2). Variations are also not large within the districts (Table 4), although the resolution of the spatial data (approximately 10 km x 10 km) is quite coarse. There are some differences in seasonality in Uganda, with all of the districts experiencing two seasons although the further east and north the less distinct are the two rainy seasons and the longer the November–March dry season.

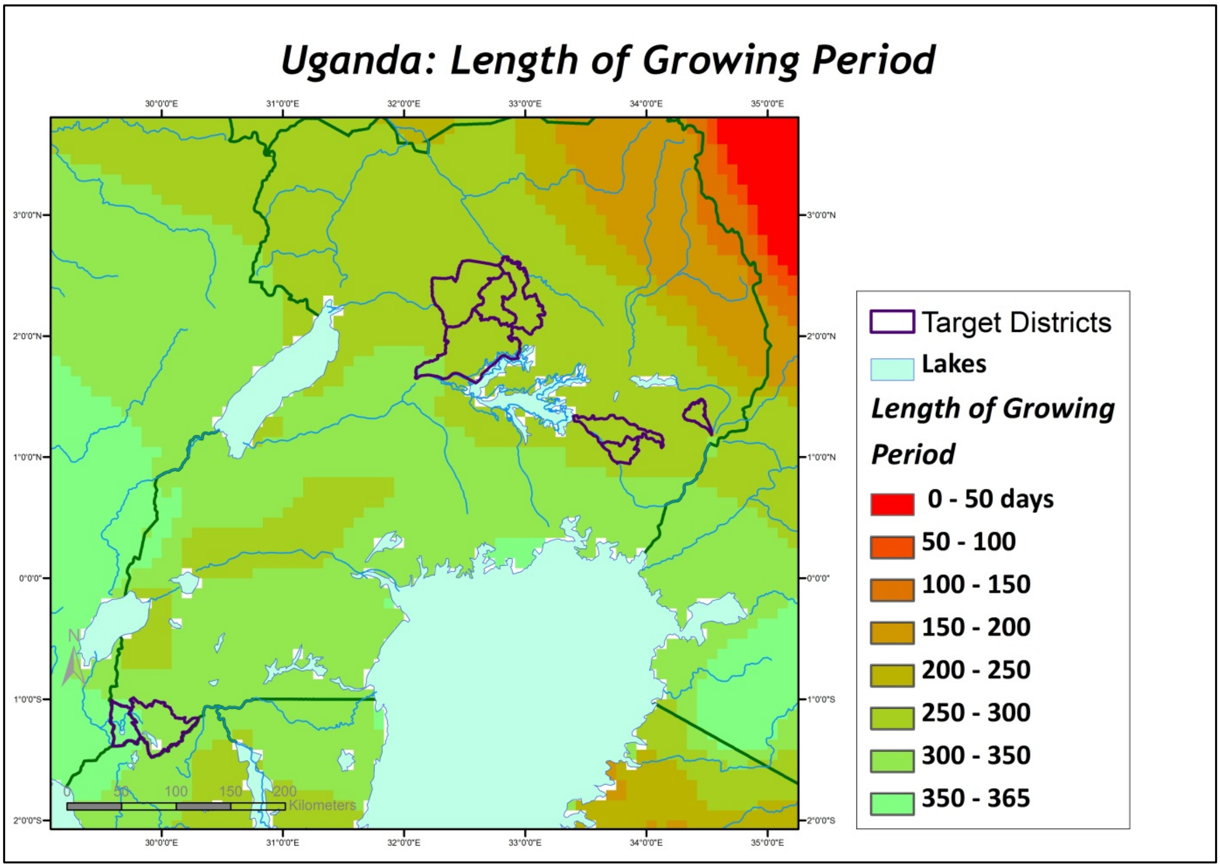


Figure 2. Length of Growing Period in Uganda. Source: van Velthuizen et al., 2007

These differences in the length of growing period have already been taken into account with the selection of best bet legume crops for the different districts, however the coarse resolution of the data and the apparent suitability for all legume crops means that alternative indicators should be sought for stratification purposes.

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

Target Area	District	'Best bet' Legume crop	LGP (days)
Northern	Lira	Soybean	255 - 285
	Kole	Soybean	285
	Apac	Soybean	285 -315
	Oyam	Soybean	285
South-western	Kabale	Common bean	315 -365
	Kisoro	Common bean	365
Eastern	Kapchorwa	Common bean	255 - 285
	Pallisa	Groundnut	255 - 285
	Kibuku	Groundnut	285

2.2 Temperature

The average temperature shows greater variation between target areas than LGP (Figure 3) and has an important effect on the suitability of different legume crops and on the best performing varieties of those legumes. The coolest target districts are Kisoro and Kabale, although these districts have significant temperature gradients according to elevation. Likewise in Kapchorwa, although the cooler areas of this district are primarily forest and are in the Mt Elgon national park. The eastern and northern lowlands are among the warmest areas in Uganda with an average temperature of 23°C (Table 5). Temperatures in the eastern lowlands are slightly higher during the wettest quarter of the year than in the northern region.

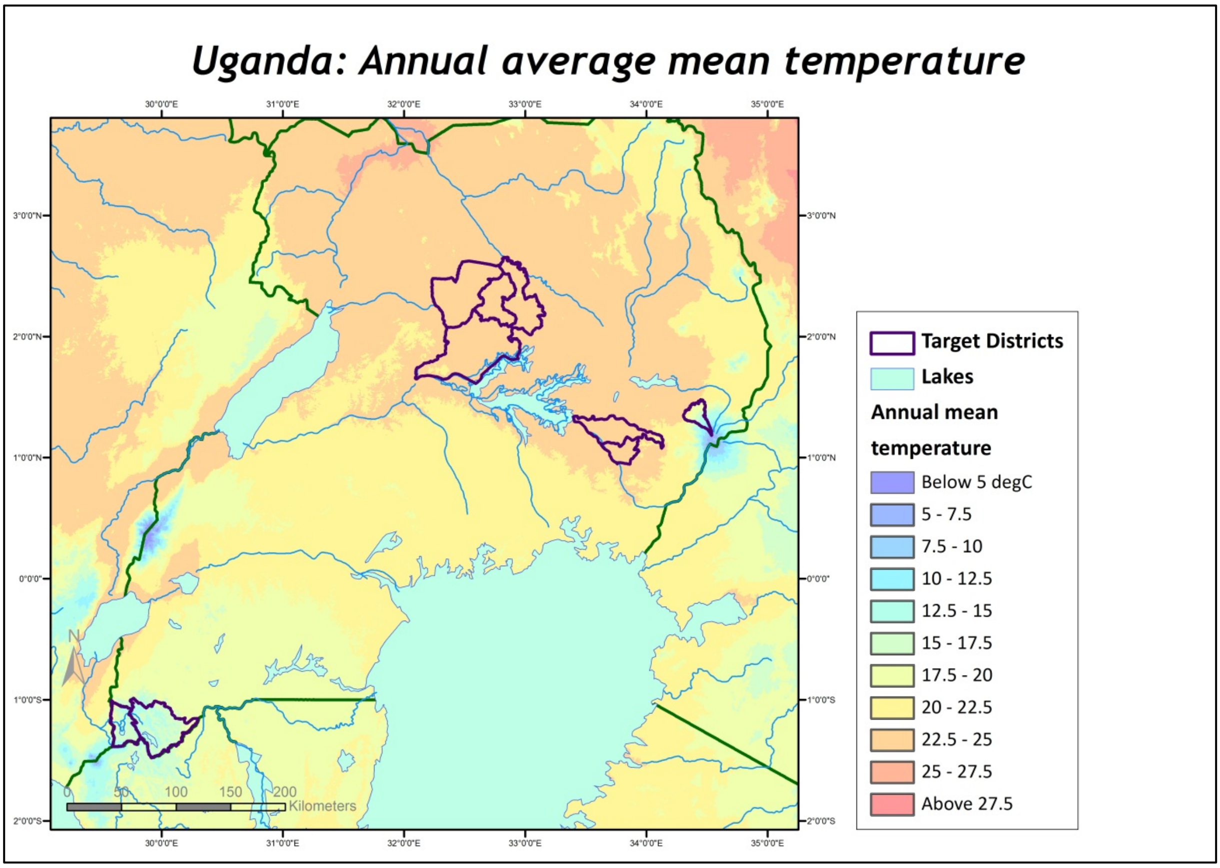


Figure 3. Annual average mean temperature in Uganda. Source: Hijmans et al., 2005

Table 5. Annual average mean temperature in Uganda per district in each target area

Target Area	District	'Best bet' Legume crop	Average annual temperature	Average temperature in wettest quarter
Northern	Lira	Soybean	22-23°C	21-23°C
	Kole	Soybean	23°C	22-23°C
	Apac	Soybean	22-23°C	22-24°C
	Oyam	Soybean	23°C	22°C
South-western	Kabale	Common bean	14-20°C	14-20°C
	Kisoro	Common bean	7-20°C	7-20°C
Eastern	Kapchorwa	Common bean	8-23°C	7-23°
	Pallisa	Groundnut	22-23°C	23-24°C
	Kibuku	Groundnut	22-23°C	23-24°C

These differences in temperature have already been taken into account with the selection of best bet legume crops for the different districts so further stratification is not necessary at this level but could be used to stratify sites within the highland districts of the south-western Uganda or in Kapchorwa.

