Characterization for index based livestock insurance

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Characterization for index based livestock insurance

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Acronyms

AMIS   Agricultural Market Information System

ASAL   arid and semi-arid lands

BADC   British Atmospheric Data Centre

CRU   Climatic Research Unit

DfID   Department for International Development

GAUL   Global administrative unit layers

GLW   Gridded livestock of the world

IBLI   Index-based livestock insurance

IFPRI   International Food Policy Research Institute

IIASA   International Institute for Applied Systems Analysis

NDVI   Normalized difference vegetation index

PAAT   Programme Against African Trypanosomosis

TLU   Tropical livestock units

UNEP   United Nations Environmental Programme

WCMC   World Conservation Monitoring Centre

WDPA   World Database of Protected Areas

Acknowledgements

Abstract

Pastoral populations of sub-Saharan Africa are particularly vulnerable to losses in wealth and productive assets via herd mortality shocks. Although conventional insurance mechanisms covering individual losses are not cost effective in low-income extensive grazing pastoral communities, index insurance for livestock offers a promising alternative. This paper identifies regions most suitable for an index-based livestock insurance product: areas predicted to have high covariate risk from drought, high potential demand for a livestock insurance product, and supporting market infrastructure for an insurance product. Our findings support current efforts to implement index insurance in Kenya and Ethiopia, and reveal additional areas for geographic expansion in western and southern Africa.

Introduction

Pastoralism today

Pastoralism, characterized by extensive livestock herding and management, constitutes a significant and vital component of the African economy.[1] There are an estimated 50 million pastoralists and agro-pastoralists active in sub-Saharan Africa today (Rass 2006), many of whom reside in arid and semi-arid lands (ASAL) where climatic factors severely constrain or prohibit economic diversification in agricultural production. ASAL populations are, therefore, particularly vulnerable to losses in wealth and productive assets via herd mortality shocks, potentially rendering extensive grazing pastoralists victim to poverty traps (McPeak and Barrett 2001).

Traditional insurance is not the solution

Unfortunately, conventional insurance is subject to high information and transaction costs that effectively price out many smallholders, and is therefore typically not a suitable solution for improving the welfare of low-income ASAL pastoralists. Offering a livestock insurance product based on individual losses requires verification, which proves prohibitively costly in expansive rural areas with little infrastructure (Mahul et al. 2009). Other concerns include adverse selection (an insured client may have superior knowledge about his or her own herd mortality risk relative to insurers) and moral hazard (e.g. neglecting livestock once insured), both of which can render the product unsustainable, and difficulties validating claims in remote locations.

Why index insurance?

Index-based livestock insurance (IBLI) is a viable solution for insuring livestock losses from covariate shocks in places where traditional insurance is not viable. Unlike traditional insurance, index insurance uses an external indicator to assess losses on an aggregate level over a particular area. Index insurance is also less susceptible to moral hazard—payout is independent of an insured client's individual behavior—and adverse selection as the index is created from external variables unrelated to individual-specific risk.

A recent example highlighting the promise of IBLI comes from the Kenya's Marsabit district, where drought contributes to 62% of reported livestock mortality (Jensen et al. 2014), motivating the construction of an index measuring covariate drought risk from low levels of forage scarcity. The resulting IBLI pilot program made use of the normalized difference vegetation index (NDVI), leveraging relatively low-cost and long-recorded satellite readings of plant photosynthetic activity to estimate a statistical relationship between NDVI and herd mortality from historical data.[2] The constructed IBLI index

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1. ILRI scientists estimate 'pastoralism contributes between 10 and 44% of the GDP of African countries', and is particularly important in sustaining poor rural populations (Boto and La Peccerella 2009).

2. Between 2010 and 2012, the IBLI Marsabit index predicted livestock mortality rates using a response function of NDVI that was developed using 20 years of historic NDVI and livestock mortality rates (Chantarat et al. 2013). Starting in 2013, the IBLI Marsabit index has no longer explicitly predicted livestock mortality rates. Similar to the IBLI–Ethiopia product launched in August 2012 and other IBLI products in Kenya, the IBLI Marsabit product now makes indemnity payments according to an index developed using only NDVI values.

therefore serves as a proxy for livestock mortality and triggers automatic payouts without the need for costly verification on a case-by-case basis. Evidence from the pilot indicates that IBLI successfully insured pastoralists during a drought period and, for simulated full coverage, reduced household exposure to risk from large covariate shocks by 63% (Jensen et al. 2016).

Insurance or lottery ticket?

Despite its potential benefits, index insurance does not necessarily imply full—indeed any—risk coverage. Because the IBLI product is designed to cover covariate risk, individual gains or losses that deviate from the index are not compensated. An insured client, therefore, might not lose any livestock during a drought and still be paid an indemnity, or lose a significant portion of his or her herd without indemnity during a period where the index does not reach its threshold for payouts. Gains and losses that are imperfectly correlated with the realized index payout are defined as basis risk. For IBLI, basis risk applies narrowly to any losses from lack of vegetation beyond a certain threshold that are not appropriately compensated by the index payout. Other risk is also present through factors not captured under NDVI, including disease, predation, or armed conflict. If basis risk is sufficiently high, index insurance can increase the level of an insured agent's income risk, rendering the IBLI product a gamble instead of a source of income smoothing. In Marsabit, IBLI effectively reduced downside risk exposure by 30%, with the remaining 69% of downside risk largely deriving from idiosyncratic risk not covered by the index (Jensen et al. 2014). The fine line between an insurance product that covers risk and a product that produces risk motivates the need to characterize regions most suitable for index insurance. These most suitable regions will exhibit low basis risk, where covariate losses correlate well with the NDVI-backed IBLI index.

IBLI characterization

Climatic constraints: Constructing a target area

In order to characterize regions suitable for index insurance for pastoral populations, we first isolate areas where (1) extensive grazing pastoralists reside and where (2) populations are exposed to high covariate risk from herd mortality. Surveyed literature indicates African pastoralists are largely confined to semi-arid zones (FAO 2001), with some possible presence in arid and dry sub-humid zones.[3] Our first step, therefore, is to identify areas of the continent that fall within arid, semi-arid and dry sub-humid zones (Figure 1).

We acquired the United Nations Environmental Programme (UNEP) world aridity index measuring average annual precipitation in millimetres per day divided by average annual potential evapotranspiration. The UNEP index was selected because it serves as a more sophisticated indicator of climate than precipitation averages alone and includes self-defined index cutoffs for arid, semi-arid and dry sub-humid zone classification. These zones cover a relatively wide swath of area compared to zoning based on precipitation averages, ensuring that most significant pastoral populations are included in the desired region. The UNEP aridity index also features thirty consecutive years of consistent data collection. Leaving aside hyper-arid and humid regions provides a preliminary climatic target region where pastoralism is viable on the African continent.

Figure 1: Initial target area of UNEP arid, semi-arid and dry sub-humid zones (in grey) overlaid on a political map of global administrative unit layers (GAUL, Figure A1) from the FAO.
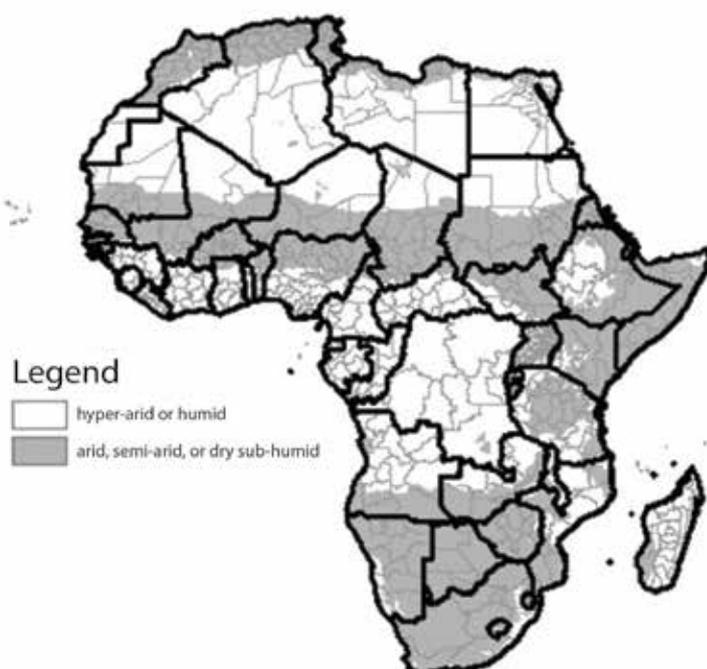
3. See International Institute for Sustainable Development, Arid and semi-arid lands: Characteristics and importance: http://www.et.undp.org/content/ethiopia/en/home/library/environment_energy/dvtpotentialsofdrylands/

It is worth noting that NDVI already serves as an index for offering index insurance in arid, semi-arid and dry sub-humid zones. NDVI offers remotely sensed data for vegetation—an indicator of drought events that are the primary cause of herd mortality, and an indicator of other forage scarcity events that raise mortality—and is freely and openly available. NDVI is also preprocessed, which provides an advantage in transparency (Chantarat et al. 2013). Additional advantages in confining our target area to arid, semi-arid and dry sub-humid zones include the fact that NDVI and other remotely sensed measures are ideal for spatially extensive averages and that there exists at least some level of exposure to extreme drought events in these areas, implying a level of covariate risk within the target area.

Having confined our target area for index insurance via climatic variables, we then refine our target area by focusing on regions more suited for extensive grazing pastoralists in contrast to more sedentized agro-pastoralists, who are able to better diversify sources of income and may be less susceptible to covariate shocks identified by remotely sensed data. Although cropping is not unheard of amongst pastoral populations, subtracting areas of significant agricultural activity from our target area allows us to isolate pastoral populations with a high proportion of covariate risk to total risk—populations most likely to benefit from an IBLI product. We have taken the effort to remove cropped regions because while there is generally little cropping within our climatic target area, our inclusion of dry sub-humid climates allows for some moderately cropped zones. Cropping within the climatic target area is also possible due to irrigation projects in low-rainfall areas. We, therefore, acquired cropland data from the International Institute for Applied Systems Analysis (IIASA) and the International Food Policy Research Institute (IFPRI). The IIASA cropland map (Figure A4) has generated significant media attention and is a (1) reputable and (2) up-to-date hybridization of several existing cropland datasets, providing the most complete cropland dataset on the African continent to date (Vancutsem et al. 2012).

Figure 2: Refined target area (blue) when subtracting areas of at least 2% cropland. Also pictured is the nearly identical 10% cropland tolerance target area (red) which overlays the unrefined target area of arid, semi-arid and dry sub-humid zones (grey).
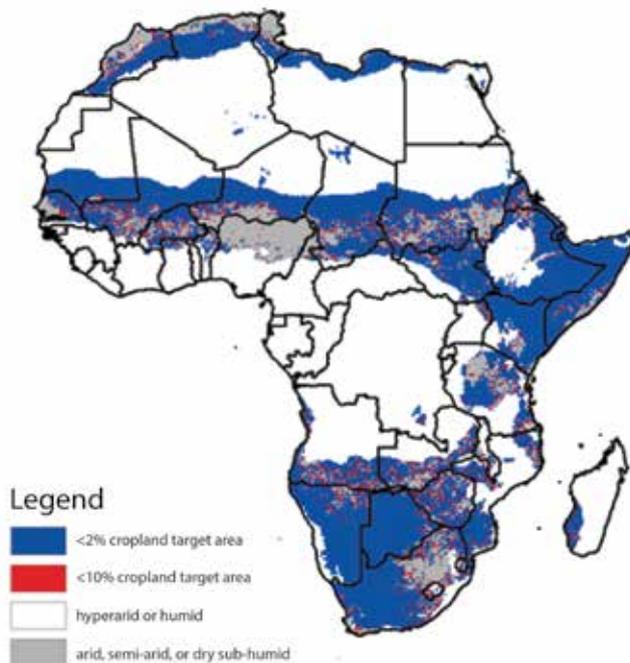
We create our refined target area by removing areas with more than 2% cropland per square kilometer from our existing aridity map. Our 2% figure is intended to represent any relevant agricultural production. As a robustness check we also generate a target area using a 10% cutoff, which produces a nearly identical region (Figure 2). Cropping covers approximately 26.964% of the climatic target area with a 2% threshold and 26.909% with a 10% threshold. Overall, the 2% threshold refined target area covers approximately 99.925% of the 10% target area. We do not subtract water bodies from our target area as these places periodically encounter high concentrations of grazing livestock, which if recorded at imprecise resolution can be inadvertently removed in the remaining steps of characterization.

Finally, we subtract areas of low variation of the NDVI index to again refine the target area. High variation in vegetation productivity implies index insurance can offer some value to pastoralists (i.e. there's risk to be covered) but sufficiently low

variation diminishes the need for IBLI. Using a seasonal layer on NDVI variation and recommendations from Anton Vrieling (Faculty of Geo-Information Science and Earth Observation, University of Twente), we generate a final target area for regions exhibiting an NDVI coefficient of variation of at least 0.1, a conservative lower bound.

Having used climatic and cropland data to estimate our target area—the area containing populations most geographically well suited for IBLI—our next step is to estimate areas of high livestock ownership within our target area. These are the places where risk reduction from IBLI can be maximized in absolute terms.

Figure 3: Coefficient of variation (CoV) for cumulative NDVI during a recent season. Missing data in white.
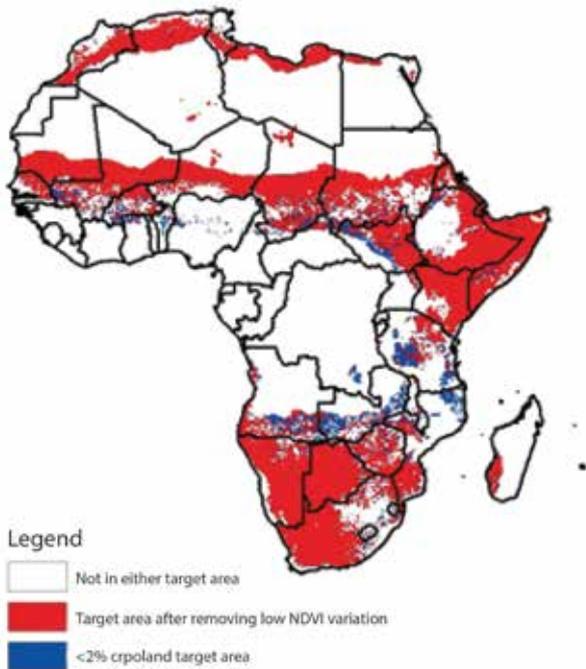
Figure 4: Final, smaller target area (red) after subtracting areas of low variation. The blue area represents those areas of <2% cropland that have been cut off under low variation.
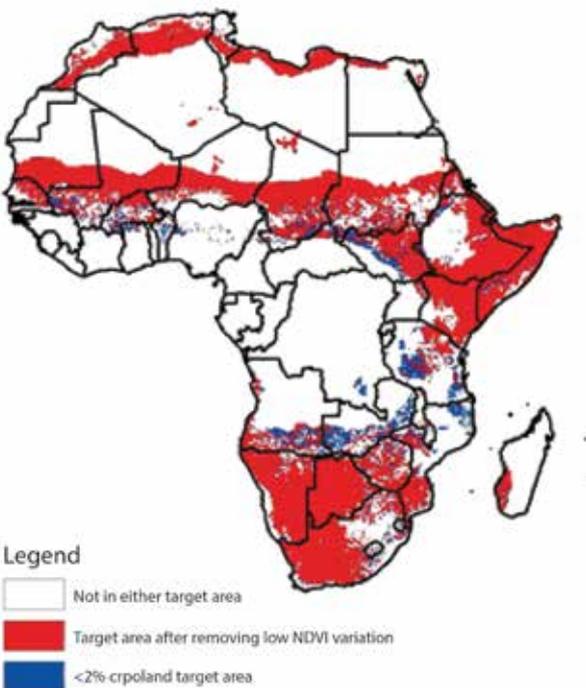
Livestock supply: Finding where IBLI can maximize impact

African pastoralists are largely dependent on camels, cattle, sheep and goats, with the former two especially common amongst extensive grazing pastoralists. We acquired data on camels, cattle, sheep and goats generated by ILRI's Tim Robinson and estimates using machine learning techniques applied to subnational livestock figures (Figure 5, Robinson et al. 2006).[4, 5]

We identified the data sources as relatively up-to-date (2006–12) and extremely detailed (three arc minute resolution or .05 degrees, fewer than 10km) compared to other published data on livestock distribution. Robinson's 'gridded livestock of the world' (GLW) layers include the additional benefit of accounting for prohibitively steep terrain and certain protected areas, effectively refining our target area. We performed a validation check by aggregating livestock totals by country from ILRI and comparing to reported country-level figures from the FAO.

