FEED THE FUTURE
The U.S. Government's Global Hunger & Food Security Initiative

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Measuring Resilience in the Horn of Africa

REPORT 5

Gaps in spatial data for social, ecological and economic systems

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technical consortium
Building Resilience in the Horn of Africa

ILRI
INTERNATIONAL LIVESTOCK RESEARCH INSTITUTE

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1 Introduction

The Technical Consortium for Building Resilience in the Horn of Africa (TC) is a project of the CGIAR, which was formed in 2011 following the effects of the 2011-2012 drought. The main aim of the Technical Consortium initially was to provide financial and technical support to the Intergovernmental Authority on Development (IGAD) and its member states (Djibouti, Ethiopia, Kenya, Somalia, South Sudan, Sudan and Uganda) to formulate regional and national investment programmes for the long-term development of ASALS and to follow this with technical support, with particular focus on monitoring and evaluation and the targeting of investments within these plans. These investment plans became the Country Programme Papers (CPPs) for drylands projects for the Member States and the Regional Programming Framework (now the IGAD Drought Disaster Resilience Sustainability Initiative (IDDRSI)), which focused on investment plans to address regional issues for IGAD. The focus of the TC's work at present is to collaborate with different partners, specifically including the governments in the region as their plans develop, to provide tools for measuring the impact of investments on enhanced resilience and to develop decision support tools for better targeting and prioritization of investments or projects. These tools will not only be useful for monitoring the impact of interventions within the national drylands investment plans and provide evidence for rational decision-making and prioritization, but will be applicable for donors, developments, NGOs and civil society when measuring or targeting their projects.

It has been noted that there is a gap between the strategies that decision makers use to allocate policy-related investments for ASALs and the analytical techniques that researchers use to model the conditions of ASALs and assess the impact of related interventions. To help bridge this gap, the TC has been working to develop and apply approaches to support evidence-based decision-making and investment prioritization to enhance resilient development trajectories in Horn of Africa (HoA).

The result will be a toolbox of methodologies and application processes that facilitate the capacities of the IGAD member states to identify the investments with greatest potential for the highest impact to build resilience to shocks and stressors, in particular to drought, in the HoA. The toolbox will be tailored to elucidate the implications of more focused interventions, for a more specific sub-population of interest, as those details are specified by IGAD or the member states. It will also be able to test how well investments perform under different conditions (climatic and otherwise) and over varied time horizons. The toolbox will be of use to multiple audiences, but the primary focus for application will be to provide tools for the Government of Kenya (GoK) National Drought Management Authority (NDMA), to assist with decision analysis and prioritization for investment proposed in the Kenya Ending Drought Emergencies Common Programme Framework (EDE CPF) drylands investment plan. It is also assumed, however, that the conceptual analysis and knowledge gained in the provision of tools to the GoK.

Technical Consortium - Gap analysis: **Approach**

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The development and trialling of composite indicators, the pilot spatial tool and indicators for use in Monitoring and Evaluation has resulted in evidential gaps in the data. This summary paper documents these initial gaps in data, which have been found, and motivated for the need for a comprehensive work plan on Data Architecture in the Horn of Africa. The gaps summarised below pertain largely from the development of the spatial tool and as the composite indicators were developed on a systems basis, the data gaps have been summarised for these three key systems.

A note on the geodatabases

Within each geodatabase are three layers of organisation: composite indicators (e.g. livelihood diversity); key indicator groups (e.g. livestock breeds); and data layers (e.g. cattle and sheep). In the spreadsheets, the coverage and resolution of each key indicator group is visualised such that continuous dark red bars across the countries represent an ideal resolution of $1km^2$ for rasters or 1:1m scale for vectors. This provides an instant overview of the data collation as of 8 October 2013. Statistics are provided in the columns and rows to summarise these coverages: Kenya invariably has the most high resolution data available across all three systems, while Somalia, Djibouti and Sudan show least detailed coverage.

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Gaps in the **social geodatabase**

Extensive information has been gathered from the data inventory carried out, to present a geographical picture of social resilience across the Horn of Africa. However, a principle hurdle encountered while gathering social and economic data has been the lack of census information for certain countries, notably Somalia and Djibouti. Furthermore, socio-economic datasets of subnational resolution are only available for part of the Horn of Africa, necessitating the use of national data to fill in gaps. For Sudan, much of the data is old with the most recent census data often being 1988. While a complete picture of social resilience has been gathered for the region, the resolution of this coverage is highly patchy across countries and administration districts. This seems to be an unavoidable product of the available data quality at present.

The datasets focused on were considered most important to social resilience, especially the quality of healthcare (including access to improved water) and education, as well as data that might effectively represent the distribution of previously disadvantaged communities or elements of the population. Ideally, an indication of representation in parliament or in decision making would be obtained.

Certain datasets will require further analysis. For instance, two datasets showing the distribution of ethnic groups at a high subnational resolution across a region can be analysed further to identify which groups occur astride national boundaries (marginal) and which groups are known to practice circular migration. While national data on displacement migration has been acquired (as well as subnational data for Eritrea), circular migration - which may be considered more positive in respect to resilience – is only indicated by arrows in the patterns of movement on the datasets accessed, which is challenging to convert to meaningful spatial data for use in the spatial tool. However, their coincidence with ethnic group polygons may provide a mechanism.

While it is acknowledged that the availability of support networks and community management would be important indicators to obtain for social resilience, data on this has not yet been found in census data, although they may come to light within high resolution household surveys. Access to information is covered by communication infrastructure and subscribers under economic, with the aim of providing an indicator showing the geographic extent of famine early warning systems.

Summary

- Lack of census information for certain countries, notably Somalia and Djibouti.
- General problem with socio-economic datasets has been the availability of subnational resolution data for only part of the Horn of Africa, so it has been necessary to fill in gaps with national data.
- The resolution of this coverage is highly patchy across countries and administration districts. This seems to be an unavoidable product of the available data quality at present.
- Availability of support networks and community management do not exist at present from within the census data.

Figure 1. Coverage and resolution of each key social indicator

Dark red bars across countries represent an ideal resolution of 1km^2 for rasters or 1:1m scale for vectors. Orange bars represent subnational coverage at coarser scale. National coverage is indicated in yellow. A white space represents no coverage.

SOCIAL INDICATORS		DATA /IND	GDB	BEST RESOLUTION ACCESSED							
				DJ	ER	ET	KE	SO	SS	SU	UG
s001	Representation in parliament										
s002	Representation in county level administration										
s003	Property rights and legal indicators	2	✓								
s004	Policing	2	✓								
s005	Conflicts	9	✓								
s006	Displacement migration	2	✓								
s007	Circular migration	2	✓								
s008	Community management										
s009	Availability of support networks										
s010	agricultural extension services (trianing)										
s011	Access to improved water	16	✓								
s012	Life expectancy	2	✓								
s013	Orphans	2	✓								
s014	Infant mortality	2	✓								
s015	Disease metrics (malaria, HIV etc.)	10	✓								
s016	% Expenditure on health	2	✓								
s017	Distance to health centres / number health centres	9	✓								
s018	Education (schools, literacy rates, gender)	3	✓								
s019	Number of schools	2	✓								
s020	Equitable society indicators	2	✓								
s021	Inclusivity indicators										
s022	Role and participation of women	5	✓								
s023	Access to info - early warning										
s024	Access to info - crop prices etc.										
s025	Trends in urban population centres in the last decade	2	✓								
s026	National Level Governance	2	✓								
s027	Change in leaders										
s028	Crime rates	1	✓								
s029	Governance Below National Level										
s030	Disasters	1	✓								
TOTAL	% INDICATORS ACCESSED	TOTAL		21%	30%	30%	36%	32%	20%	26%	31%
30	67%	78	20	0.6	0.9	0.9	1.1	1.0	0.6	0.8	0.9

	National resolution data
	Subnational resolution data
	Point data or fine resolution (1 Km^2 or better) raster data

4

Gaps in the **economic geodatabase**

Interesting economic datasets have been uncovered, in particular the estimation of GDP at a very fine subnational scale from the lights at night and Landscan datasets. These data reveal wealth at a highly local level, from separate downscaling of national agricultural and industrial income, although it is necessary to take the logarithm value of $/km^2 in order to reduce the dominance of very high values in urban areas and reveal the geographic differentiation in rural and arid areas. The agricultural GDP is downscaled on the basis of population density, illustrating areas of relative wealth. Ideally, this should be backed up with household survey data providing information on income. Census data such as household assets from Measure DHS have been accessed at a subnational scale and are available to rural and urban clusters of households at very high resolution (point data). However, these data have been deliberately displaced up to 2, 5 and 10km in order to preserve the identity of the respondents.

Possibly the biggest gap in representing economic resilience, in terms of material resources, is an indicator for diversity of livelihoods. On the presumption that this is the most important indicator for resilience in this system, an indicator for livelihood diversity was instead compiled from information on different crop yields and livestock breeds, but this method will suffer from resolution effects (crop yield data holdings can also provide measures of reliance on cash crops). Assumptions can also be made regarding access to industrial livelihoods on the basis of the lights at night dataset, because industrial employment is closely linked to the latter. However, for future versions of the spatial tool, a high resolution indicator of livelihood diversity would be of great benefit.

Other gaps that still exist include indicators of agricultural inputs, extension services e.g. agricultural training and veterinary services. The divide and allocation between social and economic indicators should not necessarily matter because these are likely to be grouped into socio-economic for the spatial tool, but the well-being of natural assets under ecological should best be treated separately from human well-being. In the case of livestock, it is useful to think of the harmful effects of high stocking rates and overgrazing under ecological but the material assets provided by livestock under economic. Future refining of the allocation of such indicators may be required. Extension services and veterinary services may only be available as national indicators and it is likely to be a challenge to get these indicators down to a fine geographic scale. Agricultural inputs, particularly fertilisers, would be worth pursuing further, alongside crop storage facilities. High resolution data may still be obtained from suppliers but the research is likely to be time consuming.Data for exchange rate systems has been obtained but these still need to be ranked, while there remain gaps in indicators of price stability and access to insurance.

Summary

New datasets on economic indicators

- GDP at a very fine subnational scale from the lights at night and Landscan datasets (f001). These data reveal wealth at a very local level from separate downscaling of national agricultural and industrial income. It is necessary to take the logarithm value of $\$/km^2$ in order to reduce the dominance of very high values in urban areas and reveal the geographic

Gaps

- Possibly the biggest gap under human well-being in terms of material resources is an indicator for diversity of livelihoods. With the present data holdings an indicator is being compiled based on different crop yields and different livestock breeds but this method will suffer from resolution effects.
- Indicators of agricultural inputs, extension services e.g. training people how to grow crops (this is listed in both social and economic but should fall best under social), and veterinary services (listed under ecological currently but should sit best under economic or social).

Figure 2. Coverage and resolution of each key economic indicator

Dark red bars across countries represent an ideal resolution of $1km^2$ for rasters or 1:1m scale for vectors. Orange bars represent subnational coverage at coarser scale. National coverage is indicated in yellow. A white space represents no coverage.

ECONOMIC INDICATORS		DATA /IND	GDB	BEST RESOLUTION ACCESSED							
				DJ	ER	ET	KE	SO	SS	SU	UG
f001	Lights at night infrastructure	3	✓								
f002	Travel time to the nearest city	1	✓								
f003	Road and rail infrastructure	8	✓								
f004	Distance to the nearest port	1	✓								
f005	Communication (Internet, Cell phones, land lines, cell towers etc.)	4	✓								
f006	Status of trade regulations	2	✓								
f007	Tax regulations	1	✓								
f008	Access to financial services	2	✓								
f009	Access to insurance										
f010	Access to development projects										
f011	Tourism (conservancies and NP)	2	✓								
f012	GDP (National, agriculture, industry)	2	✓								
f013	GDP household (income)										
f014	Household assets	2	✓								
f015	Livelihood diversity										
f016	Livestock diversity/numbers/types	13	✓								
f017	Agricultural assets	2	✓								
f018	Agricultural inputs										
f019	Extension services										
f022	SAM and GAM rates										
f023	Diet (Calories, protein, diversity)	3	✓								
f026	Livestock trade (Exports, volume, value, milk, hides, skins etc.)	12	✓								
f032	% land under irrigation	3	✓								
f033	Crop area/yield/irrigated yield/diversity/reliance on cash crops	35	✓								
f034	Irrigation potential	1	✓								
f035	Electrical infrastructure	12	✓								
f036	Distance to nearest airport	3	✓								
f037	Distance to nearest market	3	✓								
f038	Price stability										
f039	Flexible exchange rate policy	1	✓								
f040	Integration with other markets										
f041	Access to local enterprises										
f042	interest rates	1	✓								
f043	inflation rates	1	✓								
f045	crop storage facilities										
f048	poverty infrastructure	1	✓								
f049	Malnourishment rates for children under 5 years old	1	✓								
f050	Employment rates (male and female)	2	✓								
f051	Aid activity	1	✓								
TOTAL	% INDICATORS ACCESSED	TOTAL		38%	44%	44%	45%	33%	34%	39%	44%
39	72%	123	28	1.1	1.3	1.3	1.4	1.0	1.0	1.2	1.3

	National resolution data
	Subnational resolution data
	Point data or fine resolution (1 Km^2 or better) raster data

5

Gaps in the **ecological geodatabase**

Ecological indicators offered the best resolution and coverage for the region, due to most ecological indicators emanating from large-scale (continent or global) datasets gathered by the international community. A comprehensive and detailed view of the well-being or otherwise of natural resources across the region of the Horn of Africa can therefore already be presented.