2.3 Agro-Ecological zones

Agro-ecological zones have been defined for Uganda (Wortmann and Eledu, 1999) using 25 variables, including rainfall, temperature and seasonality, soil texture, soil acidity and organic matter, population density, land use and major food crops. The 25 variables were combined and preliminary boundaries between zones were defined after a cluster analysis. The resulting 33 zones were then refined using expert knowledge and relevant literature.

Table 6. Agro-ecological zones per district in each target area

Target Area	District	'Best bet' Legume crop	Agro-ecological Zone
Northern	Lira	Soybean	Northern Moist farmlands
	Kole	Soybean	Northern Moist farmlands
	Apac	Soybean	Northern Moist farmlands Northcentral Farm-bush Lands with Sandy Soils
	Oyam	Soybean	Northern Moist farmlands
South-western	Kabale	Common bean	Kabale-Rukungiri Highlands Kisoro-Kabale Highlands with Acid Soils Southwestern Medium-high Farmlands
	Kisoro	Common bean	Kisoro-Kabale Highlands with Acid Soils
Eastern	Kapchorwa	Common bean	Kapchorwa Farm-forest AEZ Mt. Elgon High Farmlands
	Pallisa	Groundnut	Southern and Eastern Lake Kyoga Basin
	Kibuku	Groundnut	Southern and Eastern Lake Kyoga Basin

A disadvantage of the AEZs is that the suitability (of a zone for a particular crop) is not immediately obvious and each zone needs to be decomposed to determine the values of the thresholds used.

Most of the districts in the target areas are characterised by a single agro-ecological zone, apart from Kabale, parts of Kapchorwa and Apac (Table 6). There is greater diversity between the target areas and for this reason the best-bet legume crops are different. There exists however the possibility (for common beans at least) to stratify according to AEZ with five different zones encountered in the target districts. For soybeans there is the possibility of stratifying within Apac, but the other districts are homogenous.

2.4 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.

Livelihood zones incorporate not only the major environmental characteristics but also the exploitation of these resources for agriculture. Zones have been characterised for all of Uganda at a fairly broad scale, and are described by the major crops which are part of the livelihood strategies in those areas or by the general agro-ecology. Two different zonation schemes have been published by FEWS NET, from 2005 and an updated version in 2010 (Table 7). Each zone has a livelihood profile which describes the major livelihood strategies for different household wealth classes, crop and labour calendars and the major hazards affecting food and income security.

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 Northern target area are instead groundnuts, pigeonpeas and common beans.

Table 7. Livelihood zones per district in each target area

Target Area	District	'Best bet' Legume crop	Livelihood Zone	Reference to legumes
Northern	Lira	Soybean	Mid North Simsim Maize Cassava Zone	Common beans noted as important food and cash crop
			South Kitgum Pader Abim Simsim Groundnuts Sorghum Cattle Zone	Pigeonpeas noted as important food crop and groundnuts as cash crop
	Kole	Soybean	Mid North Simsim Maize Cassava Zone	Common beans noted as important food and cash crop
	Apac	Soybean		
	Oyam	Soybean	Karuma Masindi Oyam Tobacco Maize Cassava Zone	Common beans noted as important food crop
			Mid North Simsim Maize Cassava Zone	Common beans noted as important food and cash crop
South-western	Kabale	Common bean	Southwestern Highland Irish Potato Sorghum Vegetable Zone	Common beans noted as important food crop
	Kisoro	Common bean		
Eastern	Kapchorwa	Common bean	Rwenzori Mt.Elgon West Nile Arabica Coffee Banana Zone	No mention
			Eastern Lowland Maize Beans Rice Zone	Common beans noted as important food crop
			Mt. Elgon Highland Irish Potato and Cereal Zone	Common beans noted as important food crop
	Pallisa	Groundnut	Eastern Central Lowland Cassava Sorghum and Groundnut Zone	Groundnuts noted as important food crop
	Kibuku	Groundnut		

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 Uganda there are ten different bean production areas, which cover nearly all of the country except for the savannah areas of the rift valley and the north-eastern districts of Karamoja. Information was collected on the cropping systems of common beans, and the main intercrop (Table 8).

Table 8. Cropping systems for common beans per district in each target area

Target Area	District	'Best bet' Legume crop	Common bean Cropping system
Northern	Lira	Soybean	Sole crop Maize Root and Tuber Banana
	Kole	Soybean	
	Apac	Soybean	
	Oyam	Soybean	
South-western	Kabale	Common bean	Sole crop Banana Maize Sorghum Root and Tuber
	Kisoro	Common bean	
Eastern	Kapchorwa	Common bean	Sole crop Maize Banana Root and Tuber Coffee
	Pallisa	Groundnut	Sole crop Maize Root and Tuber Banana Coffee Millet
	Kibuku	Groundnut	

Noticeable is the high diversity of systems with maize, banana and root and tuber intercrops in all of the target districts, but there are some differences, notably the importance of coffee in Mt Elgon compared to sorghum in the south-west.

2.5 Stratification according to biophysical relevance of the legume technology

The characterisation of Uganda 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). However, all of the districts in the target areas within Uganda experience long growing periods so an alternative indicator is required that is more relevant for the grain legumes that N2Africa will disseminate. Ruecker et al., (2003) use two different temperature thresholds, but these are oriented towards perennial crops, for annual crops the average temperature in the wettest quarter is a good indicator (Wortmann and Allen, 1994) and a threshold value of 21°C can be used to differentiate between areas within Uganda that are suitable for cool area legumes and warm area legumes (Figure 4).

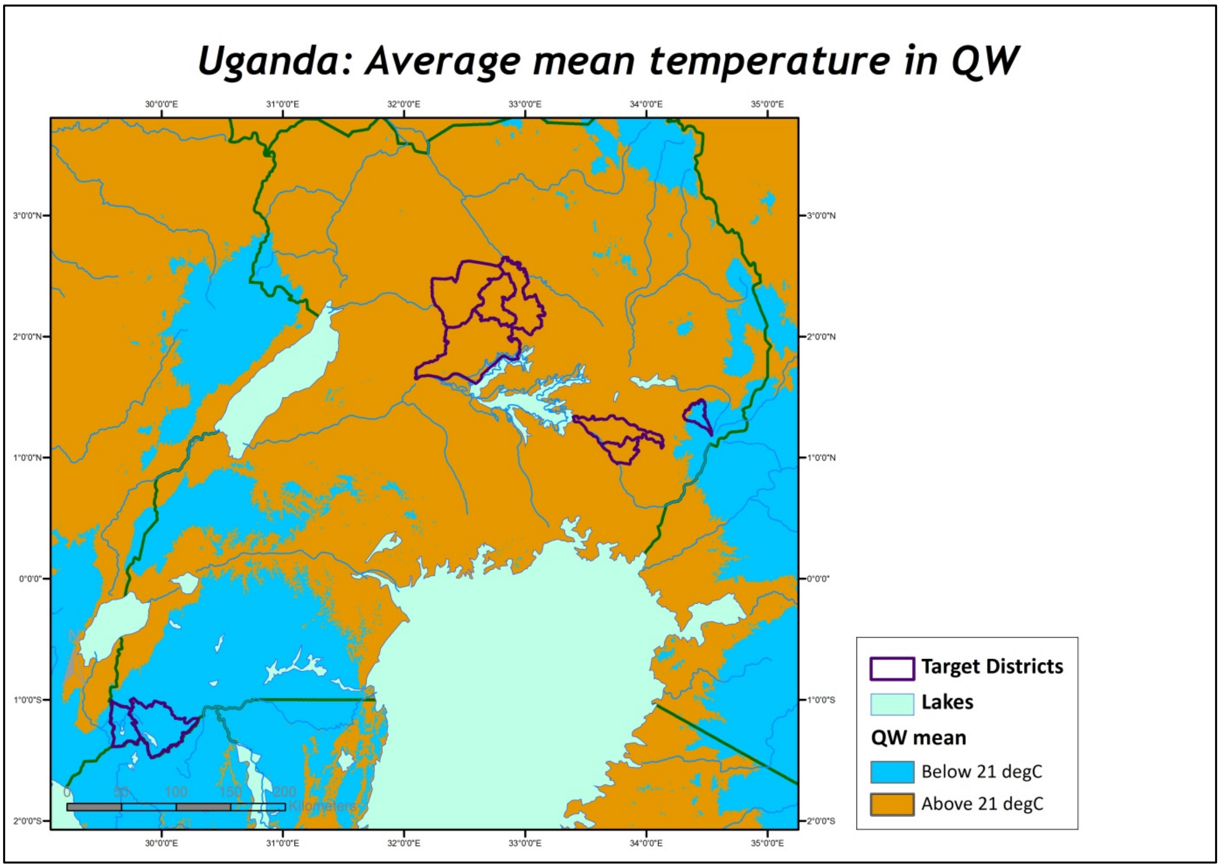


Figure 4. Average mean temperature in the wettest quarter in Uganda. Source: Hijmans et al., 2005

The result of stratifying Uganda based on the average temperature of the wettest quarter of the year is that the highland districts of Kabale, Kisoro and Kapchorwa are classified as cool and the other districts as warm (Table 9).