Figure 5: Tropical livestock units (TLUs). Includes camels, cattle, sheep and goats weighted and aggregated, with counts per 0.5x0.5 degree cell, grouped by half standard deviations around the mean number of TLU per cell.

Legend
TLU
0–34
35–98
99–163
164–227
228–291
292–235,047
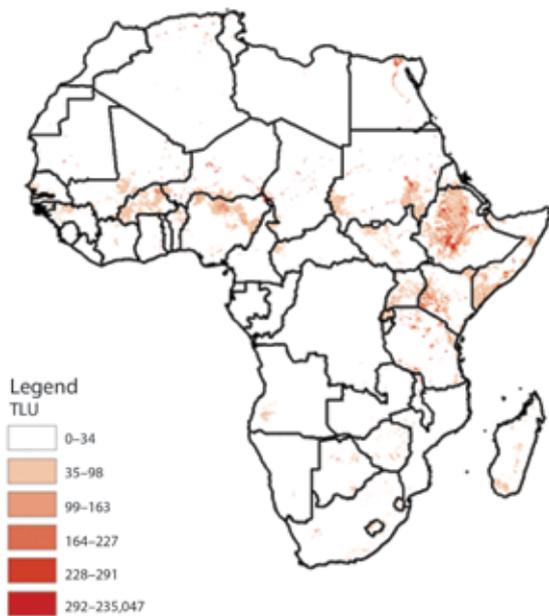
Figure 6: TLUs in target area by administrative level 1, in half standard deviations around the mean number of TLU per administrative zone.

Legend
0 - 2
3 - 6
7 - 10
11 - 14
15 - 18
19 - 6,709
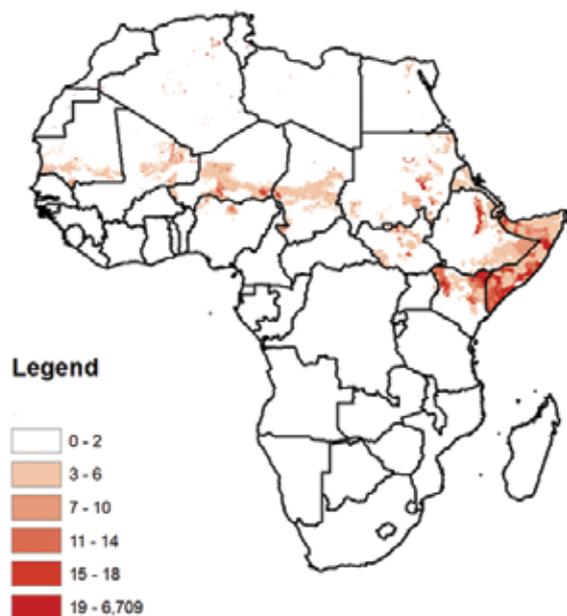
4. G.R. William Wint, Giulia Conchedda, Thomas P. Van Boeckel, Valentina Ercoli, Elisa Palamara, Giuseppina Cinardi, Laura D'Aietti, Simon I. Hay, Marius Gilbert

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We then performed a zonal summation of TLU counts within each first-level administrative unit, following a few small manipulations in layering (Figure 6). The critical insight in our methodology is that we only include livestock that fall within the already-computed target area, so that livestock holding counts are in theory more reflective of extensive grazing pastoral holdings and thus of target clients for IBLI. Our TLU counts explicitly exclude livestock in humid and hyper-arid types of climate and livestock in regions where more than 2% of the land is cropped.

The countries (Table 1) and top administrative units (Table 2) are then ordered by total TLUs to provide an estimate of total potential demand for livestock insurance. Sudan has the greatest number of livestock within the geographic zones appropriate to IBLI and three of its states top the list of potential demand at the first administrative level as well. Ethiopia, Somalia, Kenya and South Sudan follow Sudan at the country level ranks and TLU aggregation at the lower administrative level also highlight these countries as high TLU regions.

Table 1: Countries ranked by TLUs (Top 10). See appendix for complete table (A1).

TLU rank	Country	TLUs in target area	TLUs/Km^2 of target area
1	Sudan	27,955,304	45.34
2	Ethiopia	18,025,893	27.87
3	Somalia	17,511,426	33.81
4	Kenya	11,473,499	26.69
5	Mali	7,781,311	15.45
6	South Sudan	6,641,774	20.79
7	South Africa	6,535,997	7.84
8	Chad	6,520,037	11.23
9	Burkina Faso	5,609,236	44.23
10	Niger	5,375,549	15.04

Table 2: First-level administrative units ranked by TLUs (Top 10). See appendix for complete table (A2).

TLU rank	First-level administrative unit	Country	TLUs in target area
1	Southern Kordofan	Sudan	6,808,160
2	Kassala	Sudan	6,792,580
3	Northern Kordofan	Sudan	4,864,044
4	Rift Valley	Kenya	4,817,436
5	Afar	Ethiopia	4,616,763
6	Somali	Ethiopia	4,118,370
7	North Eastern	Kenya	4,064,860
8	Oromia	Ethiopia	3,503,607
9	Juba Hoose	Somalia	2,817,896
10	Mopti	Mali	2,588,237

Assessing institutional support: Insurance infrastructure

Having developed a clear picture of livestock supply in areas suitable for pastoralism and IBLI, our next step is to determine existing capacity for a new insurance product based on country-level insurance industry data. Countries with well-developed, thick insurance markets are more likely to be able to support the successful introduction of an IBLI product than those with underdeveloped, thin markets.

A strong indicator of capacity of index insurance is the relative size of a country's non-life insurance market (which captures property and casualty insurance). Despite a lack of comprehensive industry reports from insurers and reinsurers operating in Africa, we acquired wide-ranging data on non-life insurance and insurance company assets from the US Federal Reserve Bank of St. Louis' economic data repository (FRED 2009, Figures 8 and 9).[6] These two categories indicate relatively well-developed insurance markets in the southern part of the continent, possibly stemming from the many insurers operating out of South Africa and microinsurance initiatives in Namibia. These figures are supplemented by counts of insurance companies by country parsed from industry reports by the lead author (Figure A11).

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6. For example: https://research.stlouisfed.org/fred2/series/DDDI10KEA156NWDB

Figure 7: 2009 Country-level non-life insurance premium volume to GDP (per cent), in quantiles. Countries with missing data in white.
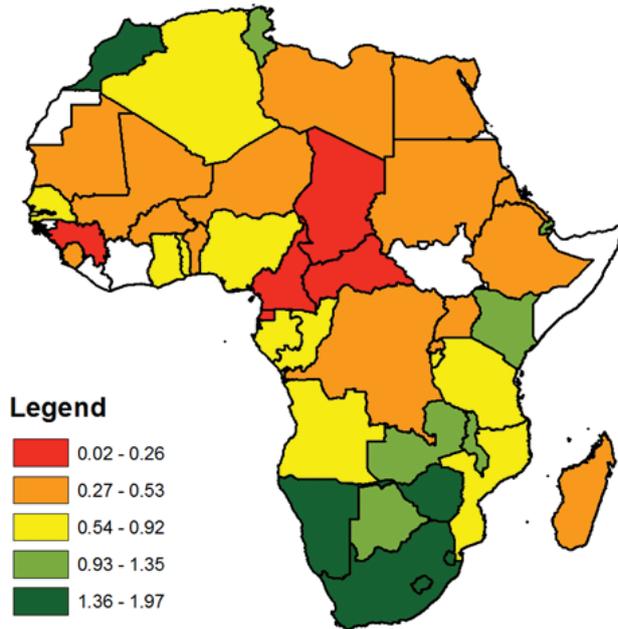
We supplement our findings with microinsurance reports form the MunichRe Foundation (Figures A12, A13). MunichRe's 2015 report grouped countries by current and predicted future suitability for microinsurance programs, again emphasizing relatively stronger infrastructure in the southern and eastern regions of the continent.

Figure 8: 2009 Country-level insurance company assets to GDP (per cent), in quantiles. Countries with missing data in white.
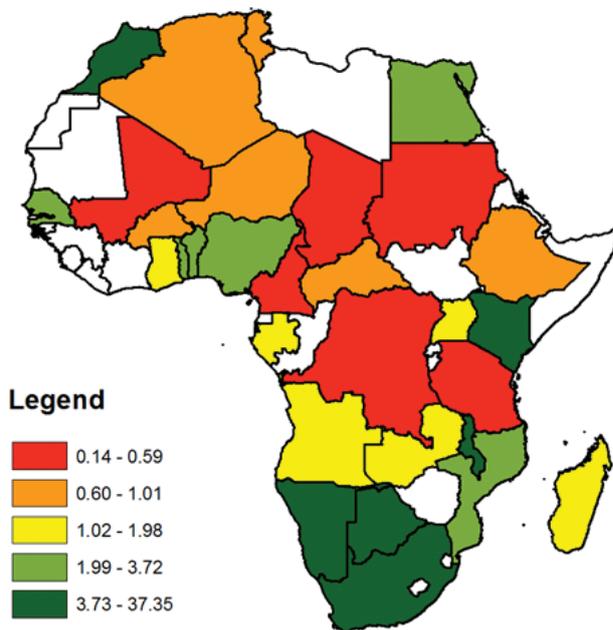
Conclusions for geographic expansion

Combining our climatic, livestock supply and insurance market (institutional) data offers a multidimensional perspective on which regions are well suited for a livestock index insurance product. We first identified a target area for pastoral activity based on climatic variables, then proceeded to estimate relevant livestock supply (in TLUs) within the target area, serving as a proxy for demand for a livestock insurance product. We then used country-level institutional data to find which livestock-rich areas already have adequate infrastructure for the introduction of an index insurance program. Taking all classes of data into account, we construct the following (Figure 9):

Figure 9: Classification of countries by TLUs supply and insurance infrastructure.

Legend

- Very low TLUs
- Low TLU s and poor or unknown insurance infrstructure
- High TLUs and poor or unknown insurance infrasture
- Low TLU s and moderate insurance infrastructure
- High TLUs and moderate insurance infrastructure
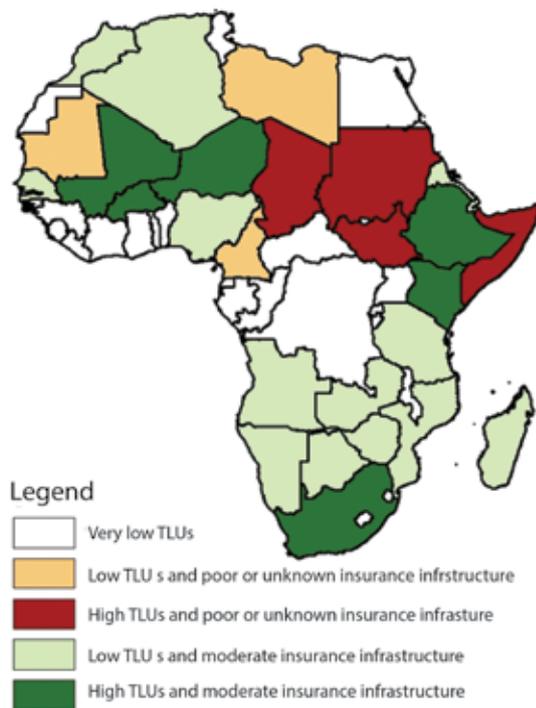
Figure 9 offers a rough sketch of our characterization work. The countries in shades of green exhibit moderate insurance infrastructure, whereas those in red-yellow were largely in the bottom quantile of insurance market metrics or had significant missing data.

Darker-shaded areas represent countries with over five million TLUs in the target area, 10 in total, and lighter-shaded countries have between five hundred thousand and five million TLUs in the target area. Countries shaded dark green, for example, have high concentrations of TLUs representing potentially strong insurance demand, and more robust insurance markets and would offer a higher probability of success for a livestock insurance program. These results lend support to the decision to initially pilot IBLI in Kenya and Ethiopia. Other countries with high livestock supply and supporting infrastructure include the Sahelian countries of Mali, Burkina Faso and Niger, as well as South Africa. Additional candidates with relatively thick insurance markets and dense pockets of livestock include the southern African countries of Botswana, Zimbabwe and Tanzania.

If one were to focus on initiatives for development, areas with high livestock supply but poor insurance infrastructure (countries in dark red) could reap considerable marginal welfare gains from the implementation of a viable insurance product if the right partner(s) can be identified and government regulators authorize the sale of such a product. Of particular interest are Sudan, South Sudan, Somalia and Chad. Mauritania and Cameroon's far North Regions are also of some interest.

Our characterization results provide a prioritization of areas in which to implement IBLI based on livestock density—corresponding to potential demand for a livestock insurance product—among extensive grazing pastoral populations. Particularly salient is the presence of high-priority areas outside Kenya, Ethiopia and Somalia. The southern administrative units of Niger and Mali, and even as far east as Mauritania all appear strong candidates for index insurance. There also appear to be potential high-priority regions south of the Zambezi River in Zimbabwe, Botswana and South Africa. Offering IBLI within these high-priority areas may require identifying specific local partners to assist with implementation. Additionally, identifying local sources of basis risk may help determine where IBLI can offer the most benefit among high-priority areas.

Approaching implementation: Next steps

We have produced a crude prioritization of which areas could most benefit from an IBLI program covering drought-related risk to livestock productivity and mortality under differing circumstances. What remains in the characterization process, having identified a region for expansion, is the identification of sources of basis risk and the removal of areas prone to high basis risk within that region. Once a subset of administrative unit(s) is identified as of interest for implementation of index insurance, for example by using Table A2 to identify units within countries of interest, we encourage further refining of the implementation area within this region by subtracting off areas prone to natural disasters (floods, wildfires), disease and pestilence (tsetse fly), and armed conflict. Examples of these types of data are included in our appendix.