While a significant component to this assessment of natural resources has been fulfilled by the modelling of rangeland conditions (explained in detail shortly), and while extensive information on livestock distribution and mortality patterns has been collated, there is still a major gap for realistic limits to reproduction and mortality rates ranging from optimum conditions to worst conditions. Livestock experts are needed to help fill this gap, as well as data on livestock mobility, agricultural systems and migratory patterns.

While data on the depth of groundwater has been acquired, input data on recharge rates of aquifers is still needed, and the numerous data available on the seasonality of rainfall needs to still be interpreted in terms of ecological.

In terms of population datasets, only the GRUMP dataset has been used as it is regarded as the most extensive and up to date, however at a later date more population datasets could be added. Although GRUMP does not reveal high resolution variation in density in rural areas, it is worth remarking that high population density per se does not necessarily infer low resilience if, for instance, the people are living sustainably in cities. Consequently, indicators of per capita resources have been used.

A full analysis of per capita food resources remains a major gap for this project, with no readily available dataset to fill this gap other than the very broad Human Appropriation of Net Primary Productivity dataset, which makes over-simplistic assumptions and can therefore only be included at a very low weighting. A full analysis of per capita food in the Horn of Africa should assess all types of accessible food but also needs to take account of distribution networks and supplies. This is beyond the scope of the current project but certainly an important gap to be kept in mind for future investigation.

A direct indicator for food web complexity is also lacking – key to representing ecological resilience, as already discussed. In consultation with other biodiversity experts at UNEP-WCMC, we find these indicators to be generally lacking. The African Raptor Databank project is expected to provide measures of ecosystem health, but in the absence of data for the timeframe of this project, it is proposed species diversity and biodiversity value be used as a proxy for food web complexity. Reasonable resolution data on soil moisture, depth and nutrient content has been acquired, and form one of the best indicator groups for ecological resilience for the purposes of this project.

Summary

- A major gap for realistic limits to reproduction and mortality rates ranging from optimum conditions to worst conditions. This requires livestock experts and resources to fill in data on livestock mobility, agricultural systems and migratory patterns.
- Recharge rates of aquifers.
- There is good data on seasonality of rainfall that we are aware of but we need to know how to interpret this in terms of ecological resilience – is a bimodal system more or less resilient?
- Alien invasive plant occurrence
- The GRUMP population dataset is generally regarded to be the best and most up to date. It doesn't however reveal high resolution variation in density in rural areas.
- A full analysis of per capita food resources - no readily available dataset to fill this gap other than the very broad brush Human Appropriation of Net Primary Productivity dataset.
- A full analysis of per capita food in the Horn of Africa
- Health of wetlands
- Biodiversity is made up of species diversity data, levels of transformation of habitats, and levels of protection.
- Species diversity data are too coarse
- A food web complexity data set missing. Ecological resilience is thought to be linked to food web complexity and functional complexity rather than species diversity.

Figure 3. Coverage and resolution of each key ecological indicator
Dark red bars across countries represent an ideal resolution of 1km^2 for rasters or 1:1m scale for vectors. Orange bars represent subnational coverage at coarser scale. National coverage is indicated in yellow. A white space represents no coverage.

ECOLOGICAL INDICATORS		DATA /IND	GDB	BEST RESOLUTION ACCESSED							
				DJ	ER	ET	KE	SO	SS	SU	UG
e001	Aquifer capacity and draw down rates	1	✓								
e002	Water source distribution	1	✓								
e003	Distance from water source	1	✓								
e004	Rainfall per person on agricultural land	3	✓								
e005	Rainfall data from remote sensing	1	✓								
e006	ENSO index	1	✓								
e007	Population density	2	✓								
e009	Biodiversity value	5	✓								
e010	Forest resources	1	✓								
e011	Deforestation	1	✓								
e012	Slope	2	✓								
e013	Length of the growing period	1	✓								
e014	Bi-seasonal or uni-seasonal growing periods										
e015	Soil degradation\moisture etc.	3	✓								
e017	Rangeland condition	8	✓								
e018	Livestock mortality data										
e019	Invasive plant occurrence										
e020	Classification of agricultural systems	2	✓								
e021	Livestock mobility and migratory patterns										
e022	Livestock related disease outbreaks (5 yrs)	3	✓								
e023	Livestock birth and death rates										
e024	Status of SPS protocols –										
e025	Access to veterinary services – agro vets, CAHWs, vets etc										
e028	net primary productivity	1	✓								
e029	food web complexity										
TOTAL	% INDICATORS ACCESSED	TOTAL		53%	53%	56%	61%	56%	56%	53%	56%
25	68%	37	17	1.6	1.6	1.7	1.8	1.7	1.7	1.6	1.7

	National resolution data
	Subnational resolution data
	Point data or fine resolution (1 Km^2 or better) raster data

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Mapping data to understand further gaps and data deficiencies

In an effort to lend support to the planning for the Regional Pastoral Livelihoods Resilience Project (RPLRP)[1], which is a three country (Kenya, Ethiopia and Uganda) project focusing on enhancing the livelihood resilience of pastoral and agro-pastoral communities in cross-border, drought prone areas, the Technical Consortium decided to use the results of the data scoping exercise to illustrate what types of spatial data were available for which purpose.

Based on the indicators outlined in the RPLRP Monitoring and Evaluation Framework, it was decided to try to provide the project with ten maps representing major indicators to be monitored, to be used as baselines. The exercise of producing these maps would bring to the fore visually, the lack or presence of spatial data which could be used to assist in decision making as well.

[1] http://www.worldbank.org/projects/P129408/regional-pastoral-livelihoods-recovery-resilience-project?lang=en

Maps of major indicators

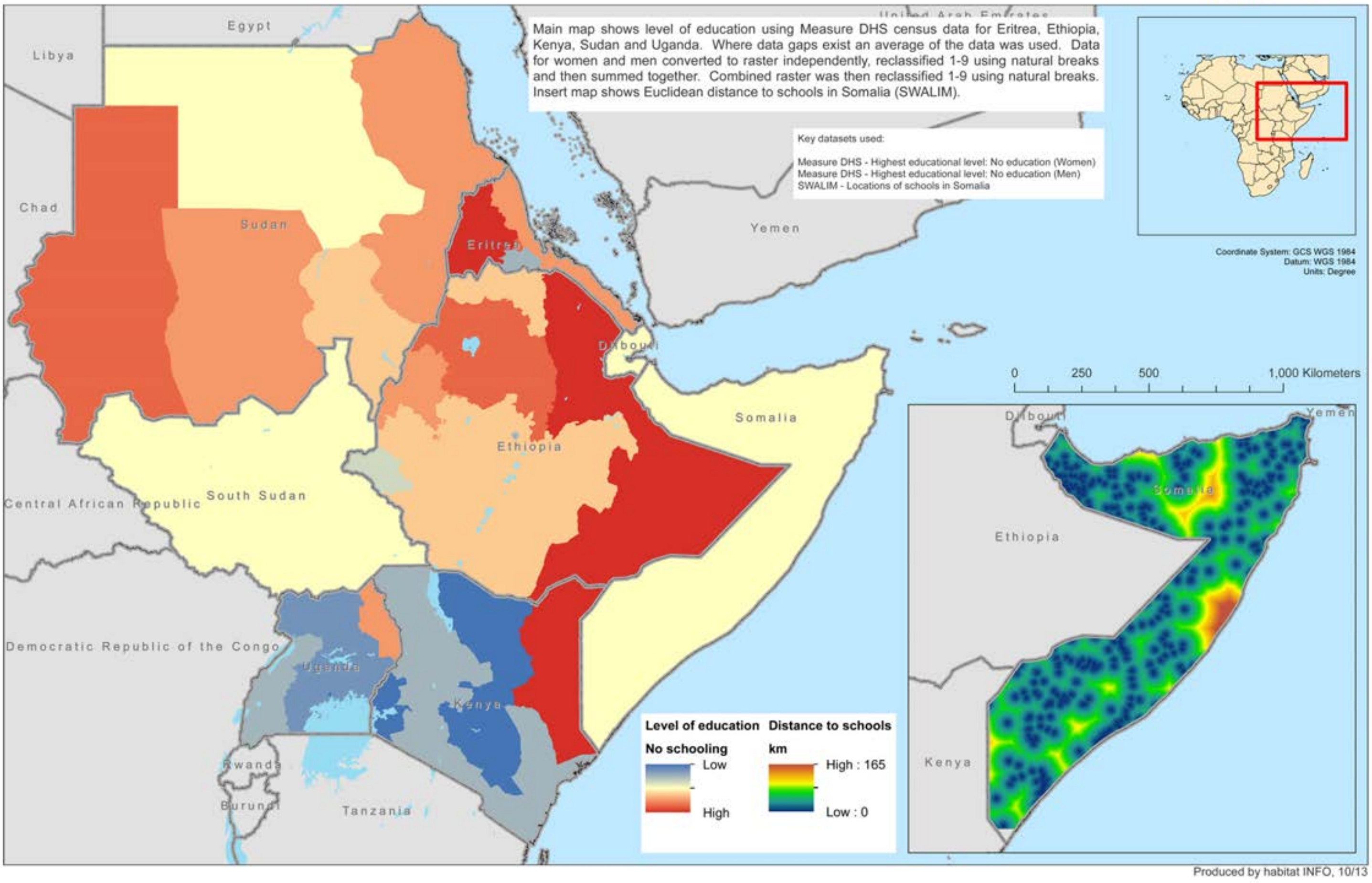
11A - EDUCATION *(see map on page 13)*

Main map shows level of education using Measure DHS censi data for Eritrea, Ethiopia, Kenya, Sudan and Uganda. Where data gaps exist, an average of the data was used. Data for women and men converted to raster independently, reclassified 1-9 using natural breaks and then summed together. Combined raster was then reclassified 1-9 using natural breaks. Insert map shows Euclidean distance to schools in Somalia (SWALIM).

4 - GENDER *(see map on page 13)*

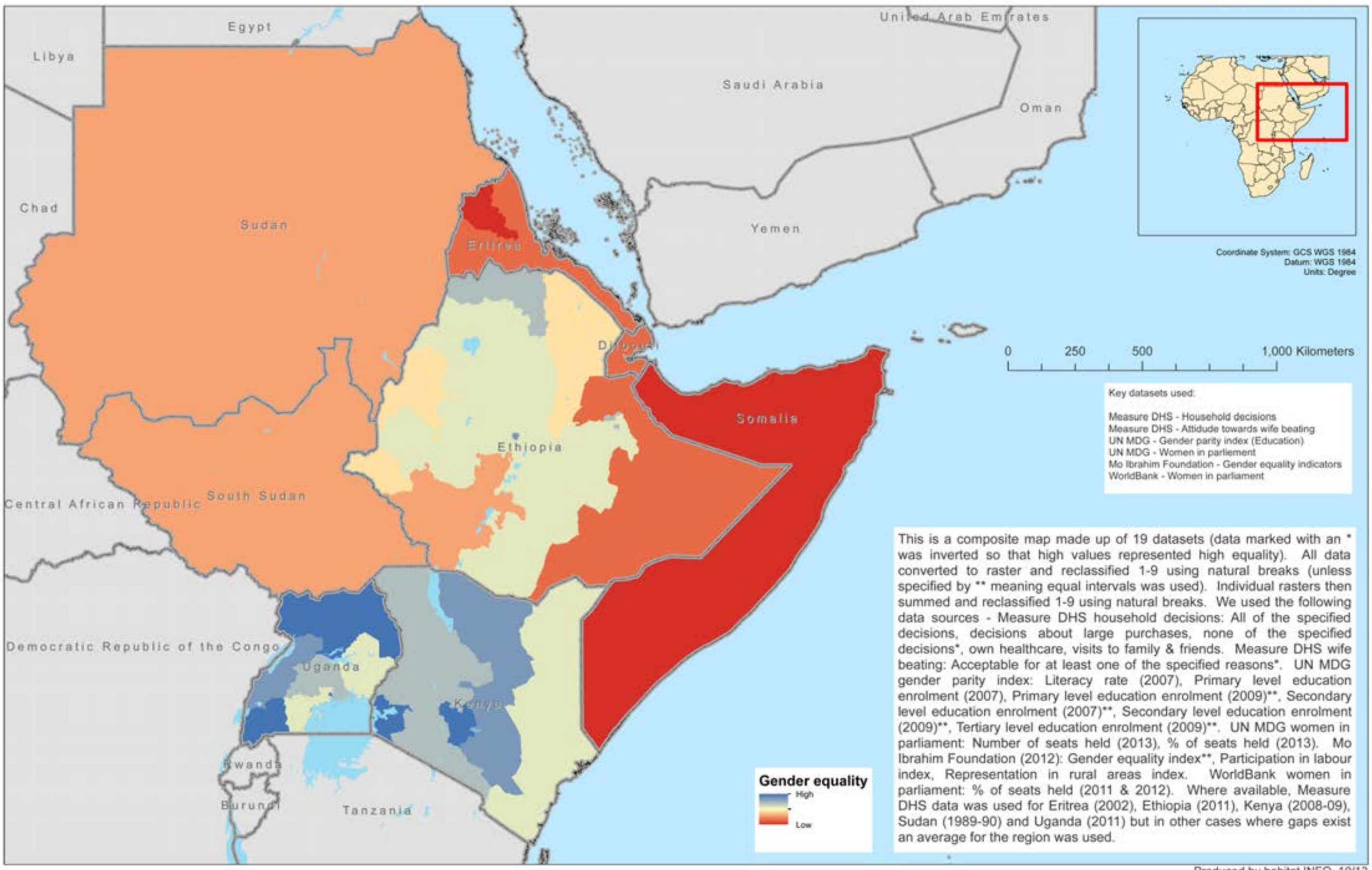
Measure DHS household decisions: All of the specified decisions, decisions about large purchases, none of the specified decisions (i), own healthcare, visits to family & friends. Measure DHS wife beating: Acceptable for at least one of the specified reasons (i). UN MDG gender parity indexes: Literacy rate (2007), Primary level education enrolment (2007), Primary level education enrolment (EI) (2009), Secondary level education enrolment (EI) (2007), Secondary level education enrolment (EI) (2009), Tertiary level education enrolment (EI) (2009). UN MDG women in parliament: Number of seats held (2013), % of seats held (2013). Mo Ibrahim Foundation (2012): Gender equality index (EI), Participation in labour index, Representation in rural areas index. WorldBank women in parliament: % of seats held (2011 & 2012). All data converted to raster and reclassified 1-9 using natural breaks (Unless specified by 'EI' meaning equal intervals was used). Data marked with an 'i' was inverted so that high values represented high equality. Individual rasters then summed and reclassified 1-9 using natural breaks. Where data gaps exist an average for the region was applied. Where available Measure DHS data used for Eritrea (2002), Ethiopia (2011), Kenya (2008-09), Sudan (1989-90) and Uganda (2011).