Table 9. Stratification of target districts according to average mean temperature in the wettest quarter in Uganda

Warm	Cool
Lira, Kole, Oyam, Apac, Kibuku and Pallisa	Kabale, Kisoro and Kapchorwa

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

A lack of reliable agricultural statistics in Uganda hinders the use of farm sizes as a variable for stratification. Data from the 1990/91 agricultural census show average farm sizes that are smaller in the highland areas of the east and southwest, with a greater number of larger units in the lower eastern areas and in the north (Figure 5).

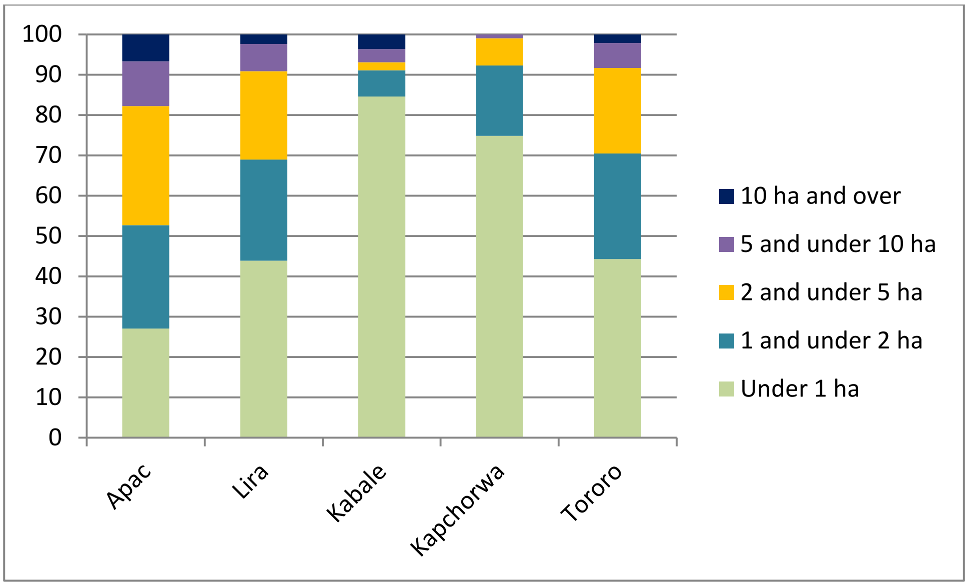


Figure 5. Farm size distribution per district in 1990/91 (Republic of Uganda, 1992)

More recent expert knowledge on the size of production units for common beans in Uganda shows some differences between the target districts, with larger landholdings in the northern districts, smaller farms in the eastern lowlands and very small holdings in the highland areas of Kapchorwa, Kabale and Kisoro. These data are somewhat contradicted by results from the 2005/6 household survey in Uganda which shows (for broad agro-ecological zones) that the area with the largest number of small farms (and fewest number of large farms) is the north central zone, whereas the south-western highlands, and especially the eastern highlands, had greater proportion of medium-sized farms (Table 10). The difference in these results may be the different methods of estimating the size of farms, the different sources of data (expert knowledge vs. survey), or in the distribution of the farm sizes themselves.

Table 10. Farm size averages and distribution per region

<table>
<tr><th rowspan="2">Target Area</th><th rowspan="2">District</th><th rowspan="2">‘Best bet’ Legume crop</th><th rowspan="2">Average farm sizes[1] 1991 ha</th><th rowspan="2">Average farm sizes[2] 2013 ha</th><th colspan="3">Farm size distribution</th></tr>
<tr><th>Small (up to 1 ha) (%)[3]</th><th>Medium (1 to 5 ha) (%)[3]</th><th>Large (more than 5 ha) (%)[3]</th></tr>
<tr><td rowspan="4">Northern</td><td>Lira</td><td>Soybean</td><td>2.2</td><td rowspan="4">1</td><td rowspan="4">62</td><td rowspan="4">35</td><td rowspan="4">2</td></tr>
<tr><td>Kole</td><td>Soybean</td><td rowspan="3">3.3</td></tr>
<tr><td>Apac</td><td>Soybean</td></tr>
<tr><td>Oyam</td><td>Soybean</td></tr>
<tr><td rowspan="2">South-western</td><td>Kabale</td><td>Common bean</td><td rowspan="2">1.3</td><td rowspan="2">0.39</td><td rowspan="2">56</td><td rowspan="2">38</td><td rowspan="2">5</td></tr>
<tr><td>Kisoro</td><td>Common bean</td></tr>
<tr><td rowspan="3">Eastern</td><td>Kapchorwa</td><td>Common bean</td><td>0.9</td><td>0.4</td><td>53</td><td>43</td><td>3</td></tr>
<tr><td>Pallisa</td><td>Groundnut</td><td rowspan="2">2.0</td><td rowspan="2">0.6</td><td rowspan="2">No Data</td><td rowspan="2">No Data</td><td rowspan="2">No Data</td></tr>
<tr><td>Kibuku</td><td>Groundnut</td></tr>
</table>

Sources: [1] Republic of Uganda(1992); [2] Bean Atlas (CIAT, unpublished); and, [3] Uganda Bureau of Statistics (2007)

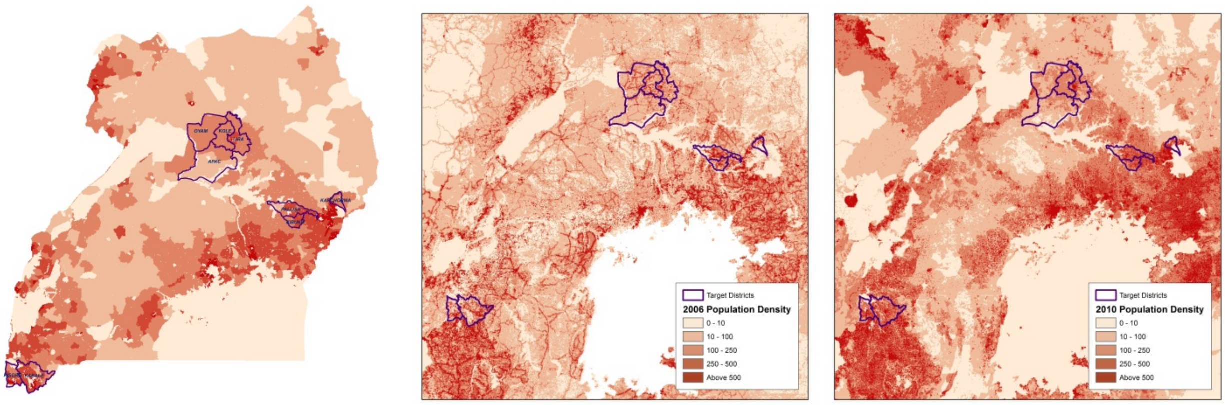
3.2 Population density

Districts in south-western and eastern Uganda are the most densely populated while those in northern Uganda have relatively fewer people per km^2 (Table 11). The district level data give the impression that Kapchorwa district has the least dense population of all the target districts, but this ignores the fact that a large proportion of that particular district is gazetted as Mt Elgon national park.

Table 11. Population density per district (Uganda Bureau of Statistics, 2006a)

Target Area	District	'Best bet' Legume crop	2002 population density
Northern	Lira	Soybean	121.2
	Kole	Soybean	116.4
	Apac	Soybean	
	Oyam	Soybean	
South-western	Kabale	Common bean	281.1
	Kisoro	Common bean	324
Eastern	Kapchorwa	Common bean	111.3
	Pallisa	Groundnut	327.8
	Kibuku	Groundnut	

Three different sources of spatially explicit data for population density from the 2000's 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 Uganda, although differences between the datasets are apparent due to the methodologies used in their creation (Figure 6).



(a) Uganda Bureau of Statistics, 2006b

(b) LandScan2006 (Bright et al., 2007)

(c) AfriPop 2010 (Linard et al., 2010)

Figure 6. Population density in Uganda

Rural population densities are high in all the target districts in Uganda with large areas above 100 persons per km^2. However the districts in the northern region have fewer people per square kilometre than the south-western and eastern regions. Stratification according to population density is therefore possible and the differences are consistent with the expert knowledge on farm sizes and the 1990's era data on farm size distribution, with higher land holdings in the areas of lower population density.