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Appendix

I.   Geodatabase reference guide: source layers and constructed layers used for characterization

II.   Tables and statistics

I.   ArcGIS geodatabase reference guide

Geodatabase name: characterization.gdb
All layers use spatial reference GCS_wgs_84, unless otherwise specified

Section 1—Source layers:

Figure A1: Global administrative unit layers (GAUL).
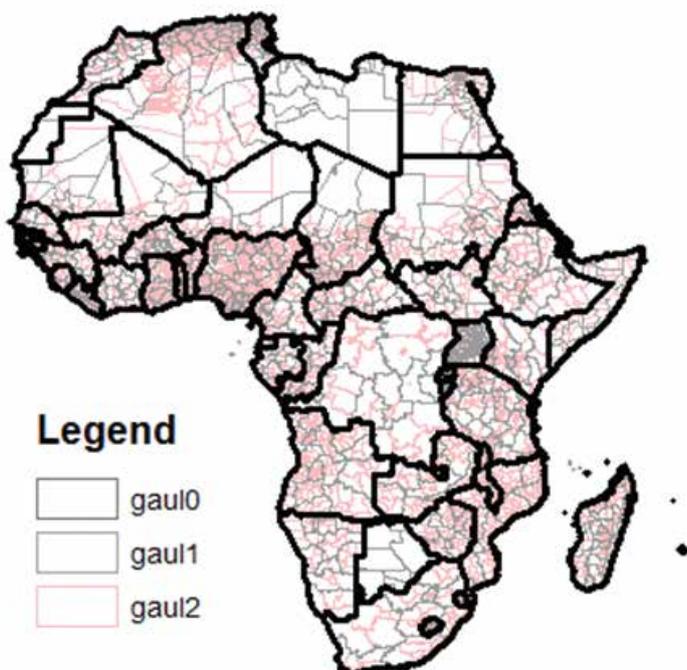
Layer names: gaul0, gaul1, gaul2, gaul3, gaul4, gaul5
Date: 2015
Acquired: FAO GeoNetwork
Source: FAO Statistics Division (ESS)
Resolution: Vector

Description: The GAUL is an initiative implemented by FAO within the Bill & Melinda Gates Foundation, Agricultural Market Information System (AMIS) and AfricaFertilizer.org projects.

The GAUL compiles and disseminates the best available information on administrative units for all the countries in the world, providing a contribution to the standardization of the spatial dataset representing administrative units. The GAUL always maintains global layers with a unified coding system at country, first (e.g. departments) and second administrative levels (e.g. districts). Where data is available, it provides layers on a country-by-country basis down to third, fourth and lower levels. The overall methodology consists of a) collecting the best available data from most reliable sources, b) establishing validation periods of the geographic features (when possible), c) adding selected data to the global layer based on the last country boundaries map provided by the UN Cartographic Unit (UNCS), d) generating codes using GAUL coding system and e) distribute data to the users (see TechnicalaspectsGAUL2015.pdf).

Because GAUL works at global level, unsettled territories are reported. The approach of GAUL is to deal with these areas in such a way to preserve national integrity for all disputing countries (see TechnicalaspectsGAUL2015.pdf and G2015_ DisputedAreas.dbf).

Figure A2: UNEP aridity zones.
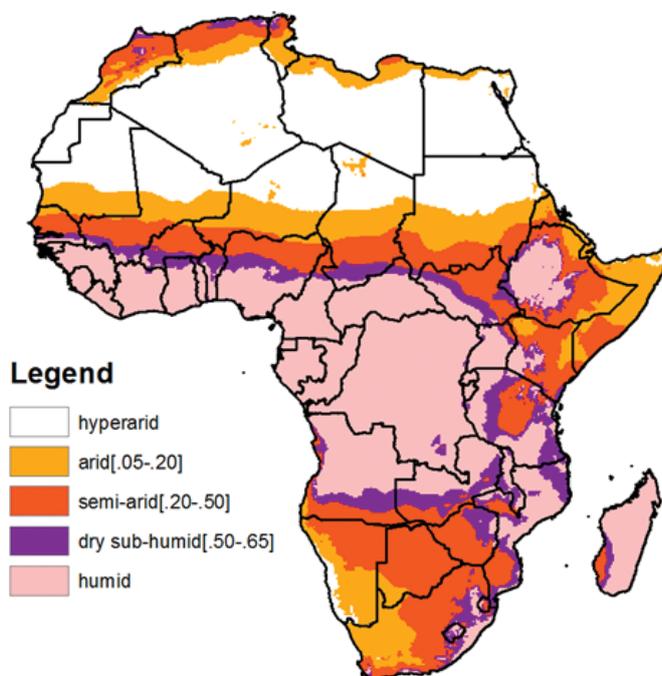
Layer name: Aridity
Date: 1961-90 (measured monthly)
Acquired: FAO GeoNetwork
Source: UNEP
Resolution: 10 arc minutes

Description: The aridity index dataset is useful to locate areas that suffer from a lack of available water. Lower values on the aridity index may adversely affect agricultural production and livestock health due to the dryness of the climate. This dataset represents average yearly precipitation (mm/day) divided by average yearly potential evapotranspiration, an aridity index defined by the UNEP.

The classification of the aridity index is (Classificaton Aridity Index Global Land Area):
Hyperarid AI < 0.05 - 7.5% of the global land area
Arid 0.05 < AI < 0.20 - 12.1% of the global land area
Semi-arid 0.20 < AI < 0.50 - 17.7% of the global land area
Dry subhumid 0.50 < AI < 0.65 - 9.9% of the global land area

Figure A3: UNEP aridity with overlaid 250–500mm rainfall levels from the British Atmospheric Data Centre (BADC) and published by HarvestChoice and IFPRI. Observe the wider swath of land covered under UNEP arid, semi-arid and dry sub-humid zones.

Legend
- ■ 250-500mm rainfall/year
- □ hyperarid
- ■ arid[.05-.20]
- ■ semi-arid[.20-.50]
- ■ dry sub-humid[.50-.65]
- ■ humid
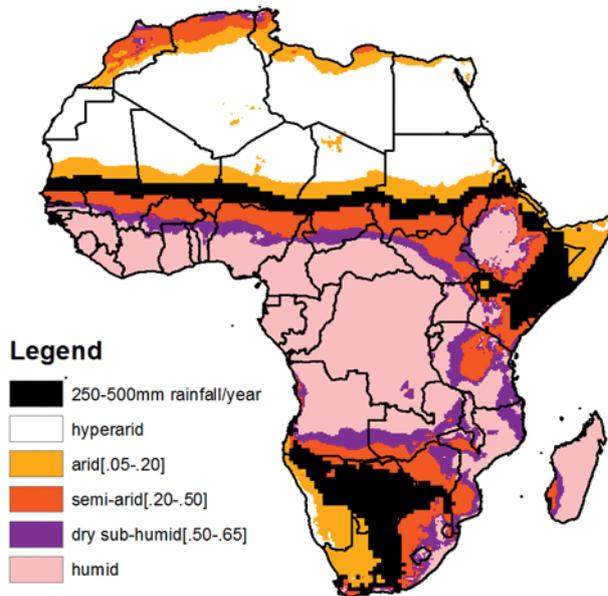
Layer name: Rainfall
Date: 1901–2005 (measured monthly)
Acquired: HarvestChoice
Source: British Atmospheric Data Centre (BADC), IFPRI
Resolution: 0.5x0.5 degree grid

Description: TS (time-series) datasets are month-by-month variation in climate over the last century or so as produced by the Climatic Research Unit (CRU) at the University of East Anglia. These are calculated on high-resolution (0.5x0.5 degree) grids, which are based on an archive of monthly mean temperatures provided by more than 4000 weather stations distributed around the world. They allow variations in climate to be studied, and include variables such as cloud cover, diurnal temperature range, frost day frequency, precipitation, daily mean temperature, monthly average daily maximum temperature, vapor pressure, Potential evapo-transpiration and wet day frequency.

Figure A4: IIASA hybridized cropland map with a quarter-standard deviation distribution of values (percentage cropland per square kilometer).

Legend
- High: 100
- Low: 0

Layer name: Cropland
Date: 2005
Acquired: Geo-Wiki
Source: IIASA-IFPRI
Resolution: 1km

Description: The hybridized cropland map shows global cropland as percentage of land per kilometer for the year 2005. It was developed by IIASA and IFPRI using a hybridization of multiple data sources contributed by many other institutes and organizations, combined with crowdsourcing validation data where volunteers used high-resolution data to check the accuracy of larger-scale maps.

'Current sources of information on cropland extent are not accurate enough for most applications', says IIASA researcher Steffen Fritz, who led the project. 'The global cropland map is a low cost solution to fill this need.'

IIASA researcher and co-author Linda See adds, 'Our hybrid approach combines existing maps to produce a better integrated product than any of the individual global base maps currently available'.

The new global cropland map is more accurate, by virtue of increased agreement between different datasets on cropland cover. The researchers used a likelihood method to quantify the level of uncertainty, using agreement between maps to assign a likelihood to each area. See explains, 'Where all maps agree there is cropland, there is a higher likelihood that cropland is present'.

Figure A5: Distribution of cattle per square kilometer, shown in half standard deviations.
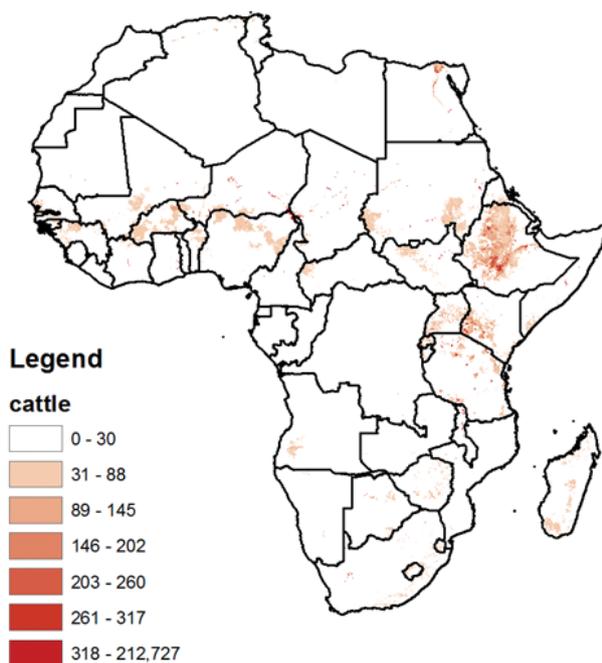
Layer name: Cattle
Date: 2007
Acquired: Geo-Wiki
Source: Tim Robinson (ILRI), et al.
Resolution: 3 arc minutes (less than 10km x 10km)

Description: The GLW database, produced in 2007, provided modelled livestock densities of the world, adjusted to match official (FAOSTAT) national estimates for the reference year 2005, at a spatial resolution of 3 minutes of arc (about 5km at the equator). Recent methodological improvements have significantly enhanced these distributions: More up-to date and detailed sub- national livestock statistics have been collected; a new, higher resolution set of predictor variables is used; and

the analytical procedure has been revised and extended to include a more systematic assessment of model accuracy and the representation of uncertainties associated with the predictions.

Protected zones, steep terrain and other prohibitive areas for livestock were subtracted from land area, and machine learning methods were applied to national survey data to predict livestock distribution.

Figure A6: Distribution of camels per square kilometer, shown in half standard deviations.
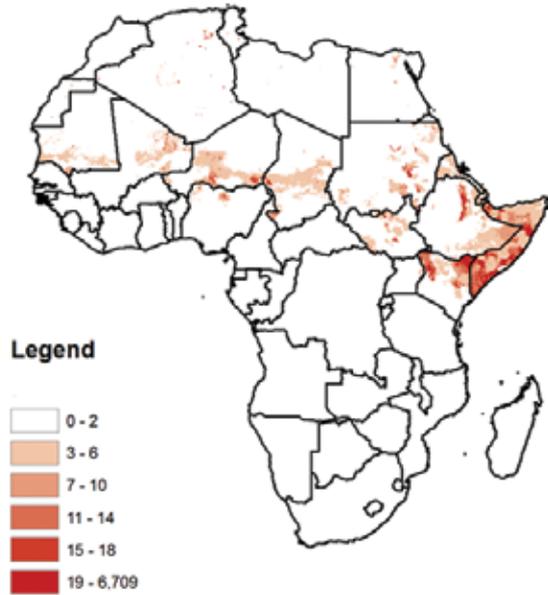
Layer name: Camels_complete
Date: 2012
Acquired: Direct from Tim Robinson
Source: Tim Robinson (ILRI), et al. Unpublished as of July 2015.
Resolution: 3 arc minutes (less than 10km x 10km)

Description: See cattle. The camels layer was created using an unpublished, compressed source layer from Tim Robinson and using transformations to expand the layer to the entire continent in proper units. Processing involved the following intermediate layers: camels, camels_expanded, camels_scaled, camels_refined, camels_nonull.

Figure A7: Distribution of sheep per square kilometer, shown in half standard deviations.
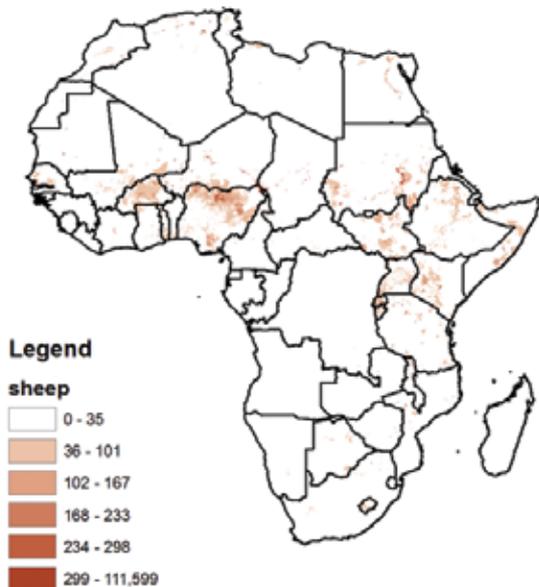
Layer name: Sheep

Date: 2007

Acquired: Geo-Wiki

Source: Tim Robinson (ILRI) et al.

Resolution: 3 arc minutes (less than 10km x 10km)

Description: See cattle

Figure A8: Distribution of goats per square kilometer, shown in half standard deviations.
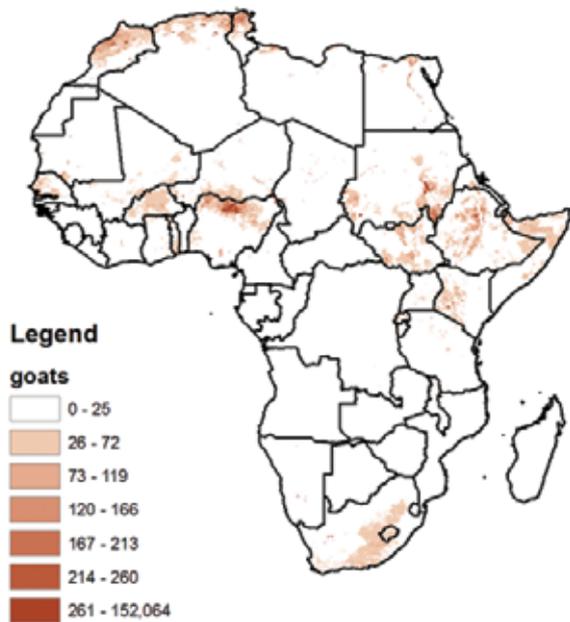
Layer name: Goats

Date: 2012

Acquired: Geo-Wiki

Source: Tim Robinson (ILRI), et al.