MAP 11a Access to education



Produced by habitat INFO, 10/13

MAP 4 Gender parity



Produced by habitat INFO, 10/13

11B - HEALTH *(see page 15 for map)*

Main map shows access to health care using two datasets; 1) % of pregnant women reporting distance to a health care centre as problematic (Measure DHS censi data for Eritrea, Ethiopia and Uganda), and 2) Number of hospitals per 100,000 people (WHS 2013). Where data gaps exist an average of the data was used. Data was converted to raster and reclassifed 1-9 using natural breaks. Insert map shows distance to health care centres in Somalia (SWALIM) and Kenya (ILRI). Health care centre data was combined and the Euclidean distance calculated to them.

5 - WATER ACCESS *(see page 15 for map)*

Main map shows access to improved water. Data available from WHO / UNICEF Joint Monitoring Program. Data for Uganda available from WRI. The two datasets have been combined, converted to raster and reclassified 1-9 using natural breaks. Insert map shows distance to water sources in Somalia (SWALIM), Kenya (ILRI) and Uganda (We Consult). Water sources were combined and the Euclidean distance calculated to them.

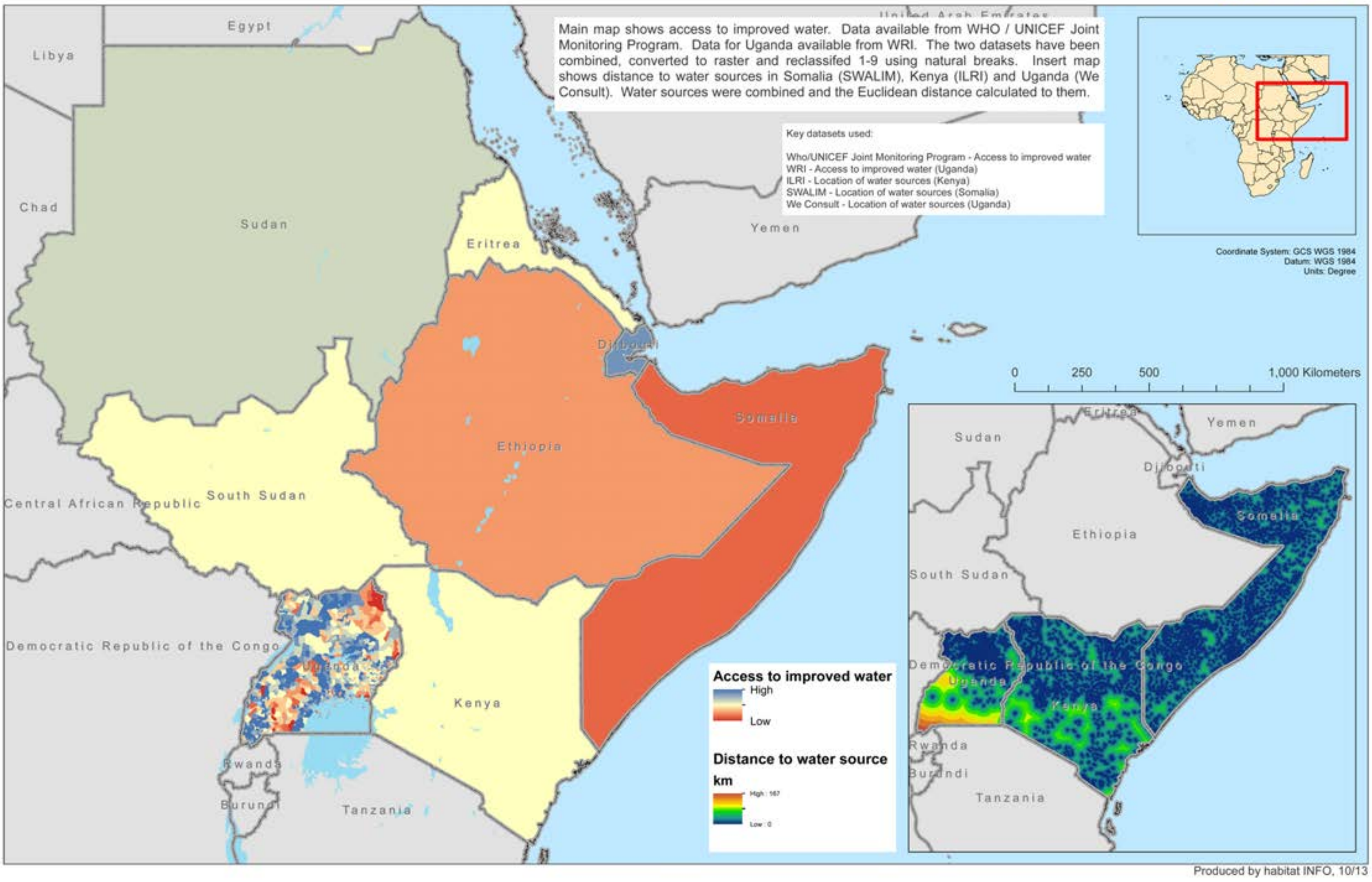
3A - UNDERSTOREY PHYTOMASS (DRY SEASON) *(see page 16 for map)*

This map shows the expected dry season phytomass of the understorey herbaceous layer. It is derived primarily from historic (1960-1990) rainfall at $1km^2$ resolution (Worldclim: Hijmans et al 2005) using the formula proposed by Schurr (2003) for ANPP and the observatiosn of Le Houerou et al (1988) for arid lands on the relationship between production and biomass. Our analysis is restricted to areas of rainfall < 1036mm per annum where these relationships are strong. This corresponds most closely to land classed as pastoral or agro-pastoral (with extension for Masai to include Tanzania). The resultant layer of above ground biomass in kg DM per ha was then modified using the percent tree cover layer in the MODIS Vegetation Continuous Fields Fields product from NASA (Townshend et al. v2001) at $0.5km^2$ resolution to remove the major portion of the tall woody vegetation element. Still, only a harvestable portion of this phytomass is relevant to livestock, but it represents a high spatial resolution start point for representation of the likely building blocks available for forage production. Values were validated against known values for biomass across the arid region.

3B - RAINFALL ANOMALY EXAMPLE: 2013 *(see page 17 for map)*

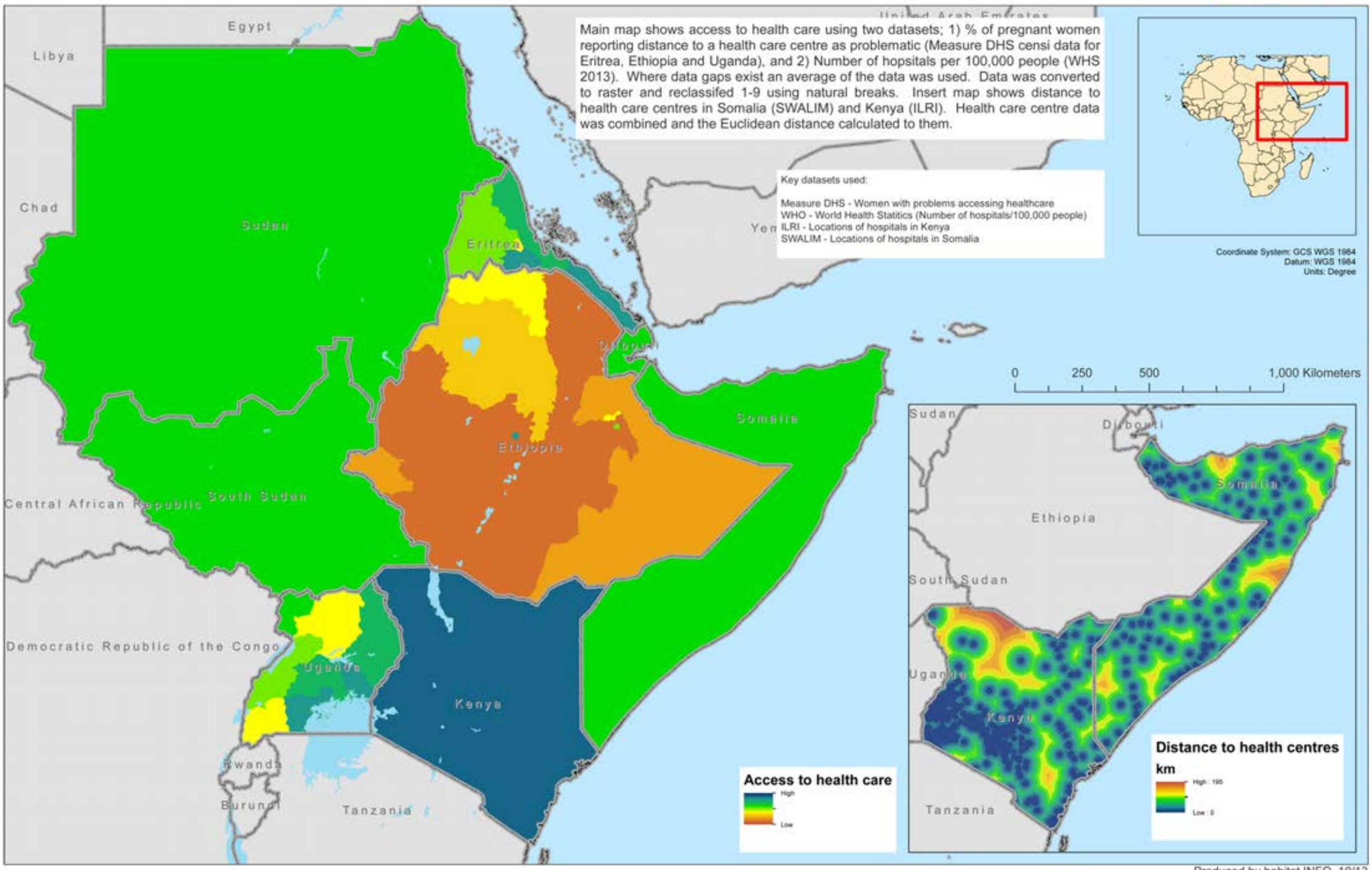
This map shows the rainfall during 2013 (up till and including August) expressed as the anomaly (difference in mm) from the long term mean annual rainfall. The dataset used is TARCAT v2 from TAMSAT University of Reading. This is drawn from a high spatial resolution ($5km^2$) and high temporal resolution (dekad) remote sensing (cloud surface temperatures) estimate of rainfall for the period 1983 - 2013. For each year in that period, the annual rainfall estimate has been used in comparison with long-term minumu, range and mean in order to compute realistic levels by which understorey phytomass may have appreciated or depreciated over cummulative time periods. The data has been used to generate estimates of fresh growth production (interest) on that plant capital to determine LSU carrying capacity for any given year.