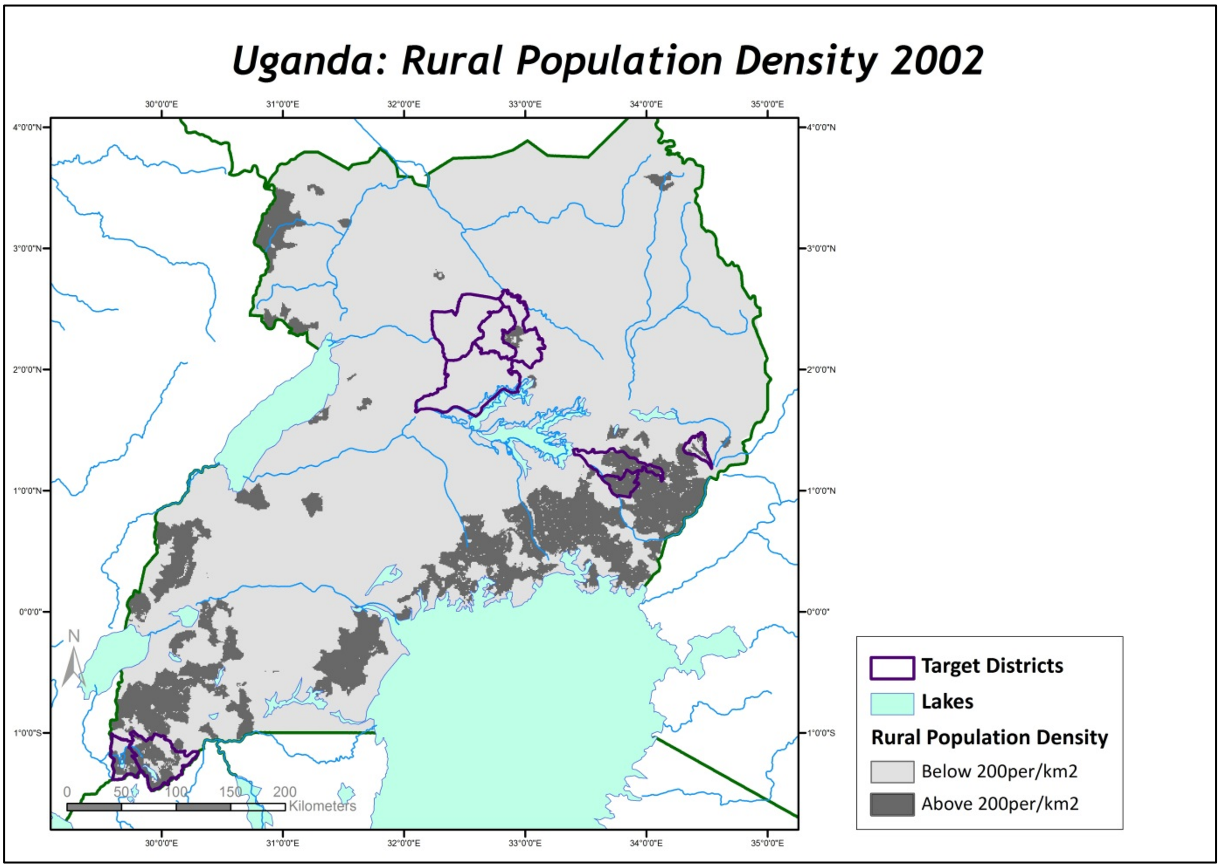


Figure 7. Population density threshold applied in Uganda

Ruecker et al., (2003) use a density of 100 persons per km^2 but this allows little discrimination between districts in the target area, whereas a value of 200 persons per km^2 shows more clearly those areas where land availability is an issue (Figure 7). The result of stratifying Uganda based on population density and farm size is that the eastern lowlands and the highland districts of Kabale, and Kisoro are classified as high density whereas the northern districts and Kapchorwa are classified as low density (Table 9).

Table 12. Stratification of target districts according to population density and farm size in Uganda

High Population density / Small farm sizes	Lower Population density / Large farm sizes
Kabale, Kisoro, Kibuku and Pallisa	Kapchorwa, Lira, Kole, Oyam, Apac

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 13) 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 8, Figure 9, and Figure 10).

Table 13. 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 Uganda 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 (Ebanyat, personal communication 20th January 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. Information from a Kilimo Trust report (2012) showed different market locations but some important districts for bean production (e.g. Kabale and Kisoro) were not sampled in that study. The importance of groundnut markets was based on the number of processors and/or traders at different markets (ICRISAT/Makerere University, unpublished) (Table 14), which was validated by experts in Uganda (Ebanyat, personal communication 20th January 2014) (Table 15).

Table 14. Classification of groundnut market types in Uganda

Groundnut market importance	Number of traders or processors
Most important groundnut market	>20 traders or >10 processors
Next important groundnut market	10 - 19 traders or 5 - 10 processors
Less important groundnut market	5 - 9 traders or 2 - 4 processors
Least important groundnut market	1 - 5 traders or 1 processor

Table 15. Markets per crop according to different market types in Uganda

Market importance	Common bean	Soybean	Groundnut
Most important markets	Kampala, Mbale	Lira, Kasese, Kampala	Busia, Kampala, Bukedea, Soroti, Iganga, Jinja, Katakwi
Next important markets	Mbarara, Masaka, Kabale	Busia, Mbale	Lira, Malaba, Mbale, Arapai, Otuboi / Abelmuny, Kumi, Tororo
Less important markets	Masindi, Iganga	Masindi, Soroti	Bugiri, Odramach
Least important markets	Busia, Bushenyi, South Sudan	Mbarara, Moroto, Arua	Adelizu, Andupaka / Ondupark, Arua, Kamuge, Kasangati, Gayaza

The model outputs show that south and east of Uganda have generally good access to markets for all three crops, due in part to their proximity to the capital Kampala or to main trading corridor towards the border with Kenya. Differences between the districts in target areas are noticeable for common bean where Kisoro has poorer market access than Kabale and Kapchorwa (Figure 8). For the soybean target area there is less difference among the districts with only southern areas of Apac experiencing poor market access (Figure 9). The situation for ground nut is similar with the eastern lowlands generally well connected to markets – only the far western areas of Pallisa have poor market access (Figure 10). Stratification based on market access (Table 16) does not therefore help significantly in differentiating among districts apart from the case of common beans, nevertheless the information 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.