Resolution: 3 arc minutes (less than 10km x 10km)

Description: See cattle

Figure A9: Country-level non-life insurance premium volume to GDP (per cent), in quantiles. Countries with missing data in white.
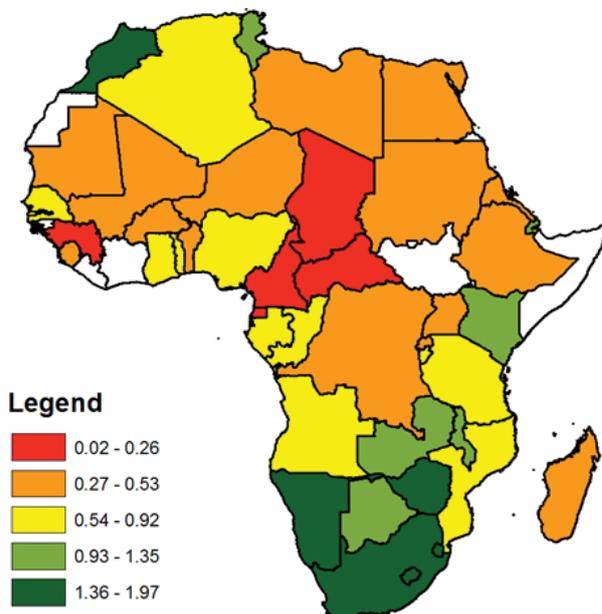
Layer name: gaul0 [nonlife attribute]

Date: 2009

Acquired: FRED (U.S. Federal Reserve St. Louis)

Source: FRED (U.S. Federal Reserve St. Louis)

Description: Country-level non-life insurance premium volume to GDP (per cent)

Figure A10: Country-level insurance company assets to GDP (per cent), in quantiles. Countries with missing data in white.
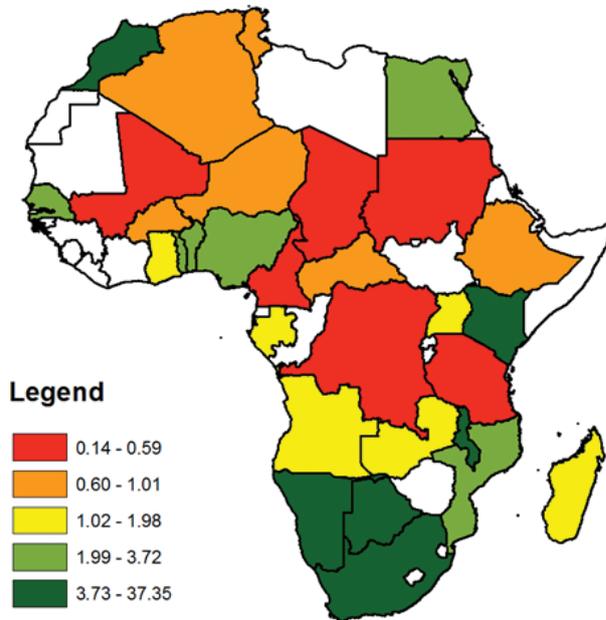
Layer Name: gaul0 [Company_Assets attribute]

Date: 2009

Acquired: FRED (U.S. Federal Reserve St. Louis)

Source: FRED (U.S. Federal Reserve St. Louis)

Description: Country-level insurance company assets to GDP (per cent)

Figure A11: Number of licensed insurance companies by country, in quantiles. Countries with missing data in white.
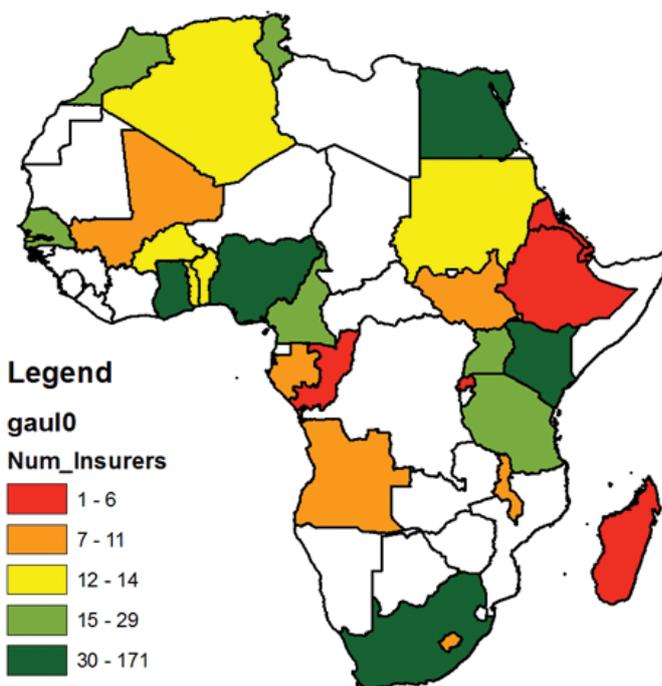
Layer name: gaul0 [Num_Insurers attribute]

Date: 2015

Acquired: Annual Review, African Insurance Organization

Source: African Insurance Organization (AIO)

Description: Number of licensed insurance companies by country, with supplemental data from various government agencies and reinsurance organizations.

Figure A12: Percentage of total population covered by some type of microinsurance, in quantiles. Countries with missing data in white.
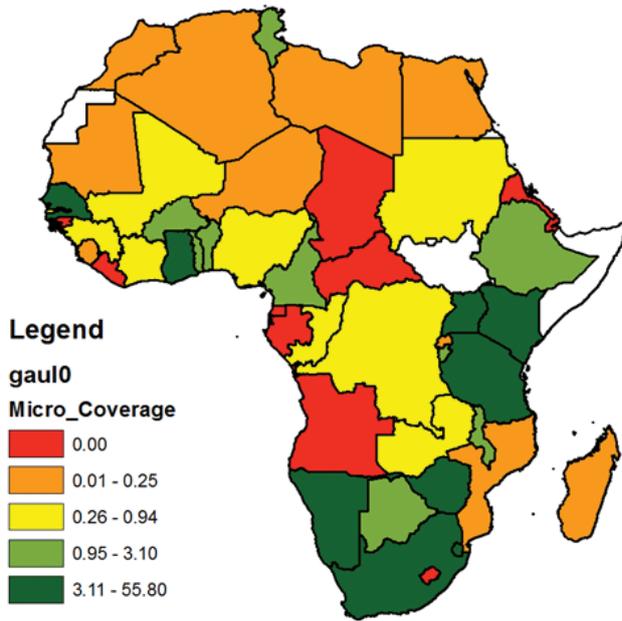
Layer name: gaul0 [Micro_Coverage attribute]

Date: 2011

Acquired: The Landscape of Microinsurance in Africa, MunichRe Foundation

Source: MunichRe Foundation

Description: Percentage of total population covered by some type of microinsurance, by country

Figure A13: Country classification by stage of microdevelopment (MunichRe).
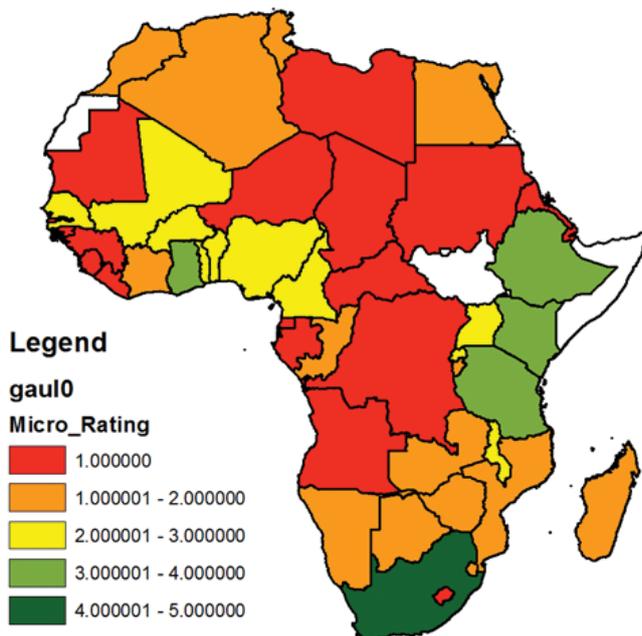
Layer name: gaul0, Micro_Rating
Date: 2012
Acquired: The Landscape of Microinsurance in Africa, MunichRe Foundation
Source: MunichRe Foundation
Description: Country classification by stage of microdevelopment (MunichRe classification):

5. Highflyers: Those markets that have a robust, thriving, microinsurance sector. Typical characteristics would be a massive outreach, several product categories on offer through a good number of providers for a number of years, as well as an effective market infrastructure that allows participants to continually improve and expand service quality.

4. Aspirants: Countries in this category have microinsurance markets that look poised for significant growth in the immediate future. Common traits include a diverse provider group with solid experience in microinsurance, an enabling environment and relatively large populations, leading to a significant untapped market potential.

3. Hidden talents: These are microinsurance markets that have most of the required fundamentals for expansion, but growth has been limited thus far. Typically, there is already some experience with microinsurance but very few commercial insurance companies, and risk pools are fragmented where community-based schemes are present. Also, the diversity of microinsurance products available is very restricted.

2. Fledglings: These microinsurance markets are in a nascent stage only. Experience with microinsurance is limited, and significant sector development is unlikely to happen without external stimuli. Yet, the size of the population provides potential for the development of a diverse market.

1. Embryonic: Countries in this category are unlikely to see the development of a thriving microinsurance sector in the short to medium term. There is no or very limited experience with microinsurance, the population is relatively small and there is no enabling infrastructure. Some countries in this category are post-conflict or plagued with unrest.

Figure A14: Protected areas (in green).
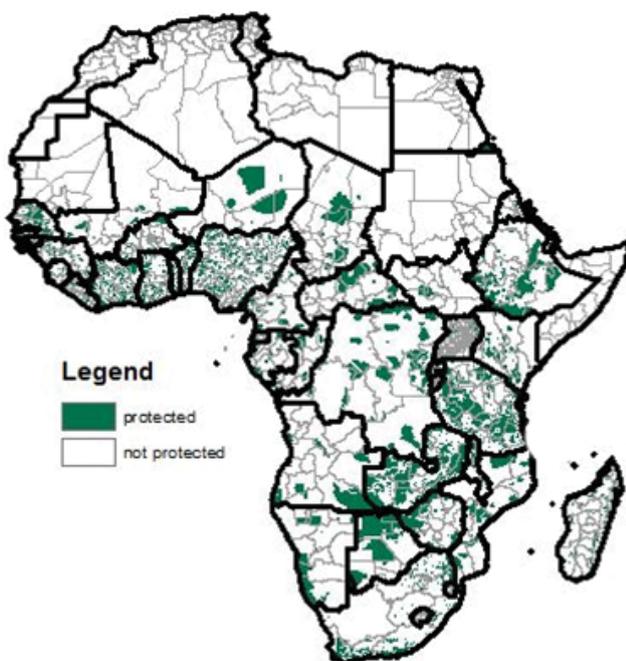
Layer Name: Protected
Date: 2009
Acquired: HarvestChoice
Source: HarvestChoice
Resolution: Unspecified

Description: Nationally designated and internationally recognized protected areas in the World Database of Protected Areas (WDPA). Raster coverage from HarvestChoice.

Figure A15: Regions of medium to extreme flooding risk, UNEP Global Risk Data Platform (numbers part of an underspecified index, broken into quantiles. Areas classified by UNEP as low risk have been removed from the data).
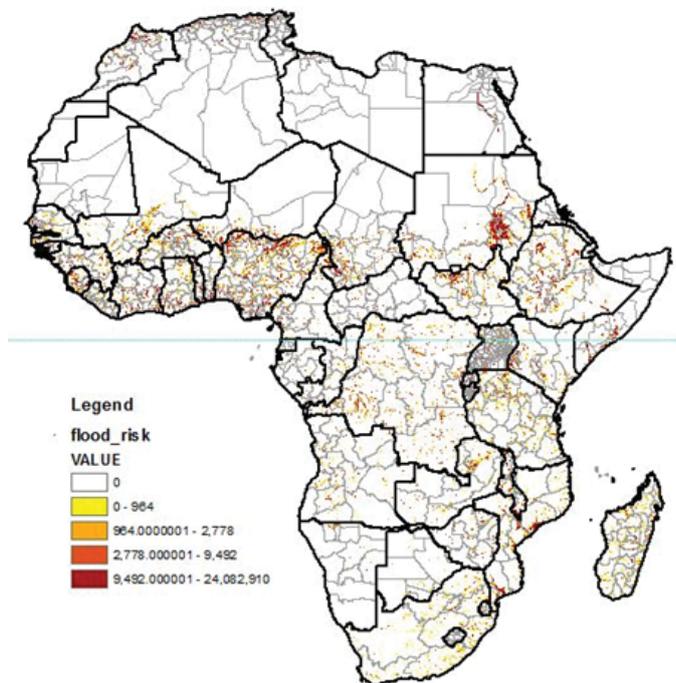
Layer name: Flood
Date: 2011
Acquired: Geo-Wiki
Source: UNEP
Resolution: Unspecified
Description: This dataset includes an estimate of the global risk induced by flood hazard. Unit is estimated risk index from 1 (low) to 5 (extreme). Here, only areas of at least risk level 3 are colored.

Figure A16: Areas of predicted tsetse fly suitability (in black).

Layer Name: Tsetse_cumulative
Date: 1999
Acquired: FAO
Source: FAO PAAT
Resolution: 5km
Description: Combined three layers on predicted tsetse fly suitability for Morsitans (savannah), Fusca and Palpalis types, respectively.

The FAO Programme Against African Trypanosomosis (PAAT) constructed the individual tsetse layers using 'logistic regression of fly presence against a wide range of predictors. The predictor variables include remotely sensed (satellite image) surrogates of climate: vegetation, temperature and moisture. Demographic, topographic and agroecological predictors are also used'. The layer above pertains particular to suitability for Morsitans (savanna tsetse), which have the most overlap with pastoral regions.

Figure A17: NDVI coefficient of variation.
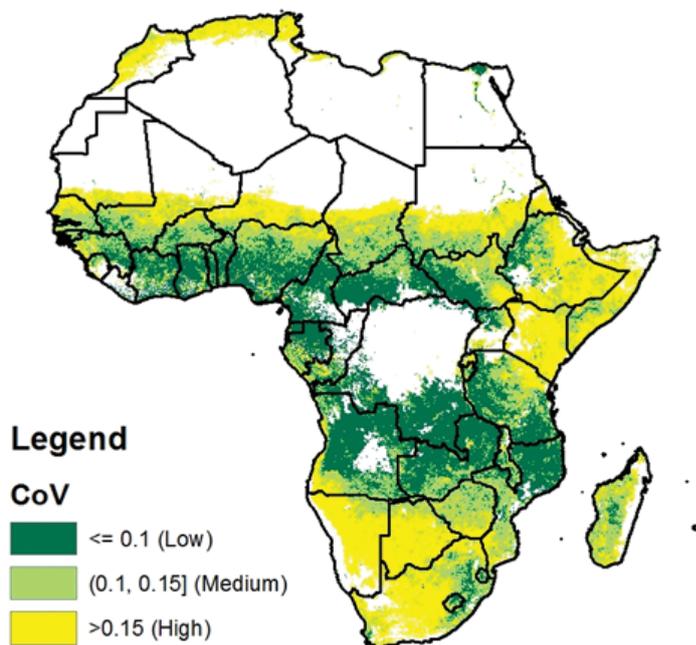
Layer name: CoV
Date: 2011
Acquired: Anton Vrieling (Faculty of Geo-Information Science and Earth Observation, University of Twente)
Description: Coefficient of variation for the average of the cumulative NDVI (vegetation index) over one season. Areas in white show missing data.