MAP 5 Access to water



Produced by habitat INFO, 10/13

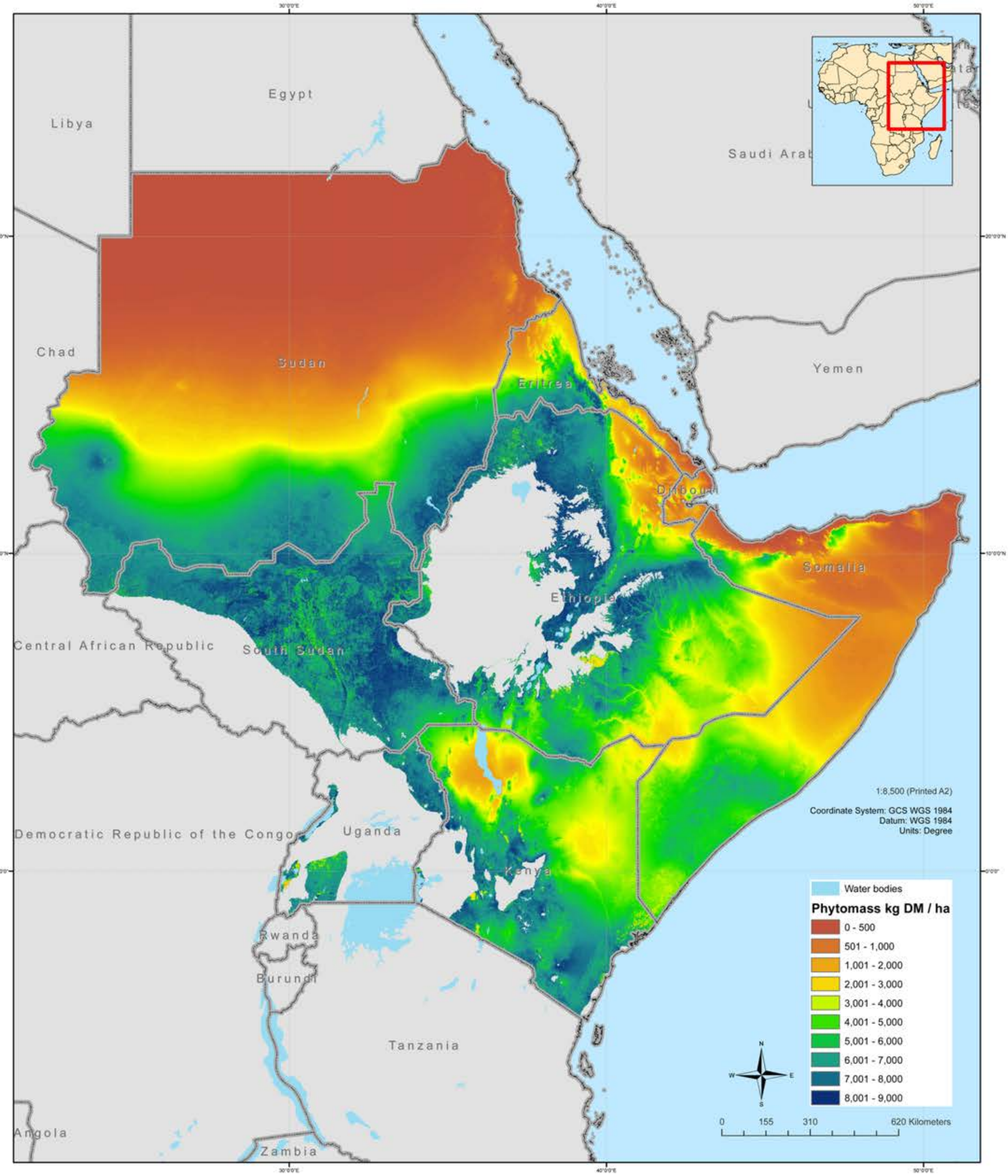
MAP 11b Access to health care



Produced by habitat INFO, 10/13

MAP
3a

Understorey Phytomass (Dry Season)



Key datasets used:

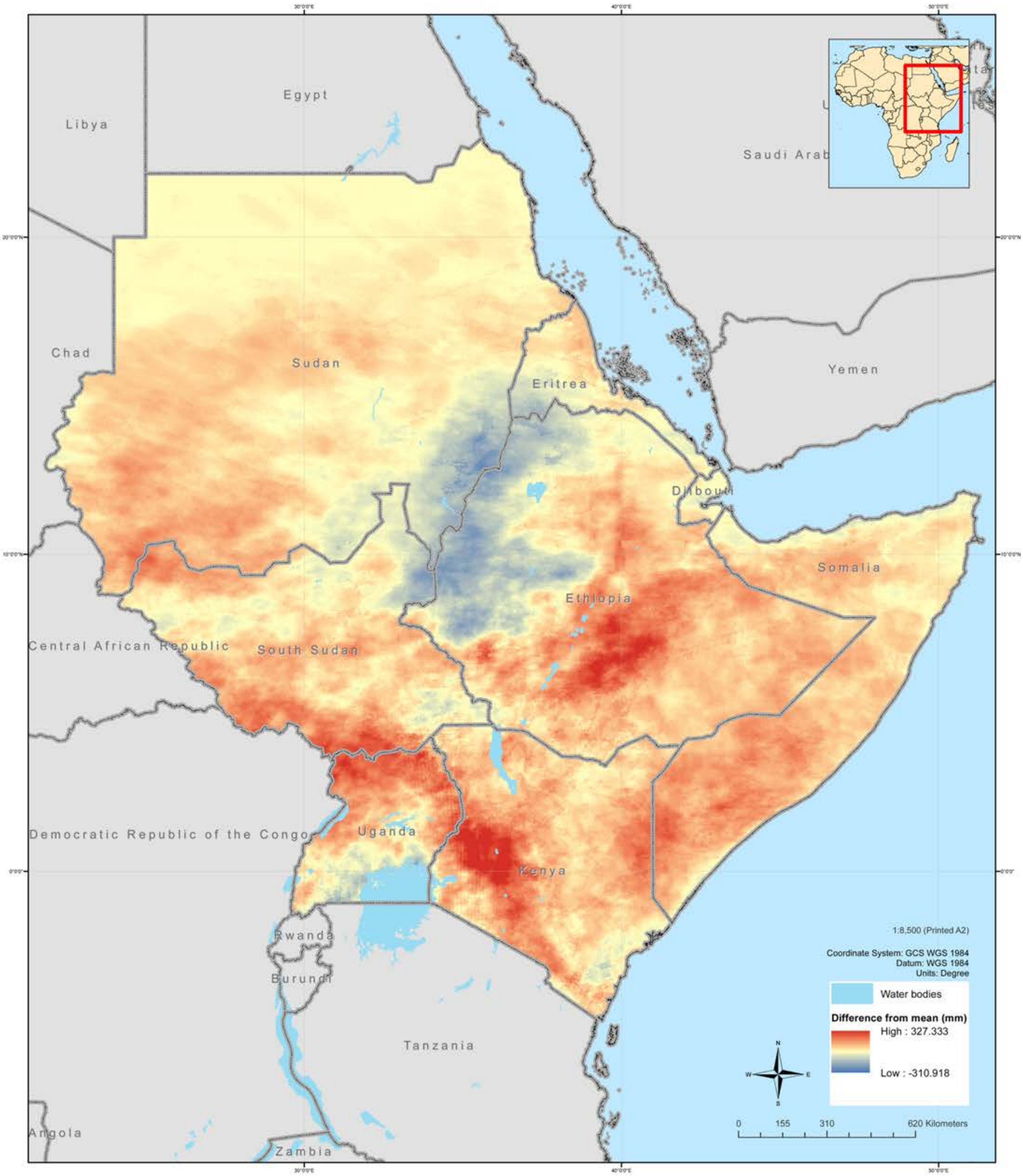
TAMSAT, Reading University - TARCAT Rainfall estimate
MODIS - Continuous Fields Dataset (Treecover)
WorldClim - Bioclim 12

This map shows the expected dry season phytomass of the understorey herbaceous layer. It is derived primarily from historic (1960-1990) rainfall at 1 km^2 resolution (WorldClim: Hijmans et al 2005) using the formula proposed by Schurr (2003) for ANPP and the observations of Le Houerou et al (1988) for arid lands on the relationship between production and biomass. The analysis is restricted to areas of rainfall less than 1036mm per annum where these relationships are strong. This corresponds most closely to land classed as pastoral or agro-pastoral (with extension for Masai to include Tanzania). The resultant layer of above ground biomass in kg DM per ha was then modified using the percent tree cover layer in the MODIS Vegetation Continuous Fields product from NASA (Townshend et al. v2001) at 0.5 km^2 resolution to remove the major portion of the tall woody vegetation element. Only a harvestable portion of this phytomass is relevant to livestock, but it represents a high spatial resolution start point for representation of the likely building blocks available for forage production. Values were validated against known values for biomass across the arid region (see methods).

map produced by habitat INFO, UK, 10/13

MAP 3b

Rainfall anomaly example: 2013



Key datasets used:

TAMSAT, Reading University - TARCAT Rainfall estimate

This map shows the rainfall during 2013 (up till and including August) expressed as the anomaly (difference in mm) from the long term mean annual rainfall. The dataset used is TARCAT v2 from TAMSAT University of Reading. This is drawn from a high spatial resolution (5 km^2) and high temporal resolution (dekad) remote sensing (cloud surface temperatures) estimate of rainfall for the period 1983 - 2013. For each year in that period the annual rainfall estimate was used in comparison with long-term minimum, range and mean in order to compute realistic levels by which understorey phytomass may have appreciated or depreciated over cumulative time periods; the data was also used to generate estimates of fresh growth production (interest) on that plant capital to determine LSU carrying capacity for any given year.

Produced by habitat INFO, UK, 10/13

3C - DYNAMIC CARRYING CAPACITY 2013 *(see map on page 19)*

Dynamic carrying capacity (LSU/km^2) was calculated for the year 2013 by referencing our estimate of understorey phytomass (winter capital) at the end of 2012. From reference to other research, it was assumed that only a relevant portion of this capital could be used by the livestock. Fresh growth (interest) on the capital was estimated using a formula from Le Houerou *et al*[2] and growth rate was modified in a standard year by a multiplier which was derived from the rainfall anomaly in each grid cell. Carrying capacity was determined from this fresh growth plus an edible component of the end of season capital using the assumption that one tropical LSU consumes 2500 kg DM p.a. Outputs were validated in an average year by comparison with field research results for known locations and given rainfall regimes.

[2] Le Houérou, H.N., R.L. Bingham, and W. Skerbek. 1988. Relationship between the variability of primary production and the variability of annual precipitation in world arid lands. Journal of Arid Environments 7:1-35.

3D - RANGELAND CONDITION 2013: LIVESTOCK FOOD BALANCE/IMBALANCE *(see map on page 20)*

The appraisal of rangeland condition for the arid (<1036mm rain) regions of the Horn of Africa in 2013 is made by comparing the dynamic estimate of carrying capacity (LSU/km^2) at 0.5km resolution for that year (see map 3c) with the FAO & ERGO Gridded Livestock of the World data at 5km^2 resolution (2000/2005). GLW density data was taken for camels, cattle, sheep and goats and combined these into a single raster of livestock (tropical LSU). Livestock densities will of course have changed since the GLW data were collated but it represents the best spatial data currently available.

6A - ACCESS TO MARKETS *(see map on page 21)*

This map shows the travel-time to markets, defined as settlements of 20k people and above. The data are supplied by Harvestchoice and IFPRI.

6B - ECONOMIC ACTIVITY (LOG GDP IN M$/KM^2) *(see map on page 19)*

This map shows a logarithm of economic activity in m$ GDP per km^2 for the Horn of Africa. The data are derived from Ghosh *et al*[3] who carried out regression analyses of the lights at night dataset from NOAA and the Landscan human population density map with measures of GDP reported at the national or subnational level. Agricultural GDP is assumed to vary with population density while commercial and industrial GDP is assumed to vary with nightlights. Once relationships were established, these regressions were then used to disaggregate the totals down to the 1km^2 resolution of the lights at night datasets. Economic activity varies so profoundly from urban to rural areas that the only way to reveal the rural pattern was to use a logarithm value. The data correspond to the year 2006.

[3] Ghosh, T. et al. 2010. Shedding Light on the Global Distribution of Economic Activity. Open Geography Journal, Volume 3, pp. 147-160.