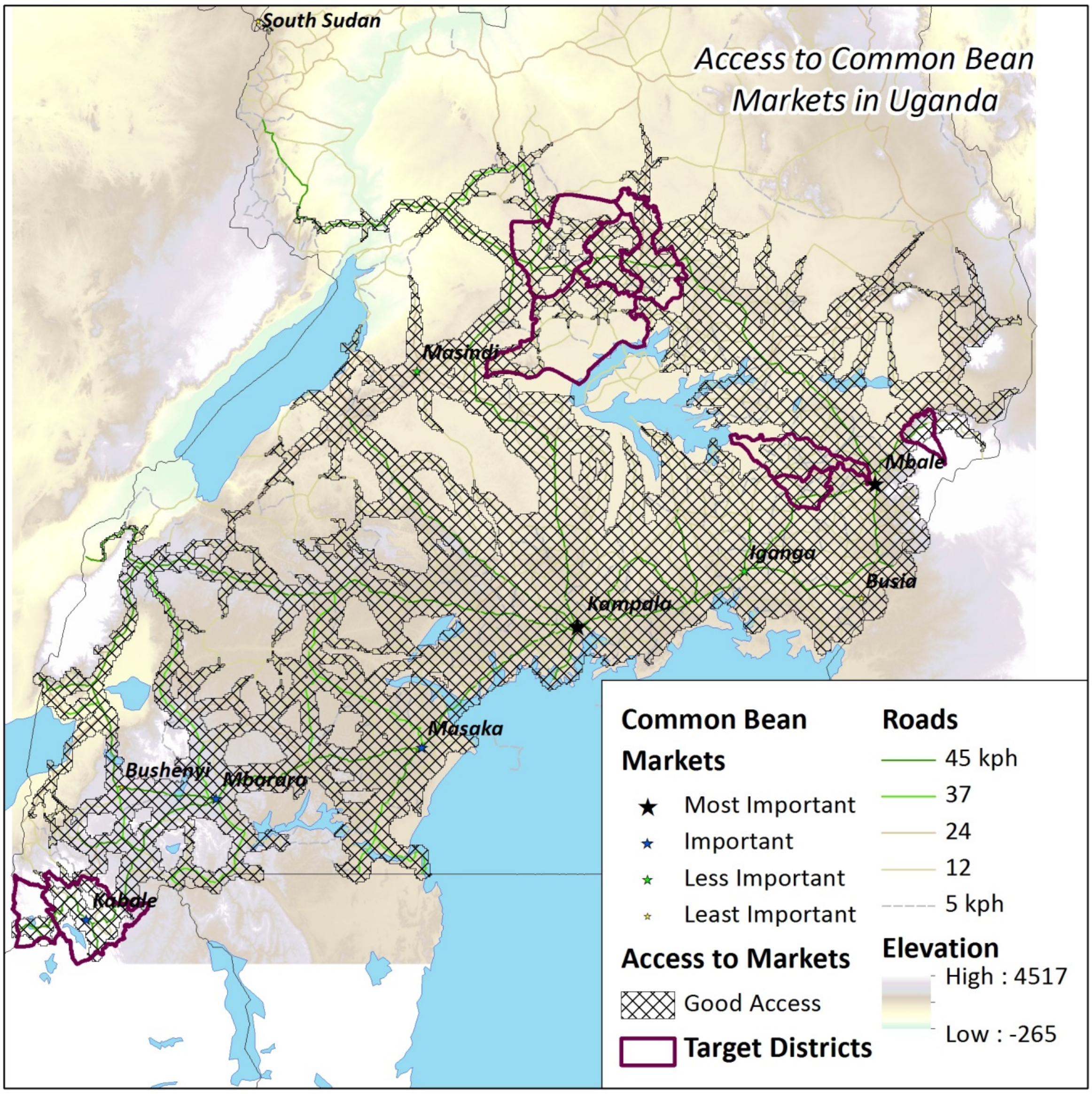


Figure 8. Access to common bean markets in Uganda

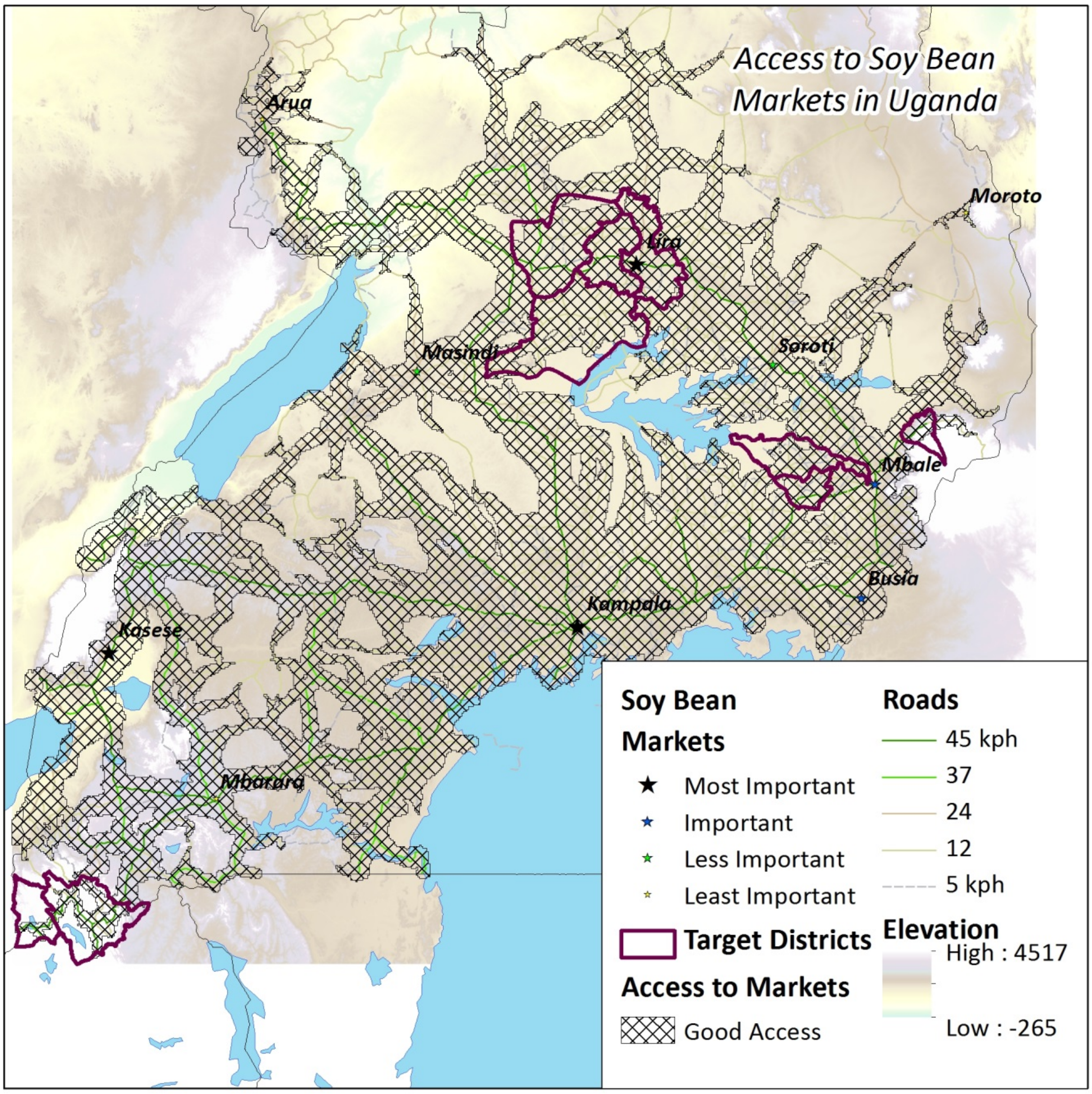


Figure 9. Access to soybean markets in Uganda

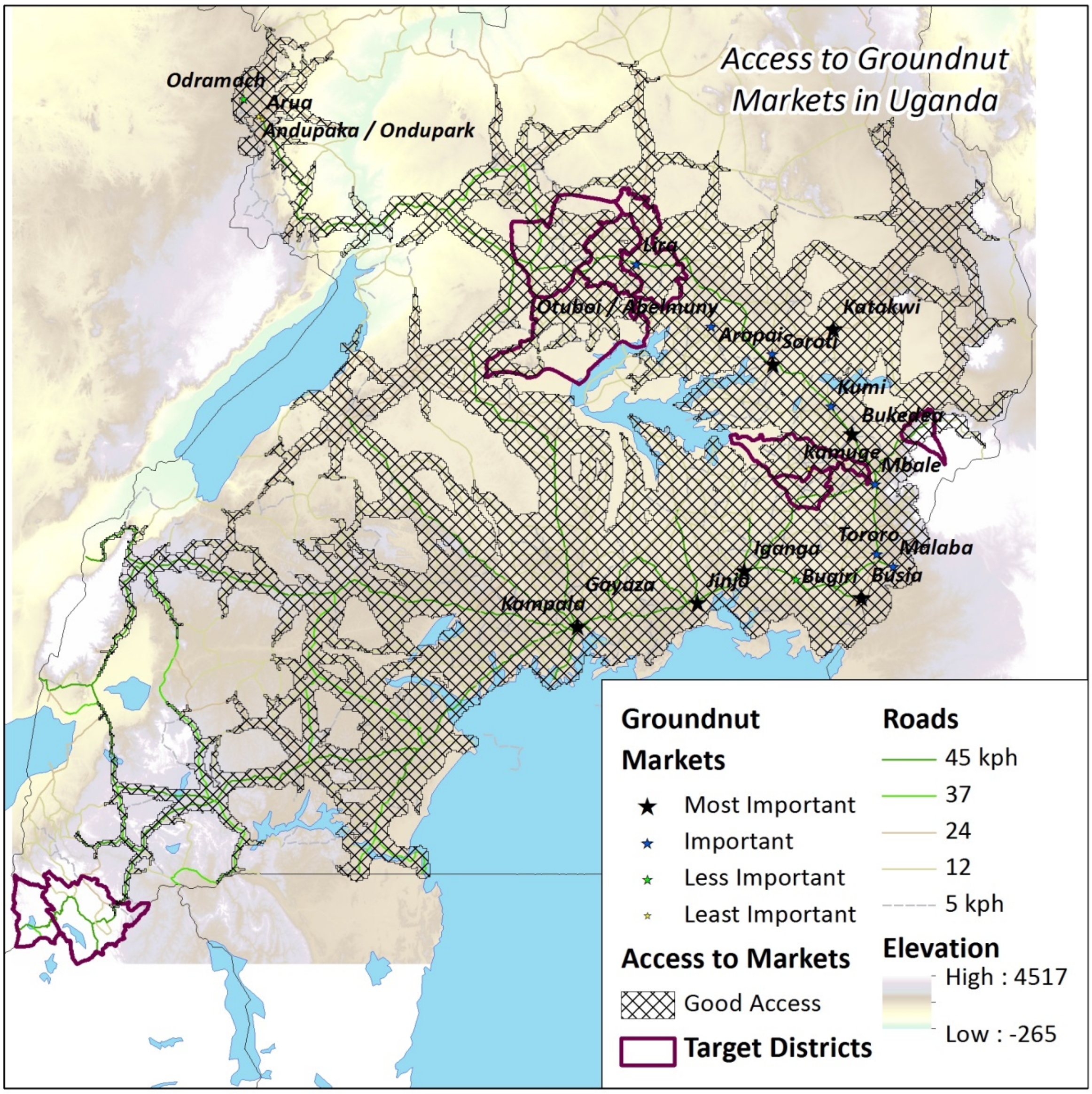


Figure 10. Access to groundnut markets in Uganda

Table 16. Stratification of target districts according to market access in Uganda

Good market access	Poor market access
Kabale, Kibuku, Kapchorwa, Lira, Kole, northern Apac and Oyam	Southern Apac, northern Kisoro, and western Pallisa

5 Adoption domains

I construct domains based on the binary stratification of temperature (Table 9), population density/farm size (Table 12) and market access (Table 16). 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 17), 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 17. Possible adoption domains based on binary stratification of key variables

		Warm areas	Cool areas
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 11, Figure 12, and Figure 13) to the different market access maps and the target districts are characterised using the adoption domain for the appropriate legume crop (e.g. Apac is characterised using the soybean adoption domain).