Section 2—Constructed Layers:

Figure A18: Aridity zones conducive for pastoral activity (in grey).
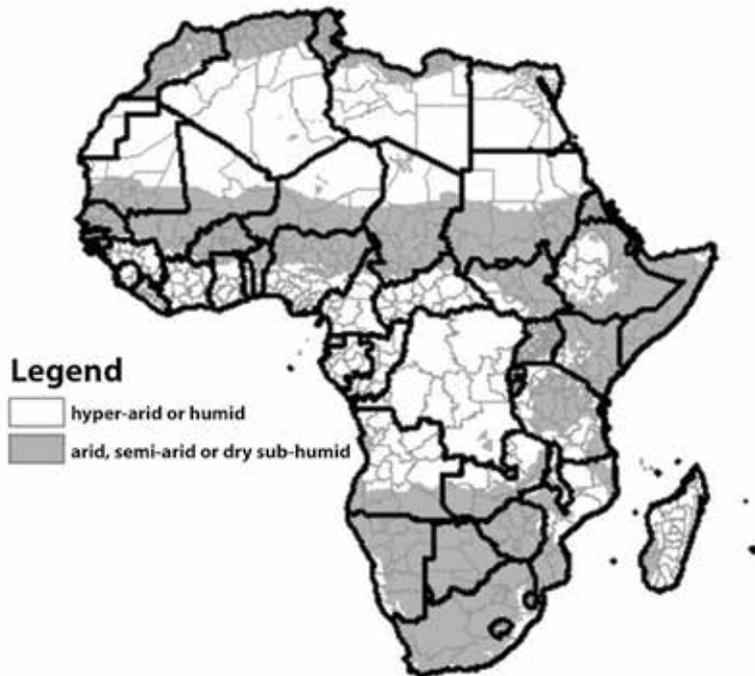
Layer name: Aridity_valid

Description: Constructed from combining arid, semi-arid and dry sub-humid zones from the UNEP aridity map (Figure A2).

Figure A19: Target Area.
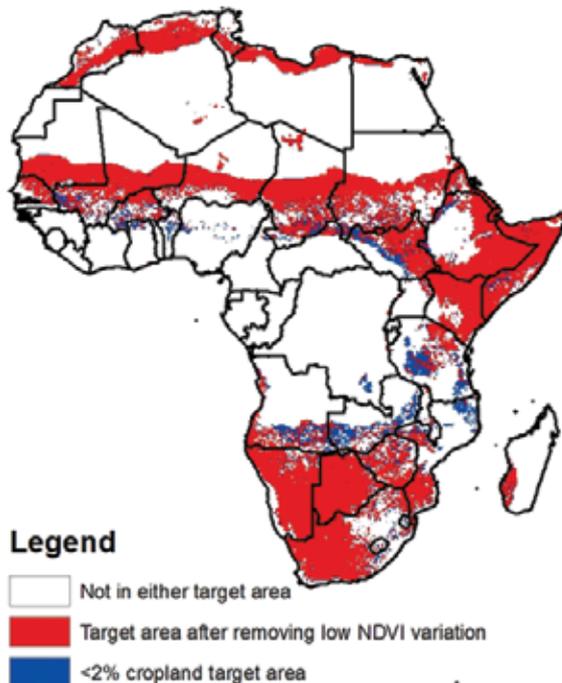
Layer name: Target

Description: The blue area (overlapped by red) is constructed by taking the valid aridity zones map (Figure A18) and subtracting off areas of at least 2% cropland per square kilometer (Figure A4). Areas in red only are areas with NDVI CoV greater than 0.1 (A16). Thus, the blue area visible on the figure represents areas of <2% cropland that have been cut off under low variation.

Figure A20: Old target area from prior iteration of characterization report.

Legend

☐ Not in either target area

🟥 Target area after removing low NDVI variation

🟦 <2% cropland target area
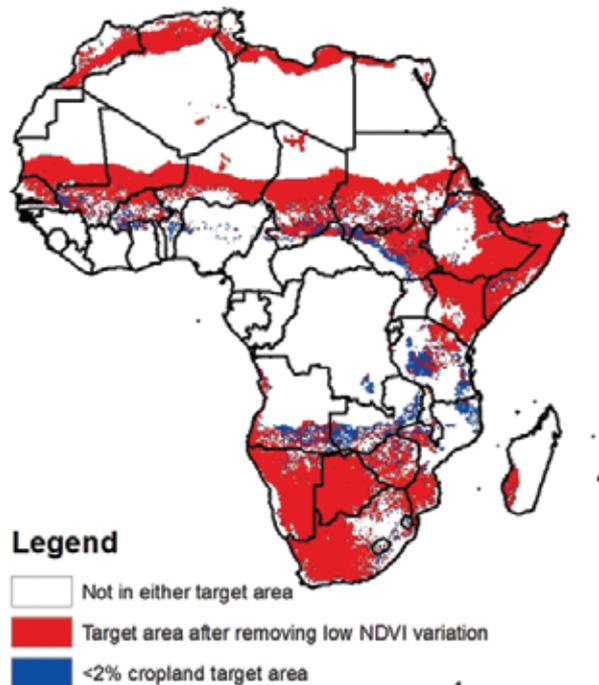
Layer name: Target_OLD_Mar11

Description: We constructed the previous target area by taking the zones of proper aridity and subtracting layers for flooding, tsetse fly suitability and irrigated lands (not shown in this report). Also of value is congruence between the old constructed target area and new target area, shown below side-by-side. These similarities motivate our removal of areas with potential factors that could deter pastoralism and/or potentially produce basis risk.

Figure A21: New target area overlaid on old target area.

Legend

☐ not in old target area

🟪 old target area

☐ not in target area

🟦 target area
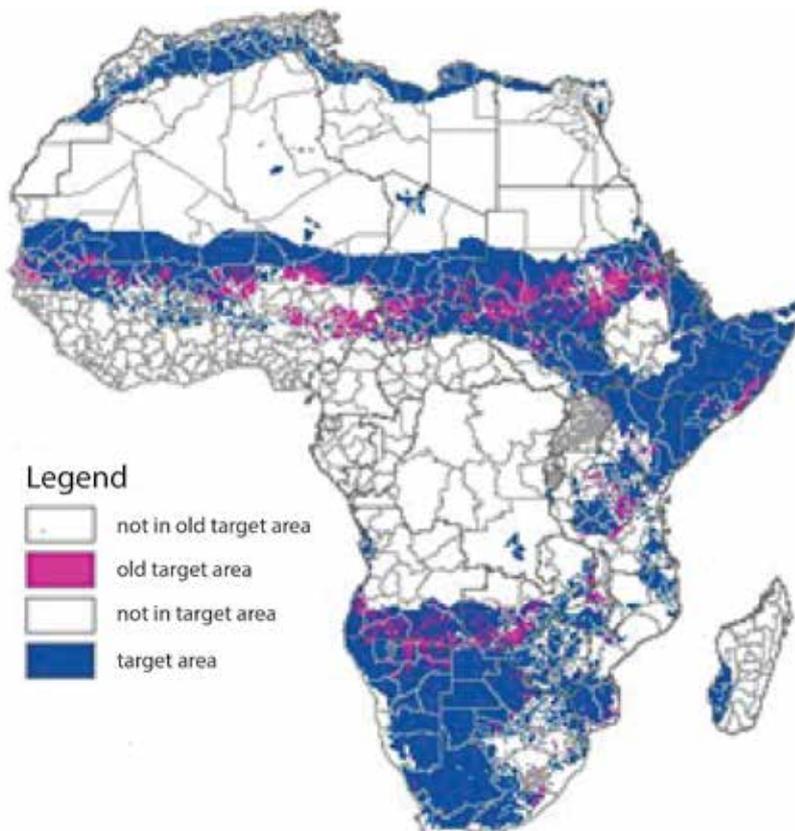
Figure A22: Tropical livestock units (TLUs), in half standard deviations.
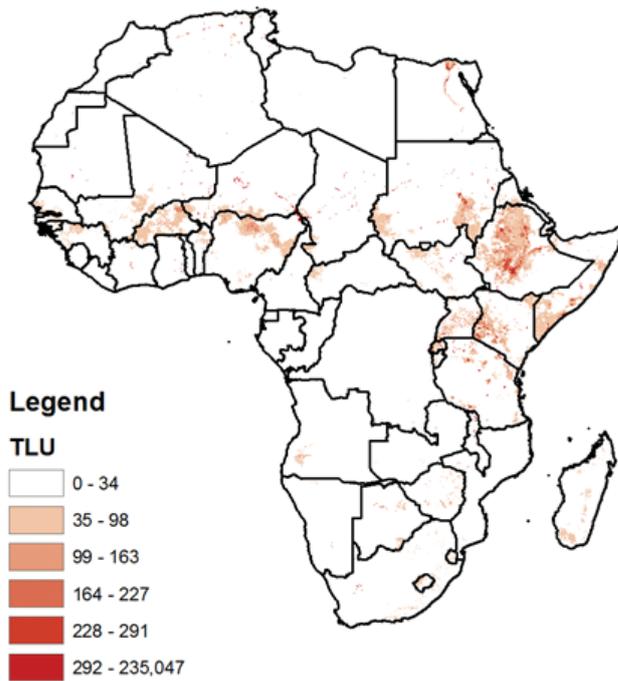
Layer name: TLU

Resolution: 3 arc minutes

Description: Created by aggregating cattle (1.4), camels (1.0), sheep (0.1) and goats (0.1) while scaling each by corresponding weights.

Figure A23: TLUs in target area, in half standard deviations.
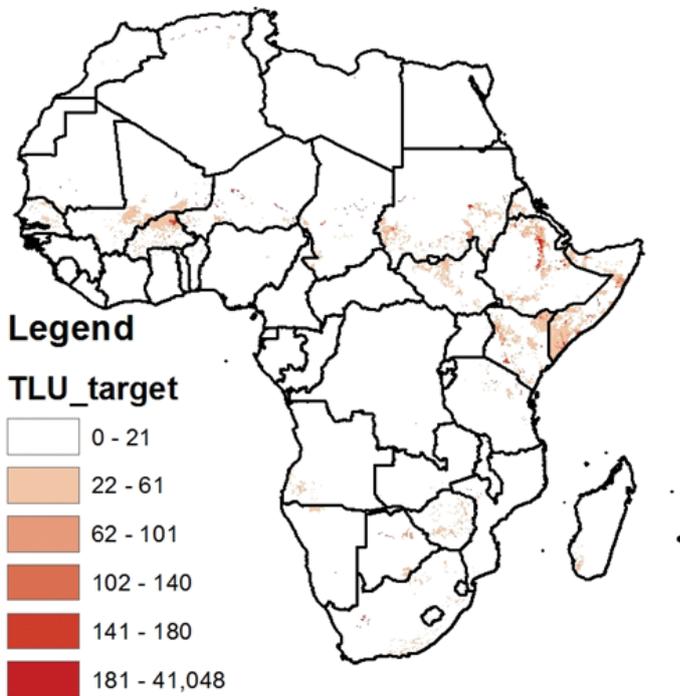
Layer name: TLU_target

Resolution: 3 arc minutes

Description: TLUs within target area

Figure A24: TLUs in target area by country, in half standard deviations.

Legend

TLU_zonal0

	0 - 3,370,066
	3,370,067 - 7,161,626
	7,161,627 - 10,953,186
	10,953,187 - 14,744,746
	14,744,747 - 18,536,307
	18,536,308 - 22,327,867
	22,327,868 - 26,119,427
	26,119,428 - 28,937,670
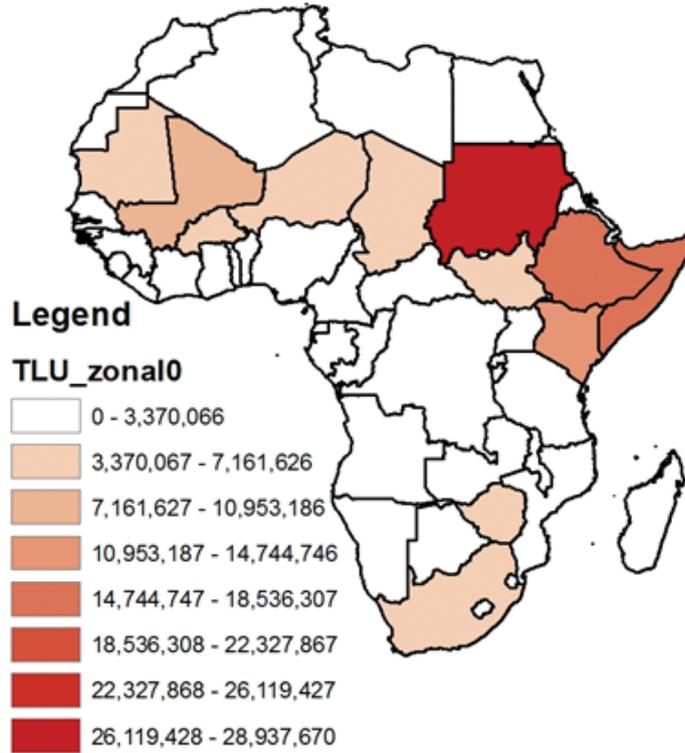
Layer name: TLU_zonal0
Description: Aggregating TLUs in target area by country (GAUL administrative level 0) using the ArcGIS zonal statistics tool

Figure A25: TLUs in target area by administrative level 1, in half standard deviations.