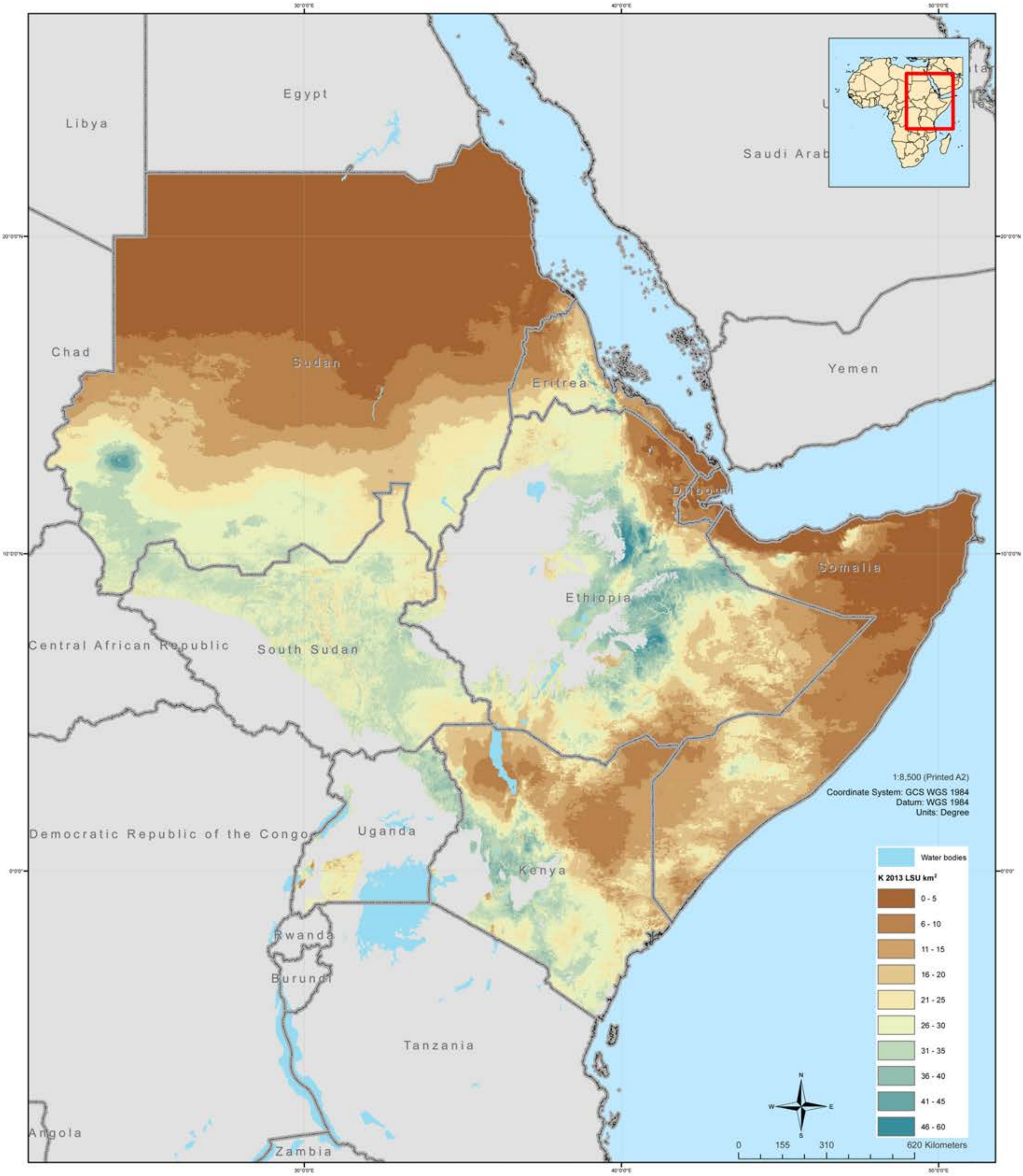
Additional maps *(see pages 23-28)*

The following additional maps were also produced:

- Malaria endemnicity (Map 7a)
- Cholera cases (Map 7b)
- Disease: HIV (Map 7c)
- Livestock mobility zones (Map 8)
- Livestock production: total cattle volume of production ($/km^2) (Map 9a)
- Livestock production: small ruminant volume of production ($/km^2) (Map 9b)
- Disasters: number of events (Map 10a)
- Disasters: numbers affected (Map 10b)

MAP 3c

Dynamic Carrying Capacity 2013



Key datasets used:

TAMSAT, Reading University - TARCAT Rainfall estimate
MODIS - Continuous Fields Dataset (Treecover)
WorldClim - Bioclim 12

Dynamic carrying capacity (LSU / km^2) was calculated for the year 2013 by referencing estimates of understorey phytomass (winter capital) at the end of 2012. As indicated by rangeland research (see methods), only a relevant portion of this capital could be used by the livestock. Fresh growth (interest) on the capital was estimated using a formula from Le Houerou et al (1988) and growth rate was modified in a standard year by a multiplier which was derived from the rainfall anomaly in each grid cell. Carrying capacity was determined from this fresh growth plus an edible component of the end of season capital using the assumption that one tropical LSU consumes 2500 kg DM p.a. The outputs were validated in an average year by comparison with field research results for known locations and given rainfall regimes. Areas with no data within the project area were not calculated for due to there being more than 1036 mm of rainfall per annum.

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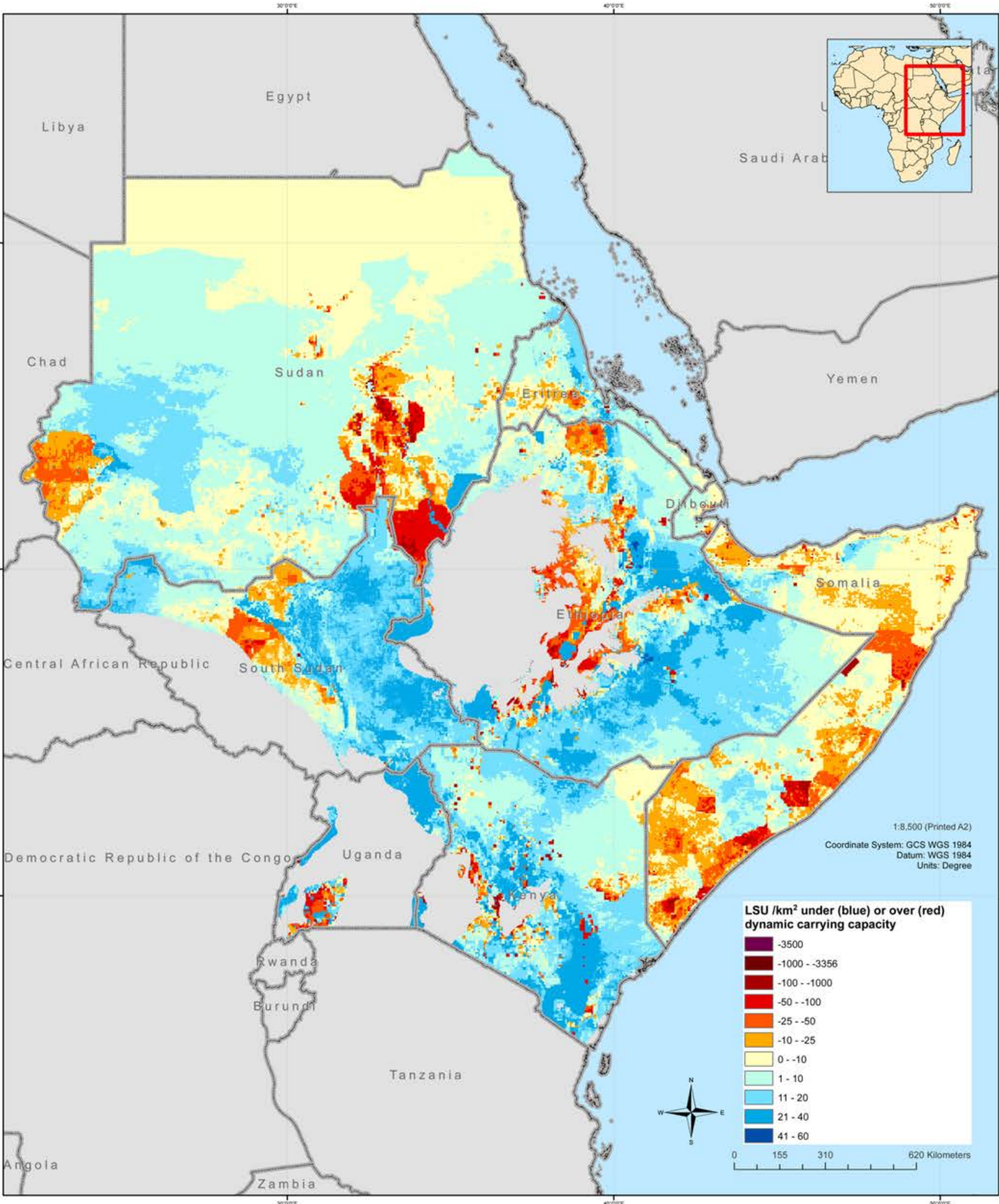
MAP 3d

Rangeland condition 2013: livestock food balance / imbalance



Key datasets used:

FAO - Gridded Livestock of the World
TAMSAT, Reading University - TARCAT Rainfall estimate

Rangeland condition for the arid (less than 1036 mm rain) regions of the Horn of Africa in 2013 is here assessed by comparing an estimate of dynamic carrying capacity (LSU/km^2) at 0.5 km resolution for that year (see map 3c) with the FAO and ERGO Gridded Livestock of the World data at 5 km^2 resolution (2000 / 2005). GLW density data for camels, cattle, sheep and goats was used and combined into a single raster of livestock (tropical LSU). Livestock densities will of course have changed since the GLW data were collated but it represents the best spatial data currently available.

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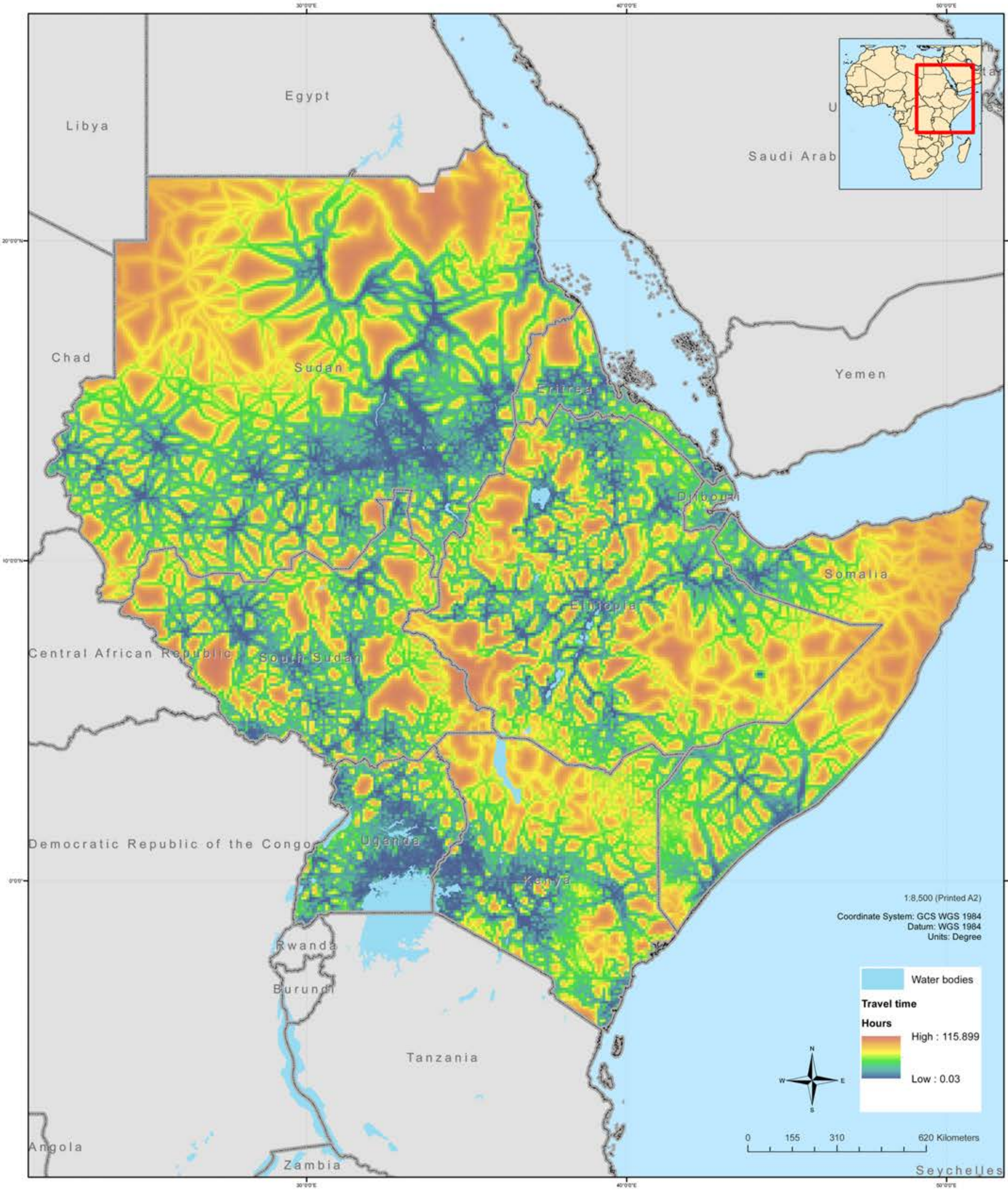
MAP 6a

Access to markets



Key datasets used:

HarvestChoice - Traveltime to cities with population over 20,000

This map shows the travel time in hours to markets defined as settlements of 20,000 people and above. The data are supplied by HarvestChoice and IFPRI. Please see http://harvestchoice.org/data/average-travel-time-nearest-town-over-20k-hours-2000 for further information.