The results (Figure 14) show that all of the domains except one (warm – poor access – high density) are encountered in the target districts. The district with the most diversity of domains is Kapchorwa and implies that site selection within the district must be undertaken with great care, but that this district offers opportunities for multiple niches to be considered. In contrast Kibuku is characterised by a single domain which implies that site selection within Kibuku is less important.

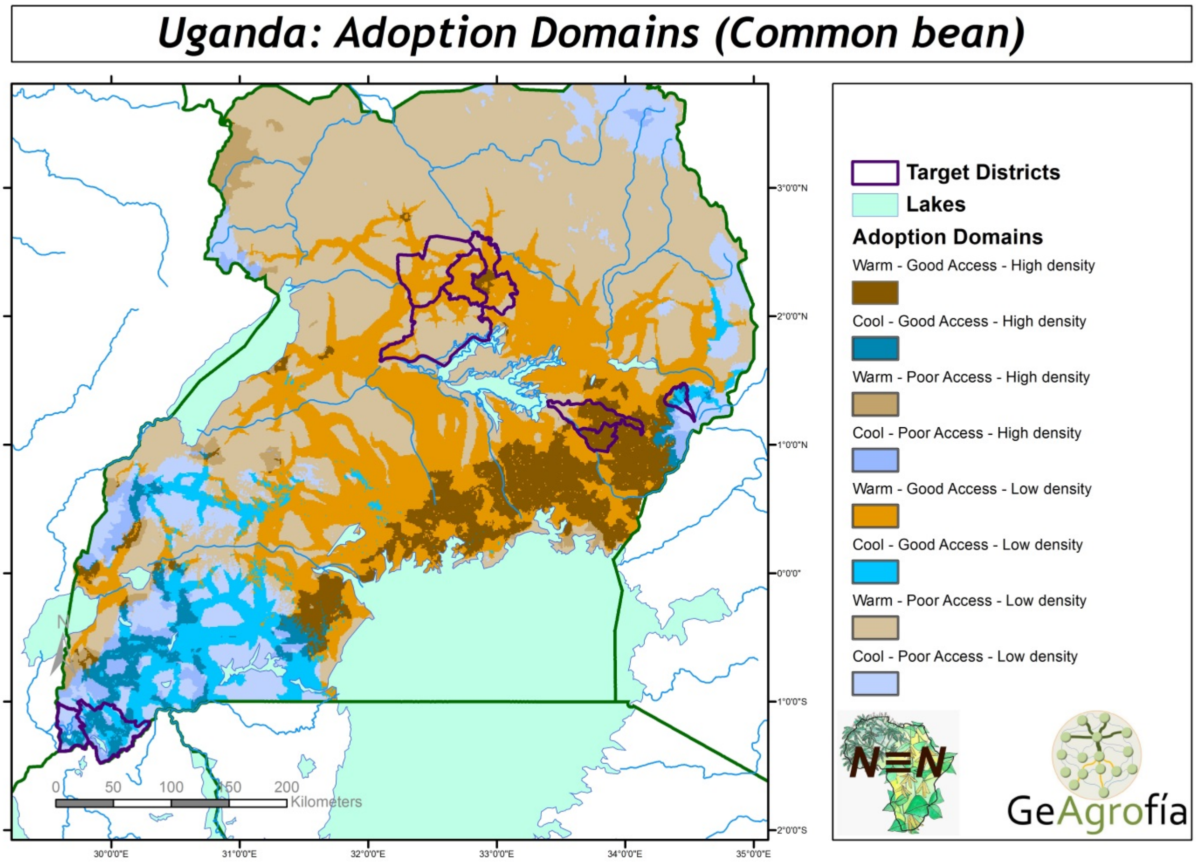


Figure 11. Common bean adoption domains

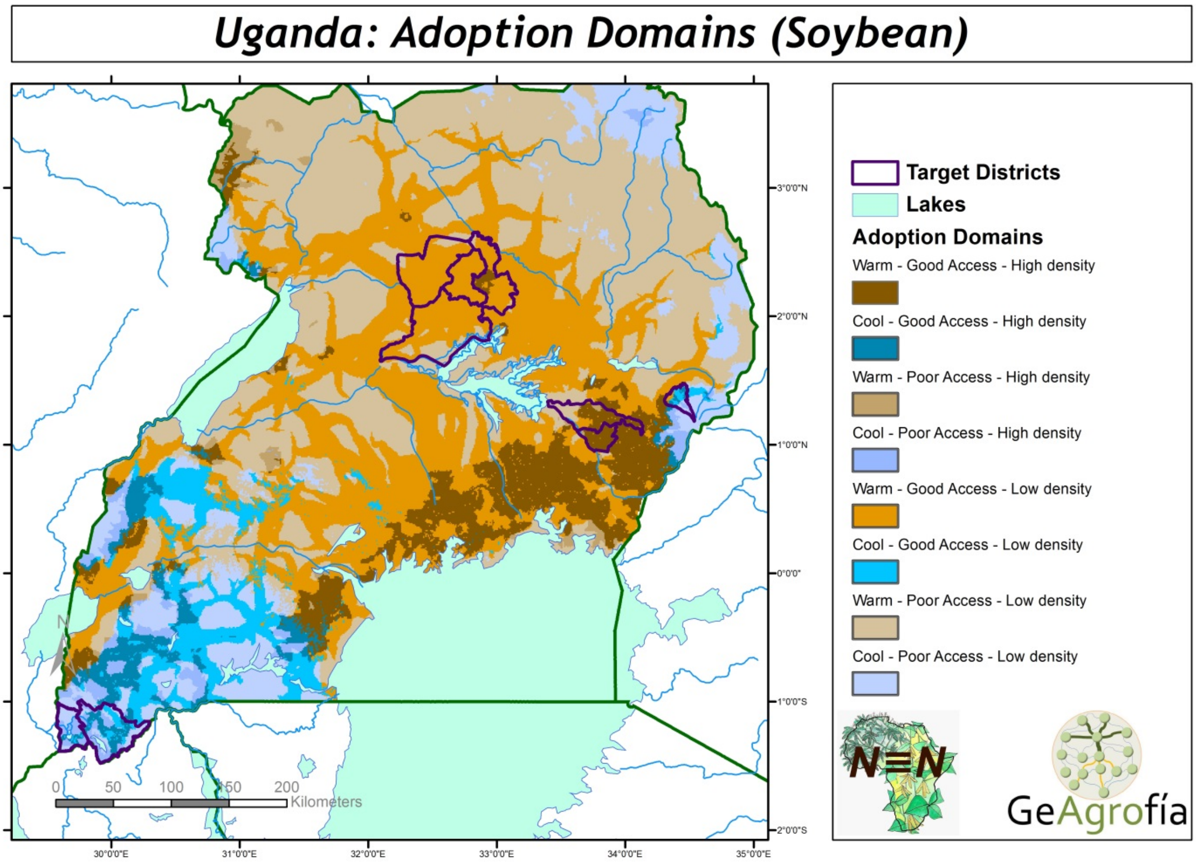


Figure 12. Soybean adoption domains

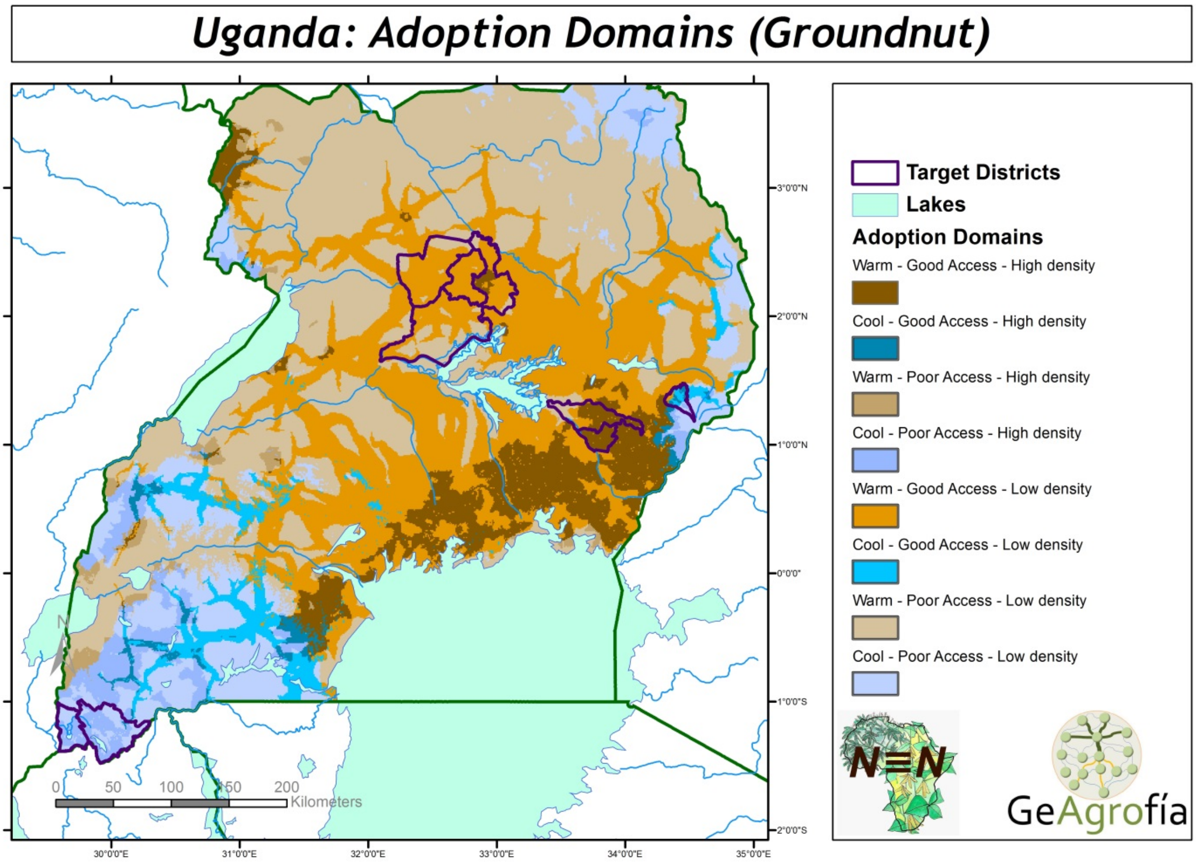


Figure 13. Groundnut adoption domains

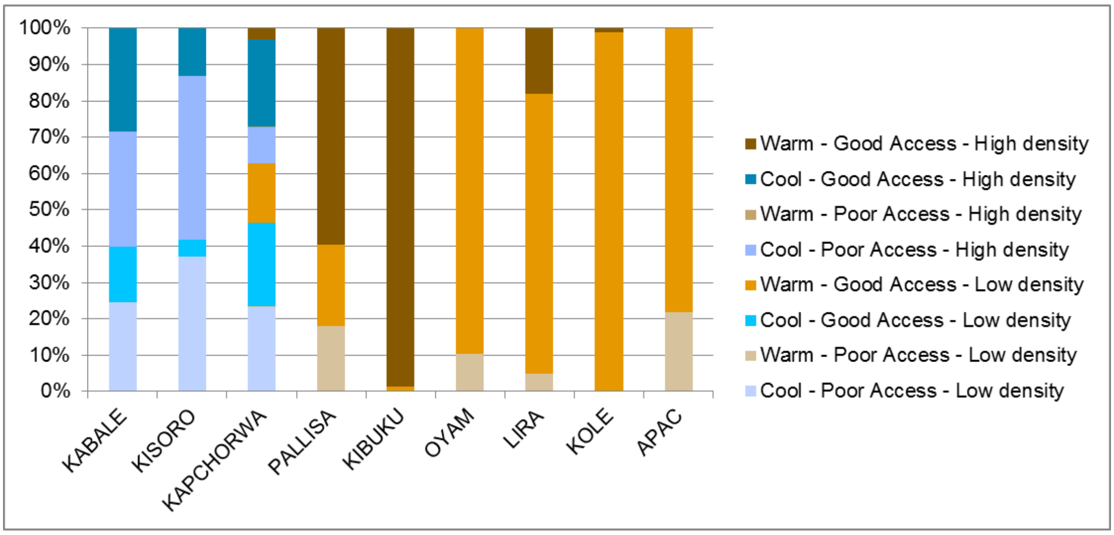


Figure 14. Characterisation of target districts using adoption domains

6 Conclusions

The adoption domains created for the different N2Africa best bet legume crops in Uganda 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 Uganda, 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

Ug_lam_Az_Eqarea

Projection: Lambert_Azimuthal_Equal_Area

False_Easting: 500000.000000

False_Northing: 500000.000000

Central_Meridian: 32.000000

Latitude_Of_Origin: 1.000000

Linear Unit: Meter

GCS_WGS_1984

Datum: D_WGS_1984

Creation of a Friction surface

Resolution 1km (995m – same as GLC2000)

Roads

gRoads v1

Speed not indicated for roads, some important roads missing (e.g. Karuma – Olwiyo), poor accuracy elsewhere (e.g. Kabale).

IFPRI

Speed indicated for all roads, but some important roads missing (e.g. Nakasongola diversion), and other roads not updated with new surface (e.g. Busunju-Hoima) but others e.g. (Kabale – Kisoro) updated.

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."

Surface indicated for all roads, but all smaller roads missing, and other roads not updated with new surface (e.g. Busunju-Hoima) but others e.g. (e.g. Nakasongola diversion) updated, and good precision of Ntuguamo - Kabale road.

IFAD

Type (but not speed or surface) indicated for all roads, but some important roads missing (e.g. Karuma – Olwiyo), poor accuracy elsewhere (e.g. Kabale).

COD-FOD Registry

"Road network in Uganda - based on different sources collected (in 2008, 2009, and 2010) by UNOCHA. Agreed to share publicly and authorized by Geo-IM working group network in Uganda chaired by UBOS and UNOCHA as Secretariat." https://cod.humanitarianresponse.info/dataset/uganda-roads