Legend

TLU_zonal1

	0 - 259,138
	259,139 - 803,122
	803,123 - 1,347,105
	1,347,106 - 1,891,089
	1,891,090 - 2,435,073
	2,435,074 - 2,979,057
	2,979,058 - 3,523,040
	3,523,041 - 7,338,188
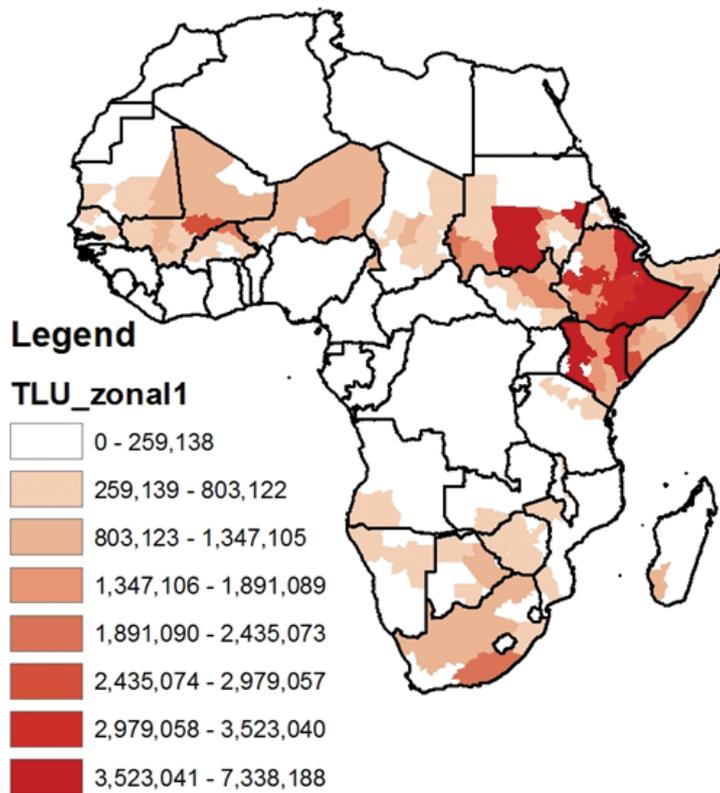
Layer name: TLU_zonal1
Description: Aggregating TLUs in target area by GAUL administrative level 1 using the ArcGIS zonal statistics tool

Figure A26: Classification of countries by TLU supply and insurance infrastructure.
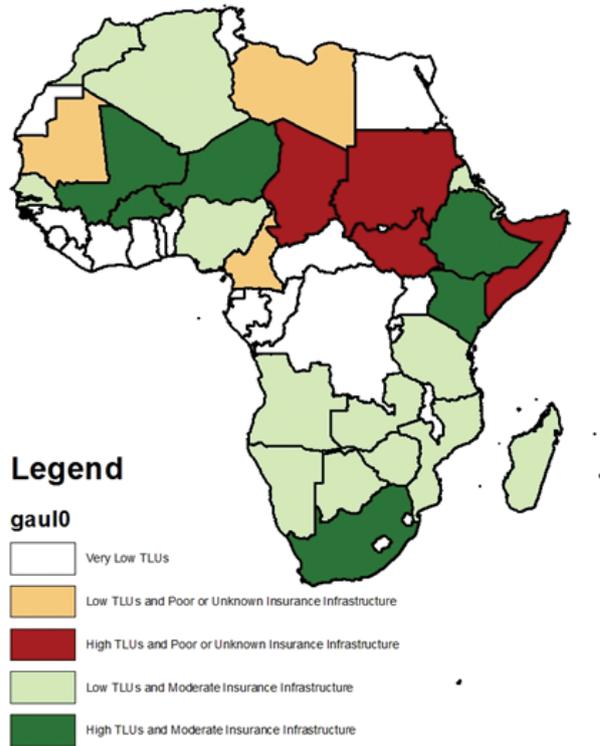
Layer name: gaul0 [TLU_ins_class attribute]
Description: Constructed using TLU counts and insurance market information, particularly from FRED sources (nonlife, insurance company assets).

Figure A27: Classification of countries by TLU supply and insurance infrastructure, displayed only in target area. Layer name: TLU_ins_class_target.
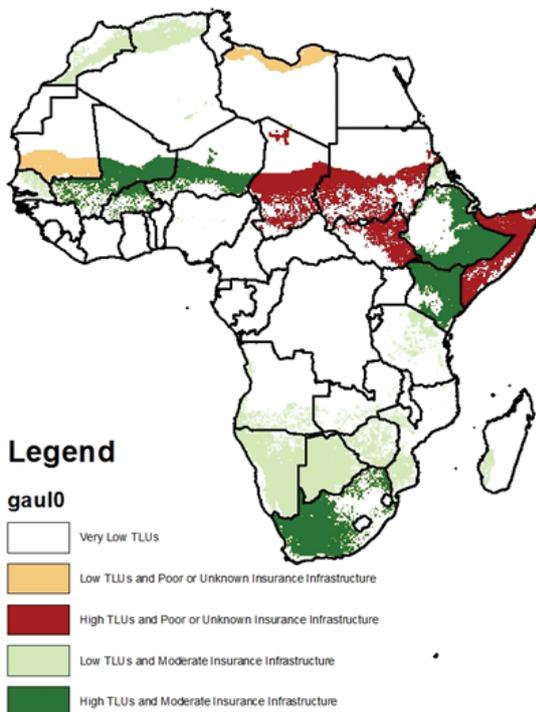
Layer name: TLU_ins_class_target
Description: Constructed using TLU counts and insurance market information, particularly from FRED sources (nonlife, insurance company assets). Displayed only in the area where TLUs were counted (the target area for pastoral populations).

II. Tables and statistics

Table A1: Countries ranked by TLUs

TLU rank	Country	TLUs in target area	TLUs/Km² of target area	Non-life insurance premium volume to GDP (per cent, 2009)	Insurance company assets to GDP (per cent, 2009)
1	Sudan	27,955,304	45.34	0.375	0.536
2	Ethiopia	18,025,893	27.87	0.387	0.802
3	Somalia	17,511,426	33.81	-	-
4	Kenya	11,473,499	26.69	1.345	7.542
5	Mali	7,781,311	15.45	0.386	0.503
6	South Sudan	6,641,774	20.79	-	-
7	South Africa	6,535,997	7.84	1.974	28.182
8	Chad	6,520,037	11.23	0.211	0.169
9	Burkina Faso	5,609,236	44.23	0.386	0.685
10	Niger	5,375,549	15.04	0.484	0.849
11	Zimbabwe	3,628,670	15.11	1.854	-
12	Mauritania	3,510,738	10.05	0.387	-
13	United Republic of Tanzania	3,026,666	18.18	0.649	0.1417
14	Botswana	2,766,847	4.78	1.025	18.717
15	Namibia	2,579,154	3.80	1.951	37.35
16	Angola	2,012,928	9.19	0.643	1.457
17	Senegal	1,788,885	19.54	0.841	2.207
18	Eritrea	1,574,722	17.70	0.522	-
19	Algeria	1,403,750	4.15	0.713	1.007
20	Madagascar	1,323,144	18.52	0.48	1.376
21	Zambia	1,088,145	15.10	0.979	1.381
22	Mozambique	907,166	4.16	0.816	2.597
23	Cameroon	846,605	290.69	0.252	0.587
24	Nigeria	699,945	68.91	0.608	2.324
25	Morocco	646,612	2.69	1.573	17.955
26	Libya	514,477	2.03	0.373	-
27	Djibouti	486,700	26.09	1.203	-
28	Uganda	455,956	19.47	0.49	1.071
29	Malawi	343,266	29.62	1.06	6.897
30	Democratic Republic of the Congo	292,983	32.88	0.373	0.498
31	Burundi	274,458	180.82	0.812	-
32	Ghana	165,982	20.71	0.6	1.976
33	Benin	159,055	17.85	0.532	2.087
34	Gambia	157,997	56.24	0.71	-
35	Lesotho	146,901	30.52	1.916	-

TLU rank	Country	TLUs in target area	TLUs/Km² of target area	Non-life insurance premium volume to GDP (per cent, 2009)	Insurance company assets to GDP (per cent, 2009)
36	Tunisia	142,541	2.48	1.255	0.887
37	Abyei	128,034	17.54	-	-
38	Swaziland	94,367	35.30	1.635	-
39	Guinea	63,560	22.50	0.024	-
40	Ilemi triangle	34,887	11.00	-	-
41	Egypt	27,135	0.48	0.417	3.72
42	Togo	24,172	26.56	0.722	2.135
43	Côte d'Ivoire	18,789	14.36	-	-
44	Central African Republic	5041	0.21	0.255	1
45	Western Sahara	662	0.20	-	-
46	Hala'ib triangle	45	0.30	-	-
47	Mayotte	-	-	1.515	-
48	Rwanda	-	-	0.313	-
49	Reunion	-	-	-	-
50	Tromelin Island	-	-	-	-
51	Juan de Nova Island	-	-	-	-
52	Glorioso Island	-	-	-	-
53	Europa Island	-	-	-	-
54	Gabon	-	-	0.922	1.676
55	Equatorial Guinea	-	-	0.127	-
56	Congo	-	-	0.768	-
57	Ma'tan al-Sarra	-	-	-	-
58	Sierra Leone	-	-	0.387	-
59	Liberia	-	-	-	-
60	Guinea-Bissau	-	-	-	-

Table A2: First-evel administrative units ranked by TLUs

TLU rank	Administrative unit name	Country	TLUs in target area
1	Southern Kordofan	Sudan	6,808,160
2	Kassala	Sudan	6,792,580
3	Northern Kordofan	Sudan	4,864,044
4	Rift Valley	Kenya	4,817,436
5	Afar	Ethiopia	4,616,763
6	Somali	Ethiopia	4,118,370
7	North Eastern	Kenya	4,064,860
8	Oromia	Ethiopia	3,503,607
9	Juba Hoose	Somalia	2,817,896
10	Mopti	Mali	2,588,237
11	Mudug	Somalia	2,339,571
12	Western Darfur	Sudan	2,240,597
13	Sahel	Burkina Faso	2,228,521
14	Khartoum	Sudan	2,164,366
15	Eastern Cape	South Africa	2,083,449
16	SNNPR	Ethiopia	1,868,531
17	Amhara	Ethiopia	1,746,656
18	Unity	South Sudan	1,585,319
19	Jonglei	South Sudan	1,527,501
20	Tigray	Ethiopia	1,481,312
21	Galgaduud	Somalia	1,462,285
22	Zinder	Niger	1,449,166
23	Gedo	Somalia	1,432,089
24	Eastern	Kenya	1,375,158
25	Southern Darfur	Sudan	1,373,453
26	Gao	Mali	1,341,596
27	White Nile	Sudan	1,318,383
28	Tombouctou	Mali	1,309,283
29	Central	Botswana	1,261,074
30	Bay	Somalia	1,241,519
31	Batha Ouest	Chad	1,153,449
32	Coast	Kenya	1,130,587
33	Hodh Ech Chargi	Mauritania	1,095,099
34	Juba Dhexe	Somalia	1,094,970
35	Agadez	Niger	1,089,750
36	Shabelle Hoose	Somalia	1,085,462
37	Atsimo Andrefana	Madagascar	1,038,564
38	Free State	South Africa	932,033

TLU rank	Administrative unit name	Country	TLUs in target area
39	Tillaberi	Niger	919,227
40	Upper Nile	South Sudan	912,702
41	Tahoua	Niger	905,802
42	Nugaal	Somalia	888,306
43	Northern Cape	South Africa	885,564
44	Diffa	Niger	874,950
45	North West	South Africa	865,948
46	Extrême-nord	Cameroon	845,302
47	Sool	Somalia	839,774
48	Limpopo	South Africa	829,083
49	Koulikoro	Mali	810,095
50	Togdheer	Somalia	799,014
51	Cunene	Angola	778,626
52	Southern	Zambia	773,615
53	Gash Barka	Eritrea	743,802
54	Bakool	Somalia	720,461
55	Tagant	Mauritania	718,822
56	Eastern Equatoria	South Sudan	697,017
57	Northern Darfur	Sudan	689,206
58	Matabeleland South	Zimbabwe	678,179
59	Masvingo	Zimbabwe	673,662
60	Segou	Mali	660,280
61	Tambacounda	Senegal	643,702
62	Kayes	Mali	640,332
63	Hiraan	Somalia	637,427
64	Northern Bahr El Ghazal	South Sudan	632,320
65	Blue Nile	Sudan	607,244
66	Assaba	Mauritania	588,064
67	Gambela	Ethiopia	586,490
68	Awdal	Somalia	582,904
69	Namibe	Angola	570,203
70	Centre-nord	Burkina Faso	563,197
71	Biltine	Chad	548,527
72	Guera	Chad	539,549
73	Warab	South Sudan	529,004
74	El Buheyrat	South Sudan	528,267
75	Nord	Burkina Faso	517,342
76	Est	Burkina Faso	511,486
77	Kweneng	Botswana	494,286

TLU rank	Administrative unit name	Country	TLUs in target area
78	Midlands	Zimbabwe	494,150
79	Kilimanjaro	United Republic of Tanzania	492,979
80	Sanaag	Somalia	487,544
81	Mashonaland West	Zimbabwe	477,079
82	Woqooyi Galbeed	Somalia	475,297
83	Otjozondjupa	Namibia	458,077
84	Manyara	United Republic of Tanzania	452,236
85	Omaheke	Namibia	446,899
86	Gadaref	Sudan	439,548
87	Lac	Chad	420,711
88	Matabeleland North	Zimbabwe	412,523
89	Barl El Gazal	Chad	403,678
90	Mashonaland East	Zimbabwe	402,040
91	Huila	Angola	389,331
92	KwaZulu-Natal	South Africa	387,960
93	Salamat	Chad	384,227
94	Saint louis	Senegal	383,040
95	Mwanza	United Republic of Tanzania	377,471
96	Omusati	Namibia	369,260
97	Hauts-bassins	Burkina Faso	365,562
98	Louga	Senegal	360,171
99	Kunene	Namibia	353,614
100	Batha Est	Chad	350,823
101	Ennedi	Chad	346,596
102	Bari	Somalia	341,581
103	Area under National Administration	Malawi	339,313
104	Hadjer Lamis	Chad	334,525
105	Ouaddai	Chad	331,059
106	Simiyu	United Republic of Tanzania	325,031
107	Trarza	Mauritania	317,123
108	Boucle Du Mouhoun	Burkina Faso	316,518
109	Sikasso	Mali	307,255
110	Hodh El Gharbi	Mauritania	299,935
111	Al Jazeera	Sudan	298,391
112	Ngamiland	Botswana	297,877
113	Semenawi Keih Bahri	Eritrea	292,299
114	Southern	Botswana	278,985
115	Tanga	United Republic of Tanzania	276,977
116	Gaza	Mozambique	264,732

TLU rank	Administrative unit name	Country	TLUs in target area
117	Tete	Mozambique	262,877
118	Shabelle Dhexe	Somalia	261,087
119	Centre-ouest	Burkina Faso	259,347
120	Borno	Nigeria	250,579
121	Bujumbura Rural	Burundi	249,961
122	Menabe	Madagascar	248,960
123	Western Cape	South Africa	246,436
124	Mpumalanga	South Africa	246,294
125	Borkou	Chad	245,617
126	Mashonaland Central	Zimbabwe	239,307
127	Matam	Senegal	234,527
128	Oshikoto	Namibia	234,351
129	Anseba	Eritrea	233,722
130	Mayo-Boneye	Chad	223,806
131	Rukwa	United Republic of Tanzania	214,446
132	Manicaland	Zimbabwe	210,530
133	Amudat	Uganda	202,490
134	Plateau Central	Burkina Faso	195,648
135	Souss-Massa-Drâa,	Morocco	193,235
136	Orientale	Democratic Republic of the Congo	191,272
137	Brakna	Mauritania	185,905
138	Debub	Eritrea	180,907
139	Kanem	Chad	170,120
140	Cuando Cubango	Angola	168,663
141	Centre-est	Burkina Faso	168,496
142	Dikhil	Djibouti	167,599
143	Guidimakha	Mauritania	165,349
144	Arusha	United Republic of Tanzania	162,753
145	Mayo-Dala	Chad	161,896
146	Ali Sabieh	Djibouti	161,867
147	Centre-sud	Burkina Faso	161,420
148	Sila	Chad	154,933
149	Maputo	Mozambique	154,854
150	Niger	Nigeria	154,836
151	Marrakech-Tensift-Al Haouz	Morocco	151,564
152	Western Bahr El Ghazal	South Sudan	151,487
153	Khomas	Namibia	150,442
154	Oshana	Namibia	150,139
155	Tandjile est	Chad	145,821