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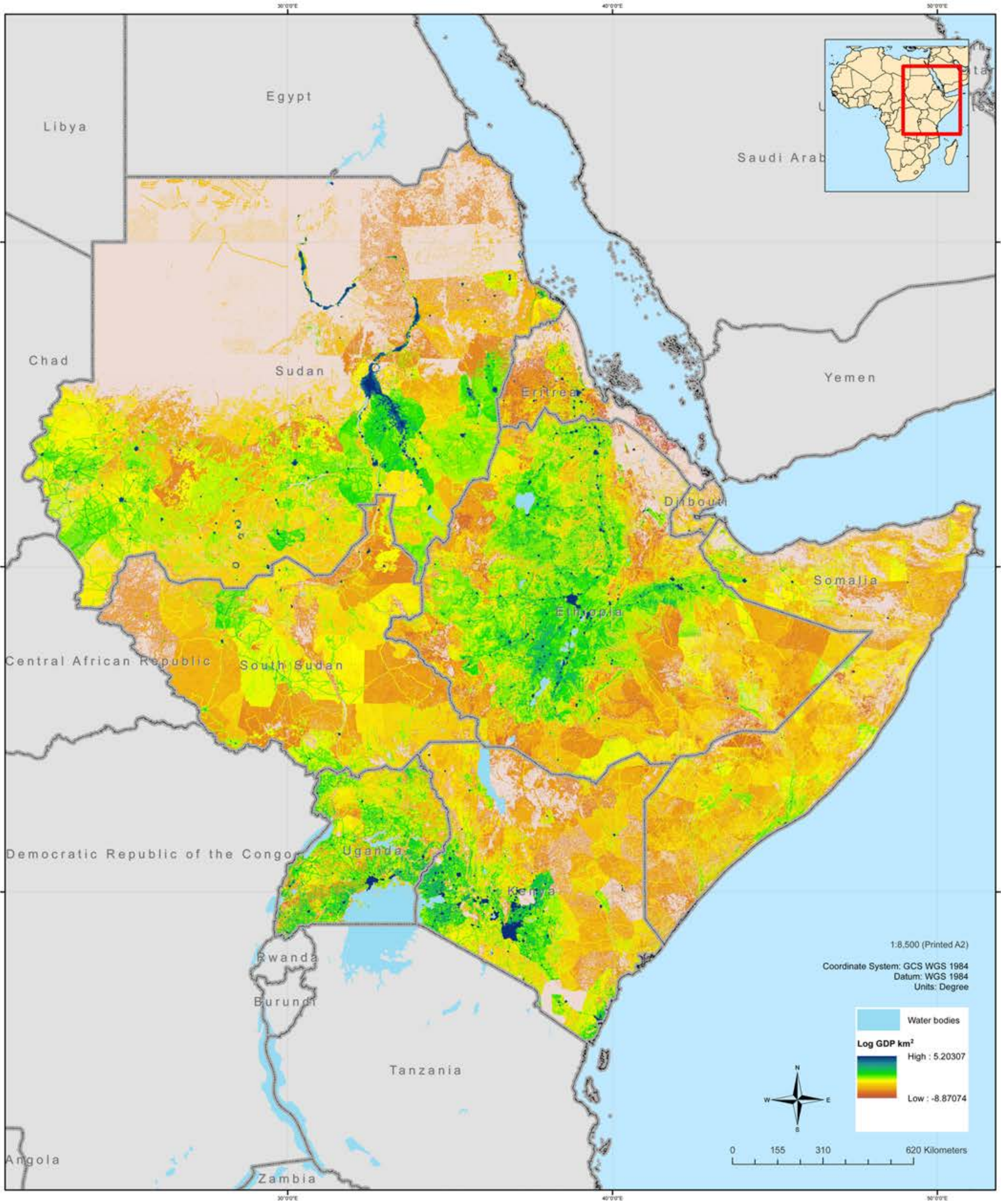
MAP 6b

Economic Activity (log GDP in m$/km^2)



Key datasets used:

NOAA - Economic activity from Lights at Night

This map shows a logarithm of economic activity in million $ GDP per km^2 for the Horn of Africa. The data are derived from Ghosh et al (2010) who carried out regression analyses of the lights at night dataset from NOAA and the Landscan human population density map with measures of GDP reported at the national or subnational level. Agricultural GDP is assumed to vary with population density while commercial and industrial GDP is assumed to vary with nightlights. Once relationships were established, these regressions were then used to disaggregate the totals down to the 1 km^2 resolution of the lights at night datasets. Economic activity varies so profoundly from urban to rural areas that the only way to reveal the rural pattern was to use a logarithm value. The data correspond to the year 2006.

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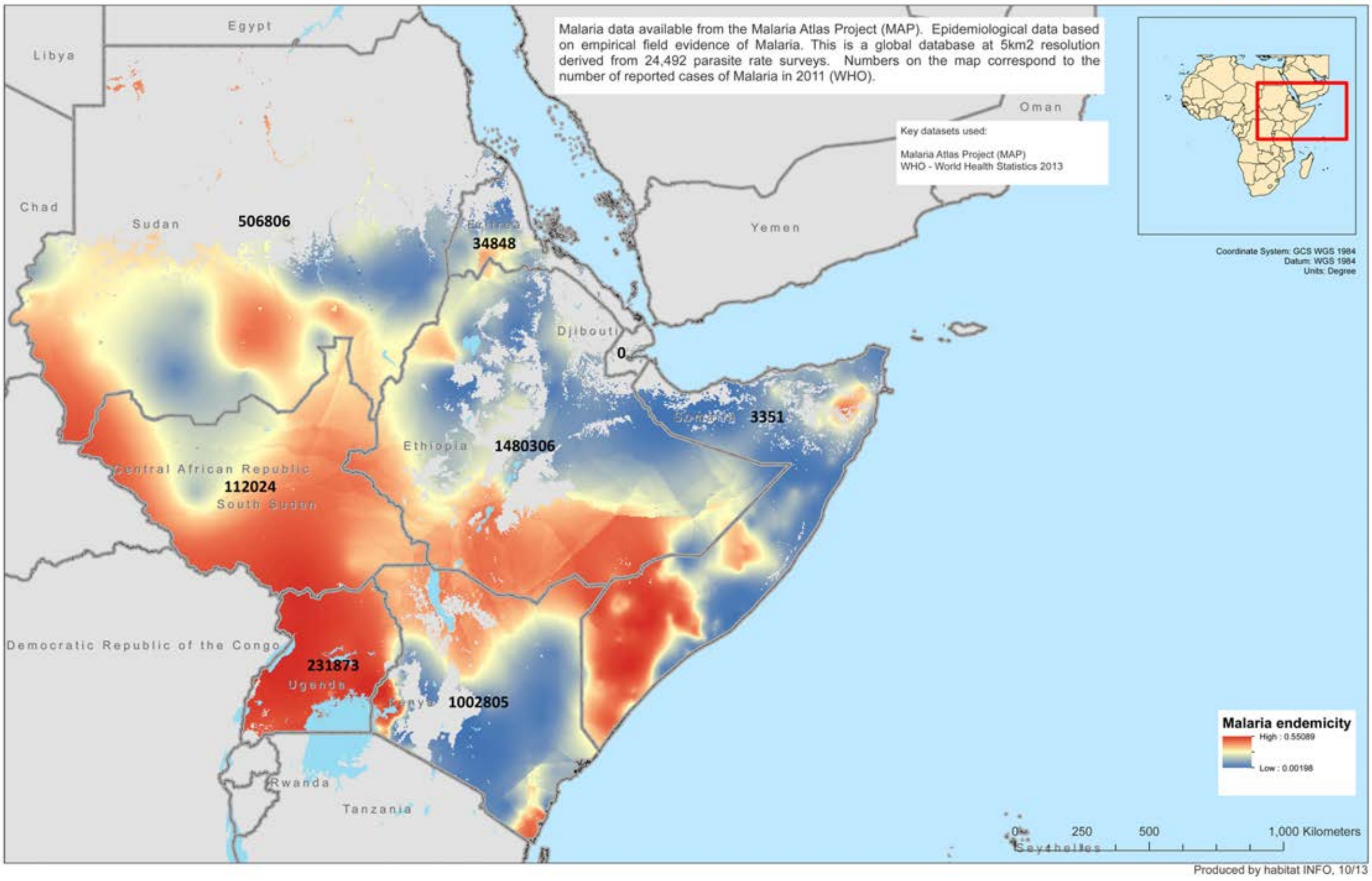
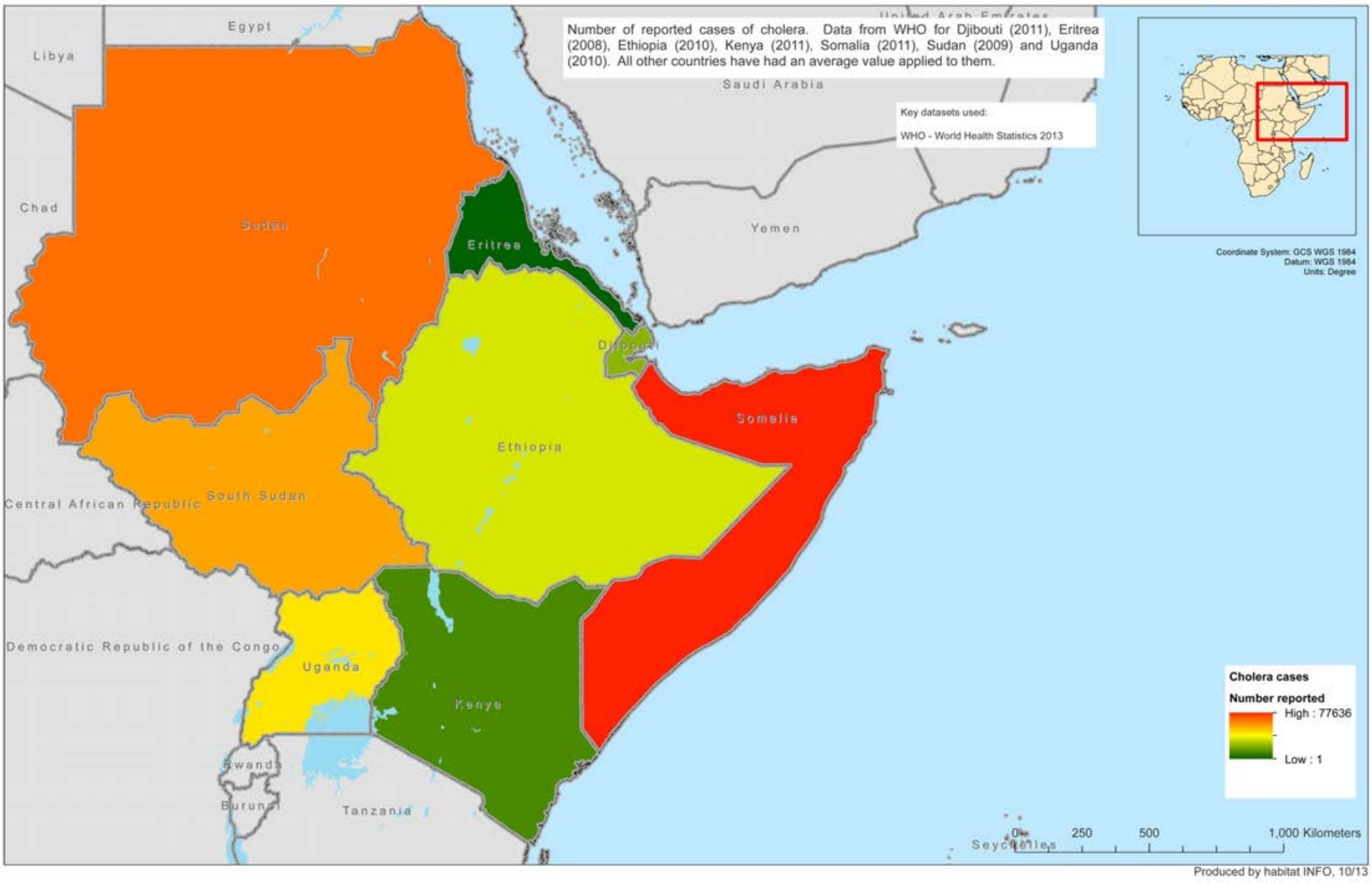
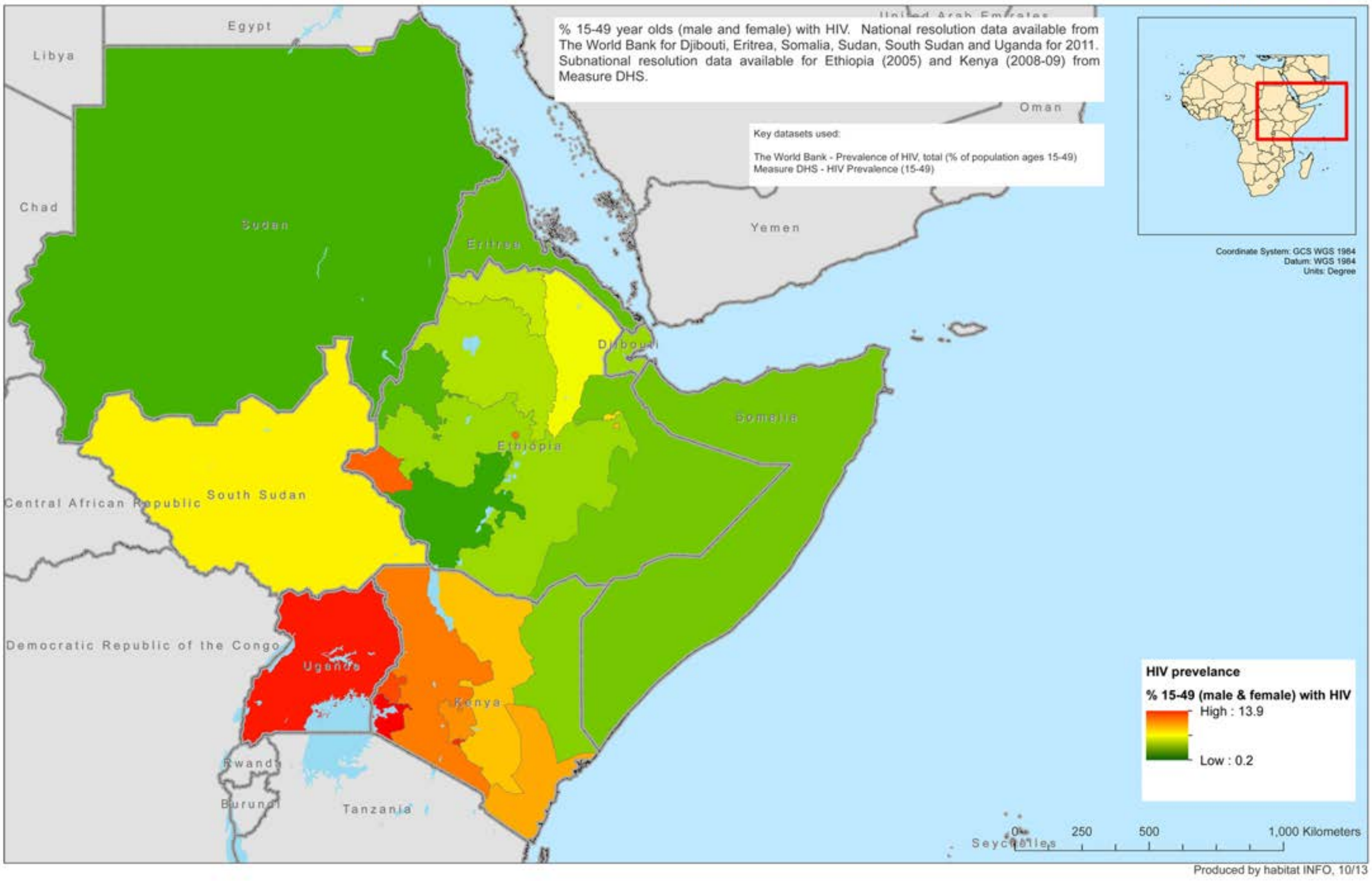
MAP 7a Malaria endemnicity