Type (but not speed or surface) indicated for all roads, but some important roads missing (e.g. Bweyale - Karuma), poor accuracy elsewhere (e.g. Kabale).

IITA (Uganda_ads_roads)

Type (but not speed or surface) indicated for all roads, but some important roads missing (e.g. Karuma – Olwiyo), poor accuracy elsewhere (e.g. Kabale).

Michelin

Speed indicated for all roads, but some important roads missing (e.g. Karuma – Olwiyo), poor accuracy elsewhere (e.g. Kabale) and other roads not updated with new surface (e.g. Kabale – Kisoro, Kampala-Hoima)

Combination of sources

The best single source is from IFPRI, but this can be augmented with additions to the network (e.g. Nakasongola) and changes to the speed (e.g. Iganga – Mbale) where improvements have been made to the network over the past 5 years.

Additions to the network

Source	Road Link
ADB	Wabigalo to Kafu Br.
ADB	Njeru (Nile) to Bukuloto

Removal from network

Source	Road Link
IFPRI	Njeru (South) to Bukuloto

Changes to Speed

Source	Road Link	from speed	to speed

IFPRI	Iganga to Mbale	37	45
IFPRI	Mulinglile to Bukoyo (Iganga)	5	45
IFPRI	Bikongozo to Kabale	24	45
IFPRI	Fort Portal to Mubende	37	45
IFPRI	Busunju to Hoima	24	45
IFPRI	Sironko to Kapchorwa	24	45
IFPRI	Kabale to Bunagana	37	45
IFPRI	Ntungamo to Rukungiri	37/24	45
IFPRI	Kikorongo (Kasese) to Mpondwe	All	45
IFPRI	Fort Portal to Lamia	12/24	45
IFPRI	Karuma to Arua	37	45
IFPRI	Soroti to Lira to Kamdini	37	45

arcpy.FeatureToRaster_conversion("ug_road_lam_merge selection","KM_PER_HR","SPATAL DATA PATH/AFRICA/AFRICA/N2AFRICA/ug_road_60","995.151066729768")

arcpy.FeatureToRaster_conversion("ug_road_lam_merge selection 2","KM_PER_HR","SPATAL DATA PATH/AFRICA/AFRICA/N2AFRICA/ug_road_97","995.151066729768")

arcpy.FeatureToRaster_conversion("ug_road_lam_merge selection 3","KM_PER_HR","SPATAL DATA PATH/AFRICA/AFRICA/N2AFRICA/ug_road_150","995.151066729768") arcpy.FeatureToRaster_conversion("ug_road_lam_merge selection 4","KM_PER_HR","SPATAL DATA PATH/AFRICA/AFRICA/N2AFRICA/ug_road_300","995.151066729768")

arcpy.FeatureToRaster_conversion("ug_road_lam_merge selection 5","KM_PER_HR","SPATAL DATA PATH/AFRICA/AFRICA/N2AFRICA/ug_road_720","995.151066729768")

arcpy.Reclassify_sa("ug_road_60","VALUE","45 60;NODATA 3600","SPATAL DATA PATH/AFRICA/AFRICA/N2AFRICA/ug_road_60rcl","DATA")

arcpy.Reclassify_sa("ug_road_97","VALUE","37 97;NODATA 3600","SPATAL DATA PATH/AFRICA/AFRICA/N2AFRICA/ug_road_97rcl","DATA")