TLU rank	Administrative unit name	Country	TLUs in target area
156	Western	Zambia	140,627
157	Sennar	Sudan	140,293
158	Naama	Algeria	139,199
159	Cascades	Burkina Faso	138,146
160	Nile	Sudan	136,648
161	El Oued	Algeria	136,501
162	Kigoma	United Republic of Tanzania	133,848
163	Barh Koh	Chad	132,819
164	Katsina	Nigeria	131,059
165	Administrative unit not available	Abyei	128,034
166	Djelfa	Algeria	127,952
167	Batna	Algeria	127,437
168	Lac Iro	Chad	119,654
169	Debubawi Keih Bahri	Eritrea	119,113
170	Gorgol	Mauritania	118,077
171	Ohangwena	Namibia	117,713
172	Tadjourah	Djibouti	110,658
173	Inhambane	Mozambique	110,499
174	Singida	United Republic of Tanzania	109,267
175	Sud-ouest	Burkina Faso	108,005
176	Ghanzi	Botswana	107,775
177	Lusaka	Zambia	104,615
178	Kidal	Mali	101,549
179	Pwani	United Republic of Tanzania	100,409
180	Upper West	Ghana	98,825
181	Maradi	Niger	98,807
182	Medea	Algeria	96,717
183	North East	Botswana	96,147
184	Kgalagadi	Botswana	95,720
185	Kolda	Senegal	93,555
186	Assongha	Chad	93,407
187	Kabia	Chad	93,372
188	Hardap	Namibia	92,884
189	Dodoma	United Republic of Tanzania	89,495
190	Sawfajjin (sofuljeen)	Libya	88,526
191	Sud-Kivu	Democratic Republic of the Congo	86,854
192	Central	Kenya	83,723
193	Tiaret	Algeria	83,579
194	Kavango	Namibia	82,838

TLU rank	Administrative unit name	Country	TLUs in target area
195	Red Sea	Sudan	82,391
196	M'Sila	Algeria	82,148
197	Nakapiripirit	Uganda	80,749
198	Laghouat	Algeria	78,250
199	Central Equatoria	South Sudan	78,157
200	Kgatleng	Botswana	78,105
201	Centre	Burkina Faso	75,549
202	Surt (sirte)	Libya	75,272
203	Moroto	Uganda	74,922
204	Oriental	Morocco	73,215
205	Alibori	Benin	71,448
206	Ajdabiya (agedabia)	Libya	70,320
207	Mara	United Republic of Tanzania	69,045
208	Dire Dawa	Ethiopia	63,854
209	Kankan	Guinea	63,560
210	Benguela	Angola	62,926
211	Oum El Bouaghi	Algeria	62,441
212	Erongo	Namibia	59,510
213	Gauteng	South Africa	59,230
214	Biskra	Algeria	58,682
215	Manica	Mozambique	57,866
216	Lower River	Gambia	56,277
217	El Bayadh	Algeria	56,018
218	Fatick	Senegal	54,641
219	Central	Zambia	54,238
220	Karas	Namibia	52,386
221	Upper East	Ghana	52,377
222	Mbeya	United Republic of Tanzania	52,220
223	Tabora	United Republic of Tanzania	51,808
224	Lubombo	Swaziland	51,516
225	Central River	Gambia	51,002
226	Kebbi	Nigeria	50,594
227	Taza-Al Hoceima-Taounate	Morocco	49,755
228	Mandoul	Chad	49,120
229	South-East	Botswana	48,884
230	Meknès-Tafilalt,	Morocco	48,630
231	Sidi Bel Abbes	Algeria	48,202
232	Jigawa	Nigeria	47,745
233	Yafran (yefren)	Libya	47,381

TLU rank	Administrative unit name	Country	TLUs in target area
234	Atakora	Benin	46,198
235	Baguirmi	Chad	46,102
236	Sofala	Mozambique	44,450
237	Al Fatah	Libya	44,346
238	Iringa	United Republic of Tanzania	42,510
239	Beneshangul Gumu	Ethiopia	40,311
240	Borgou	Benin	40,281
241	Daraba	Chad	39,651
242	Fès-Boulemane,	Morocco	37,586
243	Bulawayo	Zimbabwe	35,403
244	Administrative unit not available	Ilemi triangle	34,887
245	Ouargla	Algeria	34,530
246	Mohale's Hoek	Lesotho	33,964
247	Obock	Djibouti	33,863
248	Tataouine	Tunisia	33,081
249	Maseru	Lesotho	31,923
250	Tebessa	Algeria	31,464
251	West Coast	Gambia	31,441
252	Khenchela	Algeria	30,602
253	Shiselweni	Swaziland	30,498
254	Kebili	Tunisia	30,257
255	Saida	Algeria	30,080
256	Tadla-Azilal	Morocco	28,591
257	Bejaia	Algeria	28,203
258	Melaky	Madagascar	27,768
259	Bauchi	Nigeria	27,205
260	Misurata	Libya	27,190
261	Guelmim-Es-Semara	Morocco	24,762
262	Napak	Uganda	24,463
263	Savanes	Togo	24,172
264	Tubruq (tobruk)	Libya	23,542
265	Leribe	Lesotho	23,217
266	Bujumbura Mairie	Burundi	22,950
267	Thaba Tseka	Lesotho	22,710
268	Bamako	Mali	22,684
269	Morogoro	United Republic of Tanzania	22,047
270	Nuqat Al Khams	Libya	22,037
271	Bordj Bou Arrer	Algeria	21,837
272	Gabes	Tunisia	21,334

TLU rank	Administrative unit name	Country	TLUs in target area
273	Tandjile ouest	Chad	20,957
274	Dosso	Niger	20,378
275	Tarhunah	Libya	20,018
276	Relizane	Algeria	19,876
277	Doukkala-Abda	Morocco	18,333
278	Shinyanga	United Republic of Tanzania	17,964
279	North Bank	Gambia	17,881
280	Darnah	Libya	17,620
281	Niamey	Niger	17,469
282	Quthing	Lesotho	15,854
283	Ghadamis	Libya	15,232
284	Adrar	Mauritania	15,199
285	Eastern	Zambia	15,025
286	Katanga	Democratic Republic of the Congo	14,849
287	Savanes	Côte d'Ivoire	14,747
288	Gafsa	Tunisia	14,578
289	Tissemsilt	Algeria	14,078
290	Lindi	United Republic of Tanzania	14,026
291	Souk-Ahras	Algeria	13,930
292	Al Jabal Al Akhdar	Libya	13,928
293	Banghazi	Libya	13,292
294	Adamawa	Nigeria	13,021
295	Cuanza sul	Angola	12,900
296	Mafeteng	Lesotho	12,870
297	Kasese	Uganda	12,749
298	Djibouti	Djibouti	12,713
299	Sidi Bouz	Tunisia	12,634
300	Kedougou	Senegal	12,446
301	Medenine	Tunisia	12,357
302	Adjumani	Uganda	11,757
303	Bouira	Algeria	11,717
304	Bechar	Algeria	11,352
305	Ghardaia	Algeria	11,337
306	Bengo	Angola	11,216
307	Buliisa	Uganda	11,104
308	Caprivi	Namibia	11,039
309	Alexandria	Egypt	10,895
310	Tozeur	Tunisia	10,408
311	Setif	Algeria	10,218

TLU rank	Administrative unit name	Country	TLUs in target area
312	Nwoya	Uganda	10,031
313	Hhohho	Swaziland	9645
314	Moxico	Angola	9435
315	Tlemcen	Algeria	9236
316	Mtwara	United Republic of Tanzania	9114
317	Gharyan	Libya	8972
318	Al Khoms	Libya	8683
319	Nampula	Mozambique	8559
320	Greater Accra	Ghana	8272
321	Chobe	Botswana	7993
322	Chaouia-Ouardigha	Morocco	7953
323	Tanger-Tétouan,	Morocco	7884
324	Ihorombe	Madagascar	7851
325	Al Aziziyah	Libya	7646
326	Plateau	Nigeria	7539
327	Skikda	Algeria	7476
328	Nouakchott	Mauritania	7165
329	Sousse	Tunisia	6603
330	Northern	Ghana	6500
331	Zaire	Angola	6284
332	Behera	Egypt	6067
333	Katavi	United Republic of Tanzania	5948
334	Harare	Zimbabwe	5796
335	Matrouh	Egypt	5663
336	Geita	United Republic of Tanzania	4742
337	Yobe	Nigeria	4707
338	Az Zawia (azzawiya)	Libya	4457
339	Vakaga	Central African Republic	4273
340	Kaabong	Uganda	4258
341	North Sinai	Egypt	4243
342	Banadir	Somalia	4241
343	Archipelagos	Eritrea	4221
344	Logone Occidental	Chad	4126
345	Kaduna	Nigeria	4100
346	Zanzan	Côte d'Ivoire	4042
347	Kitgum	Uganda	3971
348	Zeleitin (zliten)	Libya	3791
349	Sokoto	Nigeria	3778
350	Katakwi	Uganda	3534

TLU rank	Administrative unit name	Country	TLUs in target area
351	Tipaza	Algeria	3371
352	Tamanrasset	Algeria	3261
353	Hoima	Uganda	3261
354	Chlef	Algeria	3240
355	Tibesti	Chad	3199
356	Agago	Uganda	3192
357	Cabo Delgado	Mozambique	3127
358	Kaolack	Senegal	3001
359	Luanda	Angola	2998
360	Jijel	Algeria	2786
361	Berea	Lesotho	2786
362	Mokhotlong	Lesotho	2756
363	Manzini	Swaziland	2709
364	Annaba	Algeria	2371
365	Mascara	Algeria	2358
366	Rabat-Salé-Zemmour-Zaer	Morocco	2324
367	Logone Oriental	Chad	2295
368	Southern Region	Malawi	2199
369	Sedhiou	Senegal	2197
370	Tripoli (tarabulus)	Libya	2014
371	Taraba	Nigeria	1852
372	Lamwo	Uganda	1813
373	Moyo	Uganda	1735
374	El-Tarf	Algeria	1529
375	Laâyoune-Boujdour-Sakia El Hamra	Morocco	1501
376	Kween	Uganda	1468
377	Ziguinchor	Senegal	1460
378	Central Region	Malawi	1447
379	Njombe	United Republic of Tanzania	1447
380	Upper River	Gambia	1396
381	Nord	Cameroon	1302
382	Grand Casablanca	Morocco	1278
383	Nairobi	Kenya	1199
384	Abim	Uganda	1141
385	Bubanza	Burundi	1134
386	Kasserine	Tunisia	1074
387	Kwara	Nigeria	1073
388	Nassarawa	Nigeria	1049
389	Bulambuli	Uganda	912

TLU rank	Administrative unit name	Country	TLUs in target area
390	Donga	Benin	912
391	Ruvuma	United Republic of Tanzania	884
392	Qacha's Nek	Lesotho	822
393	Zamfara	Nigeria	809
394	Nebbi	Uganda	781
395	Amuru	Uganda	743
396	Bamingui-Bangoran	Central African Republic	704
397	Yumbe	Uganda	674
398	Saguia El Hamra	Western Sahara	662
399	Maekel	Eritrea	658
400	Oran	Algeria	636
401	Ain-Defla	Algeria	552
402	Nyanza	Kenya	536
403	Makamba	Burundi	383
404	Kuanza Norte	Angola	345
405	Ain-Temouchent	Algeria	312
406	Northern Region	Malawi	307
407	Tizi Ouzou	Algeria	219
408	Collines	Benin	217
409	Zambezia	Mozambique	202
410	South Sinai	Egypt	196
411	Murzuq	Libya	178
412	Kotido	Uganda	136
413	Sfax	Tunisia	134
414	Diourbel	Senegal	120
415	Haute-Kotto	Central African Republic	63
416	Suez	Egypt	51
417	Tunis	Tunisia	50
418	Tindouf	Algeria	47
419	Administrative unit not available	Hala'ib triangle	45
420	Otuke	Uganda	43
421	Bururi	Burundi	29
422	Al Kufrah	Libya	27
423	Northern	Zambia	26
424	Mahdia	Tunisia	24
425	Thies	Senegal	23
426	Amuria	Uganda	20
427	Red Sea	Egypt	19
428	Nord-Kivu	Democratic Republic of the Congo	8

TLU rank	Administrative unit name	Country	TLUs in target area
429	Eastern	Ghana	8
430	Ben Arous	Tunisia	7
431	Al Jufrah	Libya	6
432	Illizi	Algeria	5
433	Rukungiri	Uganda	4
434	Rubirizi	Uganda	2
435	Cankuzo	Burundi	-
436	Cibitoke	Burundi	-
437	Gitega	Burundi	-
438	Karuzi	Burundi	-
439	Kayanza	Burundi	-
440	Kirundo	Burundi	-
441	Muramvya	Burundi	-
442	Muyinga	Burundi	-
443	Mwaro	Burundi	-
444	Ngozi	Burundi	-
445	Rutana	Burundi	-
446	Ruyigi	Burundi	-
447	Anjouan	Comoros	-
448	Moheli	Comoros	-
449	Ngazidja	Comoros	-
450	Addis Ababa	Ethiopia	-
451	Hareri	Ethiopia	-
452	Administrative unit not available	Europa Island	-
453	Administrative unit not available	Glorioso Island	-
454	Administrative unit not available	Juan de Nova Island	-
455	Western	Kenya	-
456	Alaotra Mangoro	Madagascar	-
457	Amoron I Mania	Madagascar	-
458	Analamanga	Madagascar	-
459	Analanjirofo	Madagascar	-
460	Androy	Madagascar	-
461	Anosy	Madagascar	-
462	Atsimo Atsinanana	Madagascar	-
463	Atsinanana	Madagascar	-
464	Betsiboka	Madagascar	-
465	Boeny	Madagascar	-
466	Bongolava	Madagascar	-
467	Diana	Madagascar	-

TLU rank	Administrative unit name	Country	TLUs in target area
468	Haute Matsiatra	Madagascar	-
469	Itasy	Madagascar	-
470	Sava	Madagascar	-
471	Sofia	Madagascar	-
472	Vakinankaratra	Madagascar	-
473	Vatovavy Fitovinany	Madagascar	-
474	Niassa	Mozambique	-
475	Lago niassa	Mozambique	-
476	Black River	Mauritius	-
477	Flacq	Mauritius	-
478	Grand Port	Mauritius	-
479	Moka	Mauritius	-
480	Pamplemousses	Mauritius	-
481	Plaines Wilhems	Mauritius	-
482	Port Louis	Mauritius	-
483	Riviere Du Rempart	Mauritius	-
484	Savanne	Mauritius	-
485	Administrative unit not available	Mayotte	-
486	Arrondissement-du-vent	Réunion	-
487	Arrondissement-souse-le-vent	Réunion	-
488	East/Iburasirazuba	Rwanda	-
489	Kigali City/Umujyi wa Kigali	Rwanda	-
490	North/Amajyaruguru	Rwanda	-
491	South/Amajyepfo	Rwanda	-
492	West/Iburengerazuba	Rwanda	-
493	Western Equatoria	South Sudan	-
494	Alphonse	Seychelles	-
495	Anse Aux Pins	Seychelles	-
496	Anse Boileau	Seychelles	-
497	Anse Etoile	Seychelles	-
498	Anse Royale	Seychelles	-
499	Aride	Seychelles	-
500	Assumption	Seychelles	-
501	Au Cap	Seychelles	-
502	Baie Lazare	Seychelles	-
503	Beau Vallon	Seychelles	-
504	Bel Air	Seychelles	-
505	Belombre	Seychelles	-
506	Bijoutier	Seychelles	-