MAP 7b Cholera cases

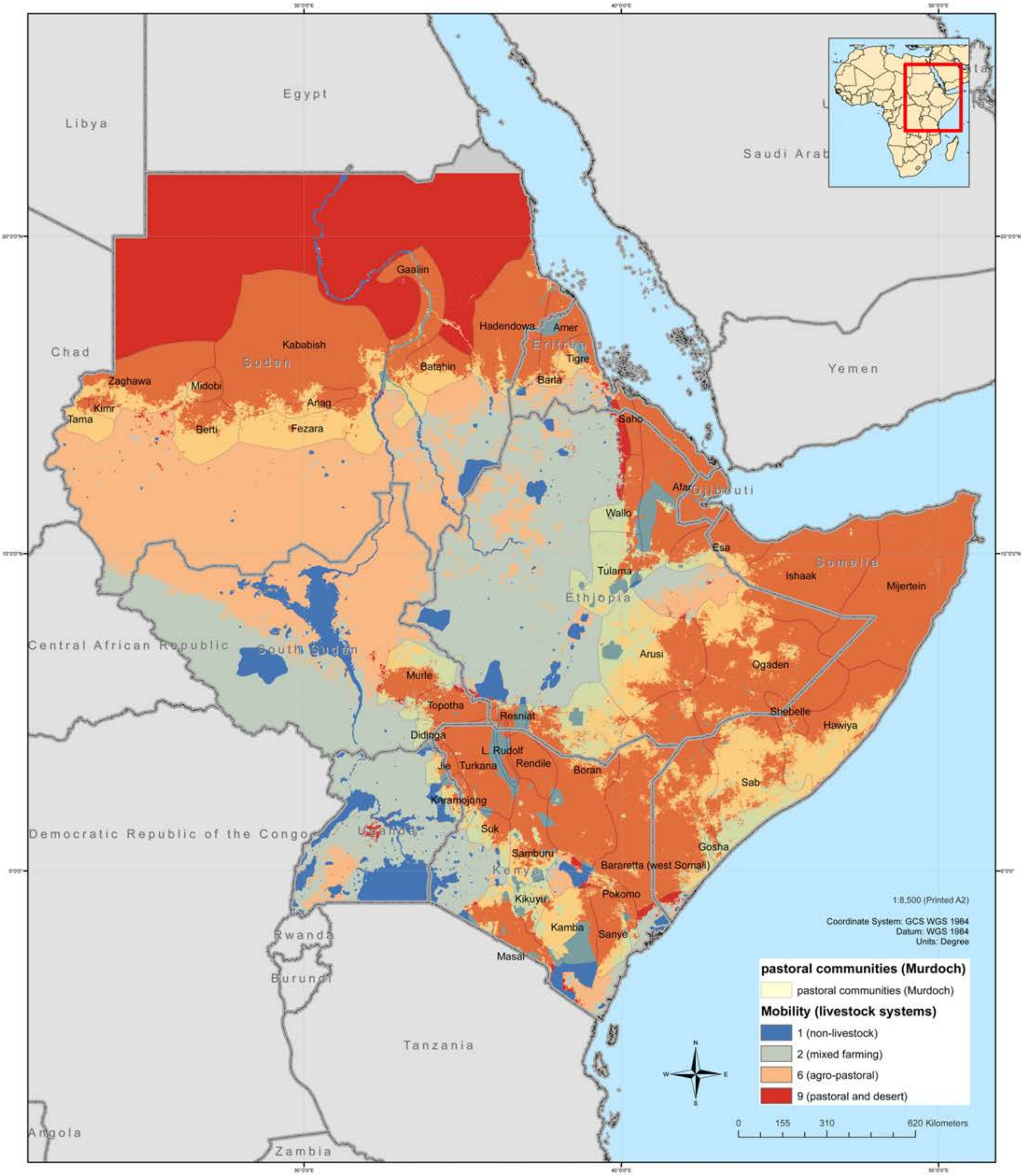


MAP 7c Disease: HIV



MAP 8

Livestock Mobility Zones



Key datasets used:

FAO: Livestock systems HoA
Africa: Its Peoples and their Culture History. George

Most livestock mobility records exist only as crude direction arrows across the whole of the pastoral region. The livestock systems database was used instead for this mapbecause it contains information relating to freedom of animal movement (see legend). Over this the extents and names of those communities which correspond most closely to the pastoral land use system have been superimposed. These are derived from Murdock (1959). It is assumed that these communities have a culture for movement within their ranges because their geography coincides with the pastoral land use system. Further data is sought for specific movement routes.

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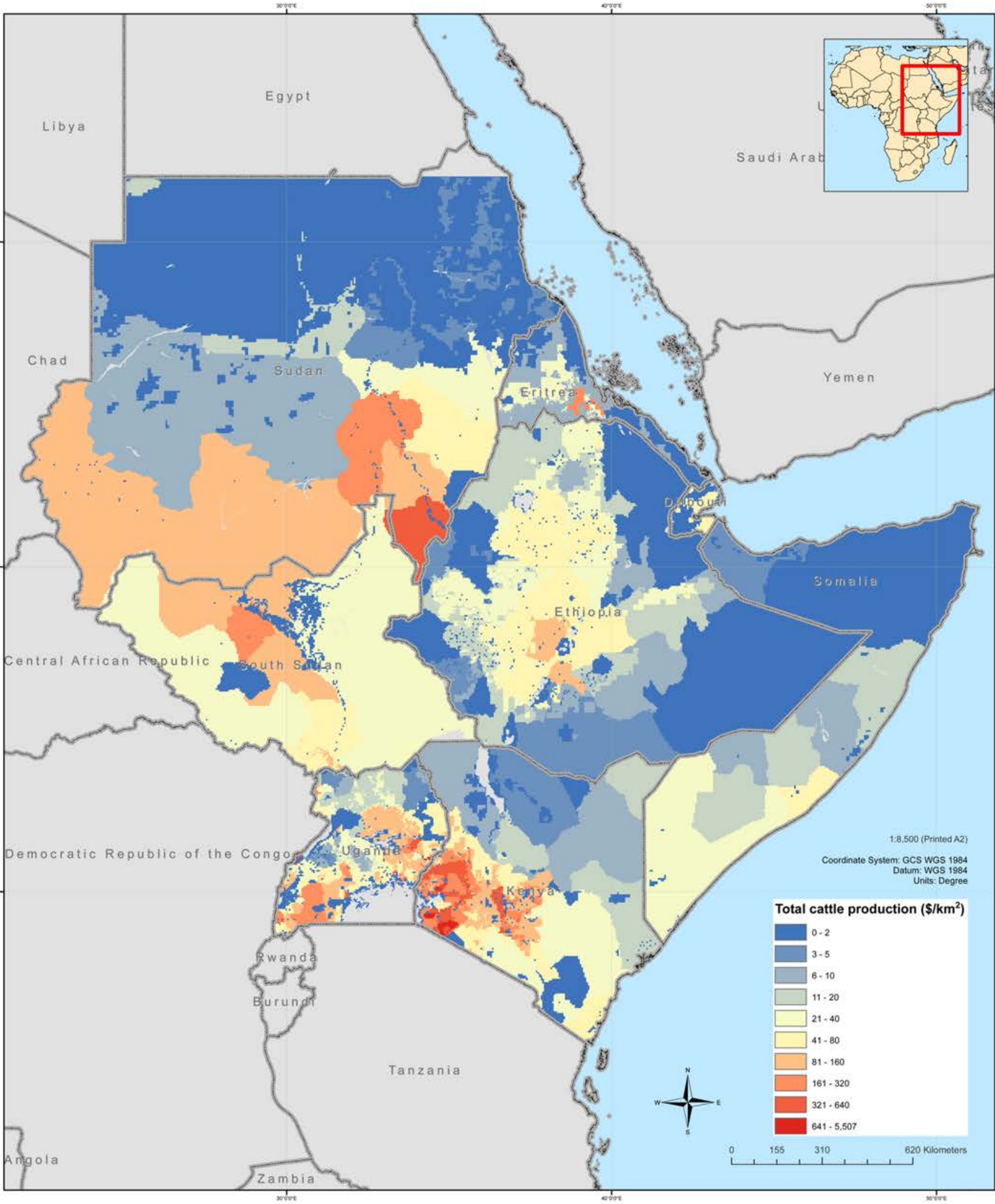
MAP
9a

Livestock Production:

total cattle volume of production ($/km^2)



Key datasets used:

ILRI total cattle volume of production
For livestock knowledge generation project funded by Bill & Melinda Gates Foundation (BMGF).

Total value of production from cattle meat and milk in US dollars per square kilometer. From ILRI: An estimated value of production per species was derived from publicly available data in a two-step process. In a first step a geographical information system (GIS) was used to calculate the numbers of animals per country and production system. In a second step, these numbers were multiplied with productivity figures and prices to come up with a value of production of the animals present. This is a broad brush analysis, based on country-level production estimates and prices. The results should therefore be used with the necessary caution. Full methods in metadata.