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arcpy.Reclassify_sa("ug_road_720","VALUE","5 720;NODATA 3600","SPATAL DATA PATH/AFRICA/AFRICA/N2AFRICA/ug_road_720rc","DATA")

arcpy.RasterCalculator_sa("Con(/\ug_road_60rcl/\ == 60, 60 , Con(/\ug_road_97rcl/\ == 97, 97 , Con(/\ug_road_150rc/\ == 150, 150, Con(/\ug_road_300rc/\ == 300, 300 , Con(/\ug_road_720rc/\ == 720, 720, 3600)))))","SPATAL DATA PATH/AFRICA/AFRICA/N2AFRICA/ug_road_m4")

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.RasterCalculator_sa("/\GLOBCOVER_L4_200901_200912_V2.3.tif/\ * 1","SPATAL DATA PATH/Africa/africa/N2Africa/ug_glob")

```
arcpy.RasterToPoint_conversion("ug_glob","SPATAL DATA PATH/Africa/africa/N2Africa/ug_glob_pt.shp","VALUE")

arcpy.Project_management("ug_glob_pt","SPATAL DATA PATH/Africa/africa/N2Africa/ug_glob_pt_lam","PROJCS['Ug_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',500000.0],PARAMETER['False_Northing',500000.0],PARAMETER['Central_Meridian',32.0],PARAMETER['Latitude_Of_Origin',1.0],UNIT['Meter',1.0]]","#","GEOGCS['GCS_WGS_1984',DATUM['D_WGS_1984',SPHEROID['WGS_1984',6378137.0,298.257223563]],PRIMEM['Greenwich',0.0],UNIT['Degree',0.0174532925199433]]")

arcpy.PointToRaster_conversion("ug_glob_pt_lam","GRID_CODE","SPATAL DATA PATH/Africa/africa/N2Africa/ug_glob_lam1k","MOST_FREQUENT","NONE","995.151066729768")
```

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	Replaced by Lakes
Permanent snow and ice	220	60 mins per km

arcpy.gp.Reclassify_sa("ug_glob_lam1k","VALUE","14 36;20 36;30 36;40 48;50 60;60 48;70 60;90 48;110 48;120 36;130 36;140 36;150 24;160 60;170 60;180 60;190 60;200 24;210 60","SPATAL DATA PATH/Africa/africa/N2Africa/ug_glob_rcl","DATA")

arcpy.gp.Reclassify_sa("ug_glob_rcl","VALUE","24 1440;36 2160;48 2880;60 3600","SPATAL DATA PATH/Africa/africa/N2Africa/ug_glob_rcl2","DATA")

Lakes

arcpy.Reclassify_sa("ug_lake_lam","VALUE","1 187 5000;NODATA 3600","SPATAL DATA PATH/AFRICA/AFRICA/N2AFRICA/ug_lake_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 Uganda

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

and projected to the equal area projection

arcpy.ProjectRaster_management("ug_glurmask","SPATAL DATA PATH/Africa/africa/N2Africa/ug_glur_lam","PROJCS['Ug_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',500000.0],PARAMETER['False_Northing',500000.0],PARAMETER['Central_Meridian',32.0],PARAMETER['Latitude_Of_Origin',1.0],UNIT['Meter',1.0]]","NEAREST","924.689120545602","#","#","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("ug_glur_lam","VALUE","1 3600;2 120","SPATAL DATA PATH/Africa/africa/N2Africa/ug_glur_rcl","DATA")

arcpy.Reclassify_sa("ug_glur_rcl","VALUE","120 120;3600 3600;NODATA 3600","SPATAL DATA PATH/AFRICA/AFRICA/N2AFRICA/ug_glur_rcl2","DATA")

Base times

The order of the inputs into the base times is:

Landcover

Lakes

Urban

Roads

arcpy.RasterCalculator_sa("Con(/\ug_road_m4/\ < 3600, /\ug_road_m4/\, Con(/\ug_glur_rcl2/\ < 3600, /\ug_glur_rcl2/\, Con(/\ug_lake_rcl/\ > 3600, /\ug_lake_rcl/\, /\ug_glob_rcl2/\)))","SPATAL DATA PATH/AFRICA/AFRICA/N2AFRICA/ug_base_3")

Slope

Slope was calculated in ArcMap from SRTM elevation grid

arcpy.Slope_sa("ug_elev_lam","SPATAL DATA PATH/Africa/africa/N2Africa/ug_slp_lam","DEGREE","1")

Slope grid was converted to points

arcpy.RasterToPoint_conversion("ug_slp_lam","SPATAL DATA PATH/Africa/africa/N2Africa/ug_slp_pt.shp","Value")

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

arcpy.PointToRaster_conversion("ug_slp_pt","GRID_CODE","SPATAL DATA PATH/Africa/africa/N2Africa/ug_slp_lam1k","MEAN","NONE","995.151066729768")

Slope was converted from degrees to vertical metres per horizontal metre

arcpy.RasterCalculator_sa("Tan(/\ug_slp_lam1k/* (math.pi / 180))","SPATAL DATA PATH/Africa/africa/N2Africa/ug_slp_lam_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("/\ug_slp_lam_m/\ * - 3","SPATAL DATA PATH/Africa/africa/N2Africa/ug_slp_-3m")

arcpy.RasterCalculator_sa("Exp(/\ug_slp_-3m/\)","SPATAL DATA PATH/Africa/africa/N2Africa/ug_slp_e-3m")

arcpy.RasterCalculator_sa("1 / /\ug_slp_e-3m/\","SPATAL DATA PATH/Africa/africa/N2Africa/ug_slp_ff")

Elevation

arcpy.RasterCalculator_sa("/\dem_s20e020/\ * 1","SPATAL DATA PATH/Africa/africa/N2Africa/ug_elev")

arcpy.ProjectRaster_management("ug_elev","SPATAL DATA PATH/Africa/africa/N2Africa/ug_elev_lam","PROJCS['Ug_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',500000.0],PARAMETER['False_Northing',500000.0],PARAMETER['Central_Meridian',32.0],PARAMETER['Latitude_Of_Origin',1.0],UNIT['Meter',1.0]]","NEAREST","92.4689351995521","#","#","GEOGCS['GCS_WGS_1984',DATUM['D_WGS_1984',SPHEROID['WGS_1984',6378137.0,298.257223563]],PRIMEM['Greenwich',0.0],UNIT['Degree',0.0174532925199433]]")

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("/\ug_base_3/\ * /\ug_slp_ff/\","SPATAL DATA PATH/AFRICA/AFRICA/N2AFRICA/ug_friction")

Costdistance modelling

Common bean

Most important markets

arcpy.PointToRaster_conversion("ug_comb_mark_5","FID","SPATAL DATA PATH/AFRICA/AFRICA/N2AFRICA/ug_comb_5","MOST_FREQUENT","NONE","995.151066729768")

arcpy.CostAllocation_sa("ug_comb_5","ug_friction","SPATAL DATA PATH/AFRICA/AFRICA/N2AFRICA/ug_comb5all","#","ug_comb_5","VALUE","SPATAL DATA PATH/AFRICA/AFRICA/N2AFRICA/ug_comb5acc","SPATAL DATA PATH/AFRICA/AFRICA/N2AFRICA/ug_comb5dir")

arcpy.RasterCalculator_sa("Int(/\ug_comb5acc/\ / 995.151066729768)","SPATAL DATA PATH/AFRICA/AFRICA/N2AFRICA/ug_comb5int")

Next important markets

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Less important markets

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Least important markets

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Kilimo Trust, 2012. Development of Inclusive Markets in Agriculture and Trade (DIMAT): The Nature and Markets of Bean Value Chains in Uganda. Available at: http://www.undp.org/content/dam/uganda/docs/UNDP%20Uganda_PovRed%20-%20Beans%20Value%20Chain%20Report%202013.pdf

Combination of markets

arcpy.RasterCalculator_sa("Con(/\ug_comb5int/\ > 28800, Con(/\ug_comb4int/\ > 21600,Con(/\ug_comb3int/\ > 14400, Con(/\ug_comb2int/\ > 3600, 0, 1), 1) , 1), 1)","SPATAL DATA PATH/AFRICA/AFRICA/N2AFRICA/ug_comb_bin")

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Soybean

Most important markets

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Next important markets

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Less important markets

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Least important markets

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Combination of markets

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Groundnut

Most important markets

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Next important markets

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Less important markets

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Least important markets

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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

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