TLU rank	Administrative unit name	Country	TLUs in target area
507	Bird	Seychelles	-
508	Cascade	Seychelles	-
509	Cerf Island	Seychelles	-
510	Conception	Seychelles	-
511	Cousin	Seychelles	-
512	Cousine	Seychelles	-
513	Curieuse	Seychelles	-
514	Darros	Seychelles	-
515	Denis	Seychelles	-
516	Desroches	Seychelles	-
517	English River	Seychelles	-
518	Glacis	Seychelles	-
519	Grand Anse Mahe	Seychelles	-
520	Grande Soeur	Seychelles	-
521	Ile du Sud	Seychelles	-
522	La Digue	Seychelles	-
523	Les Mamelles	Seychelles	-
524	Marie-Louise	Seychelles	-
525	Mont Buxton	Seychelles	-
526	Mont Fleuri	Seychelles	-
527	North Island	Seychelles	-
528	Petite Soeur	Seychelles	-
529	Plaisance	Seychelles	-
530	Platte	Seychelles	-
531	Pointe Larue	Seychelles	-
532	Poivre	Seychelles	-
533	Port Glaud	Seychelles	-
534	Praslin	Seychelles	-
535	Remire	Seychelles	-
536	Silhouette	Seychelles	-
537	St Louis	Seychelles	-
538	St. Francois	Seychelles	-
539	St. Pierre	Seychelles	-
540	Takamaka	Seychelles	-
541	Therese	Seychelles	-
542	Coetivy	Seychelles	-
543	Administrative unit not available	Tromelin Island	-
544	Dar-es-salaam	United Republic of Tanzania	-
545	Kagera	United Republic of Tanzania	-

TLU rank	Administrative unit name	Country	TLUs in target area
546	Kaskazini Pemba	United Republic of Tanzania	-
547	Kaskazini Unguja	United Republic of Tanzania	-
548	Kusini Pemba	United Republic of Tanzania	-
549	Kusini Unguja	United Republic of Tanzania	-
550	Mjini Magharibi	United Republic of Tanzania	-
551	Busia	Uganda	-
552	Jinja	Uganda	-
553	Kabale	Uganda	-
554	Kalangala	Uganda	-
555	Kibaale	Uganda	-
556	Kisoro	Uganda	-
557	Ntungamo	Uganda	-
558	Ssembabule	Uganda	-
559	Kabarole	Uganda	-
560	Kaberamaido	Uganda	-
561	Kampala	Uganda	-
562	Kamwenge	Uganda	-
563	Kanungu	Uganda	-
564	Kayunga	Uganda	-
565	Mayuge	Uganda	-
566	Nakasongola	Uganda	-
567	Wakiso	Uganda	-
568	Amolatar	Uganda	-
569	Butaleja	Uganda	-
570	Ibanda	Uganda	-
571	Isingiro	Uganda	-
572	Kaliro	Uganda	-
573	Kiruhura	Uganda	-
574	Koboko	Uganda	-
575	Luwero	Uganda	-
576	Mbale	Uganda	-
577	Mbarara	Uganda	-
578	Mityana	Uganda	-
579	Mubende	Uganda	-
580	Nakaseke	Uganda	-
581	Tororo	Uganda	-
582	Budaka	Uganda	-
583	Namutumba	Uganda	-
584	Maracha	Uganda	-

TLU rank	Administrative unit name	Country	TLUs in target area
585	Oyam	Uganda	-
586	Dokolo	Uganda	-
587	Arua	Uganda	-
588	Manafwa	Uganda	-
589	Bukedea	Uganda	-
590	Bududa	Uganda	-
591	Rakai	Uganda	-
592	Lyantonde	Uganda	-
593	Buikwe	Uganda	-
594	Buyende	Uganda	-
595	Kamuli	Uganda	-
596	Zombo	Uganda	-
597	Kyegegwa	Uganda	-
598	Kyenjojo	Uganda	-
599	Apac	Uganda	-
600	Bugiri	Uganda	-
601	Bukomansimbi	Uganda	-
602	Bukwo	Uganda	-
603	Bundibugyo	Uganda	-
604	Bushenyi	Uganda	-
605	Butambala	Uganda	-
606	Iganga	Uganda	-
607	Kalungu	Uganda	-
608	Kapchorwa	Uganda	-
609	Sheema	Uganda	-
610	Kole	Uganda	-
611	Luuka	Uganda	-
612	Masaka	Uganda	-
613	Masindi	Uganda	-
614	Ngora	Uganda	-
615	Buhweju	Uganda	-
616	Ntoroko	Uganda	-
617	Pader	Uganda	-
618	Sironko	Uganda	-
619	Soroti	Uganda	-
620	Alebtong	Uganda	-
621	Buvuma	Uganda	-
622	Gomba	Uganda	-
623	Gulu	Uganda	-

TLU rank	Administrative unit name	Country	TLUs in target area
624	Kiboga	Uganda	-
625	Kibuku	Uganda	-
626	Kiryandongo	Uganda	-
627	Kumi	Uganda	-
628	Kyankwanzi	Uganda	-
629	Mitooma	Uganda	-
630	Mpigi	Uganda	-
631	Serere	Uganda	-
632	Lwengo	Uganda	-
633	Mukono	Uganda	-
634	Namayingo	Uganda	-
635	Pallisa	Uganda	-
636	Lira	Uganda	-
637	Copperbelt	Zambia	-
638	Luapula	Zambia	-
639	North-Western	Zambia	-
640	Bouenza	Congo	-
641	Brazzaville	Congo	-
642	Cuvette	Congo	-
643	Cuvette-Ouest	Congo	-
644	Kouilou	Congo	-
645	Lekoumou	Congo	-
646	Likouala	Congo	-
647	Niari	Congo	-
648	Plateaux	Congo	-
649	Point-Noire	Congo	-
650	Pool	Congo	-
651	Sangha	Congo	-
652	Annobon	Equatorial Guinea	-
653	Bioko Norte	Equatorial Guinea	-
654	Bioko Sur	Equatorial Guinea	-
655	Centro Sur	Equatorial Guinea	-
656	Kientem	Equatorial Guinea	-
657	Litoral	Equatorial Guinea	-
658	Welenzas	Equatorial Guinea	-
659	Estuaire	Gabon	-
660	Haut-Ogooue	Gabon	-
661	Moyen-Ogooue	Gabon	-
662	Ngounie	Gabon	-

TLU rank	Administrative unit name	Country	TLUs in target area
663	Nyanga	Gabon	-
664	Ogooue-Ivindo	Gabon	-
665	Ogooue-lolo	Gabon	-
666	Ogooue-Maritime	Gabon	-
667	Woleu-Ntem	Gabon	-
668	Mont De Lam	Chad	-
669	Principe	Sao Tome and Principe	-
670	Sao Tome	Sao Tome and Principe	-
671	Bandundu	Democratic Republic of the Congo	-
672	Bas-Congo	Democratic Republic of the Congo	-
673	Equateur	Democratic Republic of the Congo	-
674	Kasai Occidental	Democratic Republic of the Congo	-
675	Kasai Oriental	Democratic Republic of the Congo	-
676	Kinshasa	Democratic Republic of the Congo	-
677	Maniema	Democratic Republic of the Congo	-
678	Adamaoua	Cameroon	-
679	Centre	Cameroon	-
680	Est	Cameroon	-
681	Littoral	Cameroon	-
682	Nord-Ouest	Cameroon	-
683	Ouest	Cameroon	-
684	Sud	Cameroon	-
685	Sud - Ouest	Cameroon	-
686	Bangui	Central African Republic	-
687	Basse-Kotto	Central African Republic	-
688	Haut-Mbomou	Central African Republic	-
689	Kémo,	Central African Republic	-
690	Lobaye	Central African Republic	-
691	Mambéré-Kadéï,	Central African Republic	-
692	Mbomou	Central African Republic	-
693	Nana-Gribizi	Central African Republic	-
694	Nana-Mambéré	Central African Republic	-
695	Ombella M'Poko	Central African Republic	-
696	Ouaka	Central African Republic	-
697	Ouham	Central African Republic	-
698	Ouham-Pendé	Central African Republic	-
699	Sangha-Mbaéré	Central African Republic	-
700	Bie	Angola	-
701	Cabinda	Angola	-

TLU rank	Administrative unit name	Country	TLUs in target area
702	Huambo	Angola	-
703	Lunda Norte	Angola	-
704	Lunda Sul	Angola	-
705	Malanje	Angola	-
706	Uige	Angola	-
707	Administrative unit not available	Ma'tan al-Sarra	-
708	Northern	Sudan	-
709	Ariana	Tunisia	-
710	Bizerte	Tunisia	-
711	Beja	Tunisia	-
712	Jendouba	Tunisia	-
713	Kairouan	Tunisia	-
714	Le Kef	Tunisia	-
715	Manouba	Tunisia	-
716	Monastir	Tunisia	-
717	Nabeul	Tunisia	-
718	Siliana	Tunisia	-
719	Zaghouan	Tunisia	-
720	Gharb-Chrarda-Béni Hssen	Morocco	-
721	Ash Shati	Libya	-
722	Awbari (ubari)	Libya	-
723	Sabha	Libya	-
724	Rio De Oro	Western Sahara	-
725	Assiut	Egypt	-
726	Aswan	Egypt	-
727	Beni Suef	Egypt	-
728	Cairo	Egypt	-
729	Dakahlia	Egypt	-
730	Damietta	Egypt	-
731	Fayoum	Egypt	-
732	Gharbia	Egypt	-
733	Giza	Egypt	-
734	Ismailia	Egypt	-
735	Kafr El-Shikh	Egypt	-
736	Kalyoubia	Egypt	-
737	Luxor	Egypt	-
738	Menia	Egypt	-
739	Menoufia	Egypt	-
740	New Valley	Egypt	-

TLU rank	Administrative unit name	Country	TLUs in target area
741	Port Said	Egypt	-
742	Qena	Egypt	-
743	Shrkia	Egypt	-
744	Suhag	Egypt	-
745	Adrar	Algeria	-
746	Alger	Algeria	-
747	Blida	Algeria	-
748	Boumerdes	Algeria	-
749	Constantine	Algeria	-
750	Guelma	Algeria	-
751	Mila	Algeria	-
752	Mostaganem	Algeria	-
753	Butha Buthe	Lesotho	-
754	Kanifing Municipal Council	Gambia	-
755	Ashanti	Ghana	-
756	Brong Ahafo	Ghana	-
757	Central	Ghana	-
758	Volta	Ghana	-
759	Western	Ghana	-
760	Dakhlet-Nouadhibou	Mauritania	-
761	Inchiri	Mauritania	-
762	Tiris-Zemmour	Mauritania	-
763	Abia	Nigeria	-
764	Abuja	Nigeria	-
765	Akwa Ibom	Nigeria	-
766	Anambra	Nigeria	-
767	Bayelsa	Nigeria	-
768	Benue	Nigeria	-
769	Cross River	Nigeria	-
770	Delta	Nigeria	-
771	Ebonyi	Nigeria	-
772	Edo	Nigeria	-
773	Ekiti	Nigeria	-
774	Enugu	Nigeria	-
775	Gombe	Nigeria	-
776	Imo	Nigeria	-
777	Kano	Nigeria	-
778	Kogi	Nigeria	-
779	Lagos	Nigeria	-

TLU rank	Administrative unit name	Country	TLUs in target area
780	Ogun	Nigeria	-
781	Ondo	Nigeria	-
782	Osun	Nigeria	-
783	Oyo	Nigeria	-
784	Rivers	Nigeria	-
785	Bafata	Guinea-Bissau	-
786	Biombo	Guinea-Bissau	-
787	Cacheu	Guinea-Bissau	-
788	Gabu	Guinea-Bissau	-
789	Oio	Guinea-Bissau	-
790	Quinara	Guinea-Bissau	-
791	Sector Autonomo De Bissau	Guinea-Bissau	-
792	Tombali	Guinea-Bissau	-
793	Ascension	Saint Helena	-
794	Centrale	Togo	-
795	Kara	Togo	-
796	Maritime	Togo	-
797	Plateaux	Togo	-
798	Boa Vista	Cape Verde	-
799	Brava	Cape Verde	-
800	Cima	Cape Verde	-
801	Fogo	Cape Verde	-
802	Ilheu Raso	Cape Verde	-
803	Maio	Cape Verde	-
804	Sal	Cape Verde	-
805	Santa Luzia	Cape Verde	-
806	Santiago	Cape Verde	-
807	Santo Antao	Cape Verde	-
808	Sao Nicolau	Cape Verde	-
809	Sao Vicente	Cape Verde	-
810	Atlantique	Benin	-
811	Couffo	Benin	-
812	Littoral	Benin	-
813	Mono	Benin	-
814	Oueme	Benin	-
815	Plateau	Benin	-
816	Zou	Benin	-
817	Kaffrine	Senegal	-
818	Dakar	Senegal	-

TLU rank	Administrative unit name	Country	TLUs in target area
819	Boke	Guinea	-
820	Conakry	Guinea	-
821	Faranah	Guinea	-
822	Kindia	Guinea	-
823	Mamou	Guinea	-
824	Nzerekore	Guinea	-
825	Labe	Guinea	-
826	Bomi	Liberia	-
827	Bong	Liberia	-
828	Gbarpolu	Liberia	-
829	Grand Bassa	Liberia	-
830	Grand Cape Mount	Liberia	-
831	Grand Gedeh	Liberia	-
832	Grand Kru	Liberia	-
833	Lofa	Liberia	-
834	Margibi	Liberia	-
835	Maryland	Liberia	-
836	Montserrado	Liberia	-
837	Nimba	Liberia	-
838	Rivercess	Liberia	-
839	River Gee	Liberia	-
840	Sinoe	Liberia	-
841	Bas Sassandra	Côte d'Ivoire	-
842	Denguele	Côte d'Ivoire	-
843	Vallee Du Bandama	Côte d'Ivoire	-
844	Comoe	Côte d'Ivoire	-
845	District autonome de Abidjan	Côte d'Ivoire	-
846	District autonome de Yamoussoukro	Côte d'Ivoire	-
847	Lôh-Djiboua	Côte d'Ivoire	-
848	Lacs	Côte d'Ivoire	-
849	Lagunes	Côte d'Ivoire	-
850	Montagnes	Côte d'Ivoire	-
851	Sassandra-Marahoue	Côte d'Ivoire	-
852	Woroba	Côte d'Ivoire	-
853	Eastern	Sierra Leone	-
854	Northern	Sierra Leone	-
855	Southern	Sierra Leone	-
856	Western area	Sierra Leone	-