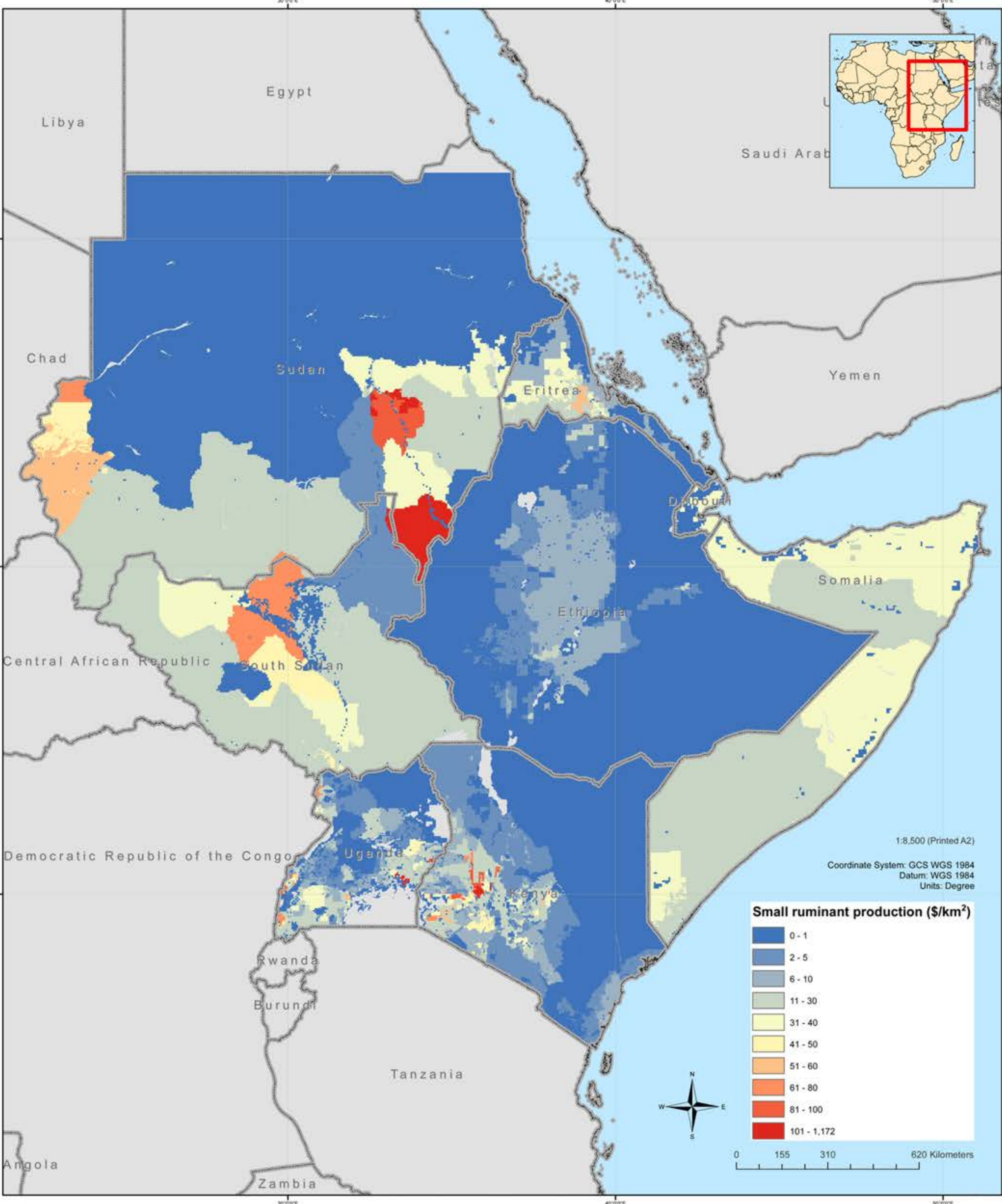
ILRI INTERNATIONAL LIVESTOCK RESEARCH INSTITUTE CGIAR habitat INFO

Produced by habitat INFO, 10/13

MAP 9b

Livestock Production:

small ruminant volume of production ($\$/km^2$)



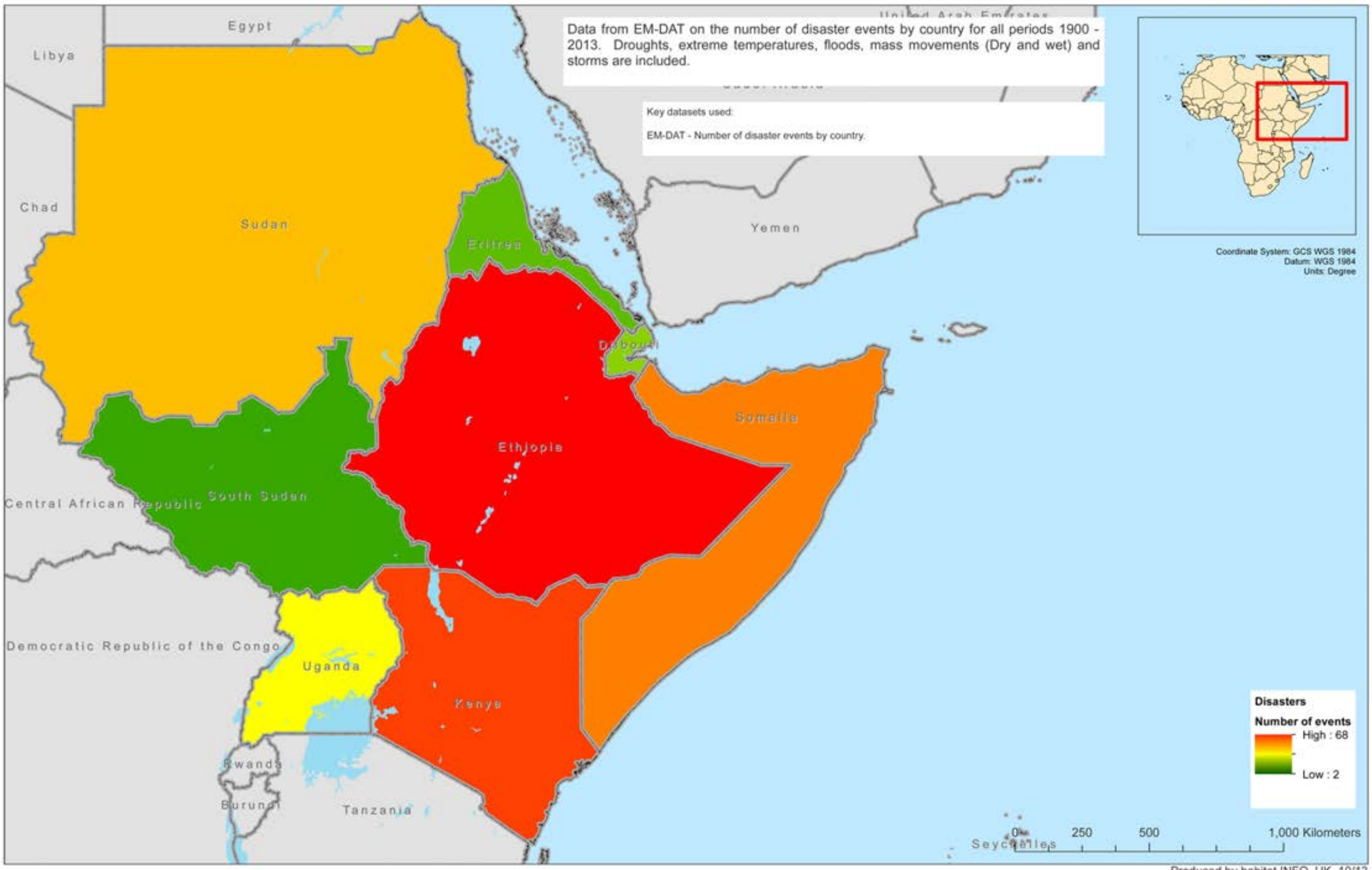
Key datasets used:

ILRI small ruminant volume of production
For livestock knowledge generation project funded by Bill & Melinda Gates Foundation (BMGF).

Value of production from small ruminants in US dollars per square kilometre. From ILRI: An estimated value of production per species was derived from publicly available data in a two-step process. In a first step a geographical information system (GIS) was used to calculate the numbers of animals per country and production system. In a second step, these numbers were multiplied with productivity figures and prices to come up with a value of production of the animals present. This is a broad brush analysis, based on country-level production estimates and prices. The results should therefore be used with the necessary caution. See metadata for complete methods.

Produced by habitat INFO, 10/13

MAP 10a Disasters: number of events



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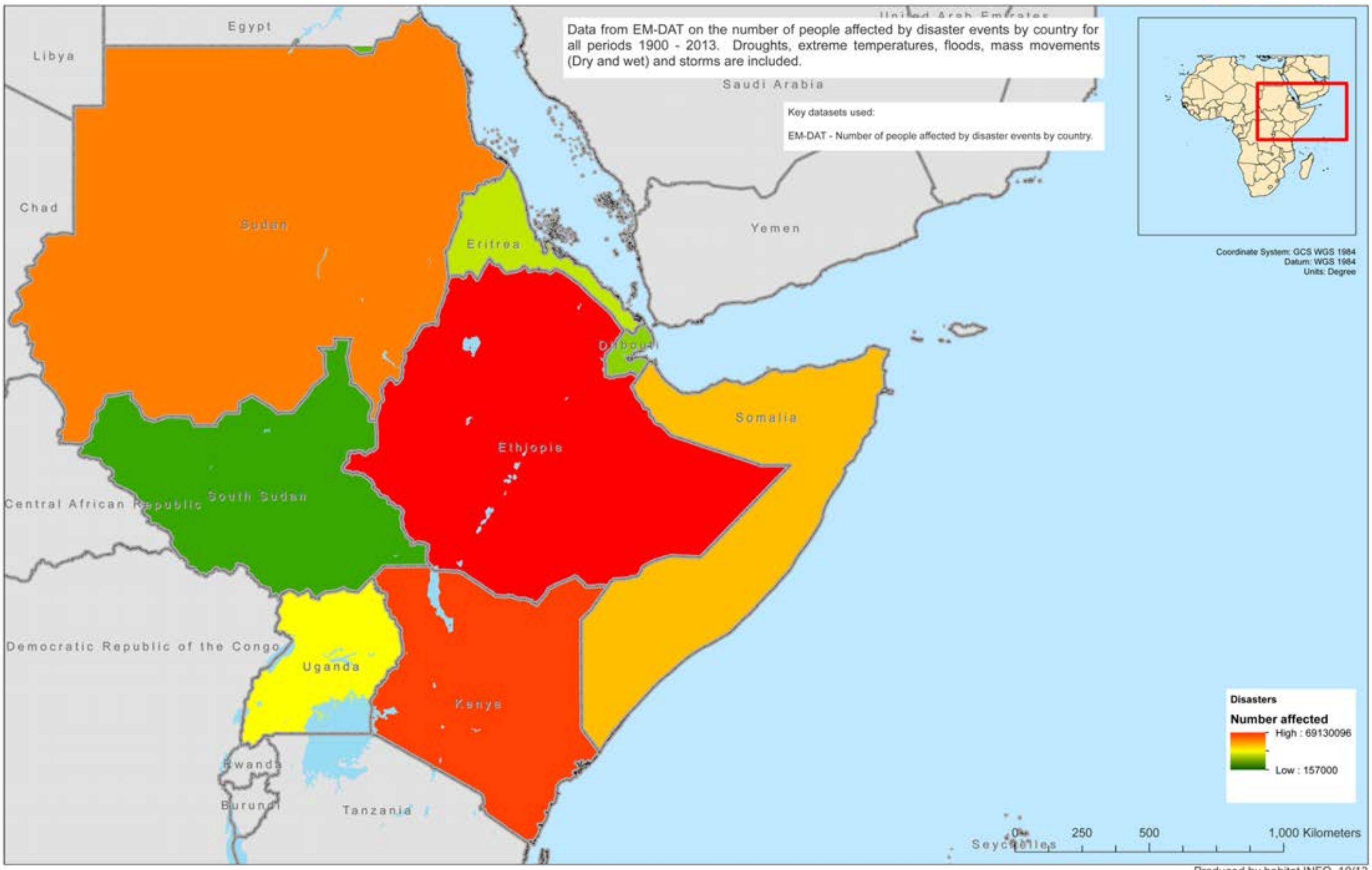
MAP 10b Disasters: numbers affected



Produced by habitat INFO, 10/13

Appendix 1:
Detailed composite indicator gap analysis

7

INDICATOR	GAPS
ECOLOGICAL COMPOSITE INDICATORS	
Water resources	The spatial data on water are adequate for drawing large scale regional comparisons at province scale but do not yet permit fine-scale comparisons. The dam data sourced from DCW are likely incomplete / out of date and could be improved. This composite could most be improved by the inclusion of high resolution point data on borehole distribution which might then be used in the rangeland condition model. In this layer combination, distance to freshwater along the Nile is being over-ridden by the influence of groundwater in the desert. The inclusion of water-bodies and irrigation systems / canals to compensate for this in future versions is recommended and possibly allow these layers to trump the ground-water layers.
Land use	The spatial data on land use are very good for drawing broad- and fine-scale comparisons at grid-square resolution (1km^2). Strong data sets within this composite are considered to be the habitat transformation layer, which is based on Globcover at 300m and is a very useful representation of the loss of natural habitat; and the likely livestock overheads based on recent rainfall history. The livestock mobility layer can be improved by digitising more data on livestock movement patterns. But the major improvement to this composite would be soil degradation at fine geographic scale. The current soil degradation layer is a very crude representation precluding higher weighting. Better soil quality layers are included in ecosystem services. Soil condition is considered to be one of the best indicators of ecological resilience.
Ecosystem services	The spatial data on ecosystem services are very good for drawing broad- and fine-scale comparisons at grid-square resolution (1km^2). Strong data sets within this composite are considered to be the levels of protection layer which is based on $ spend per km^2 in protected areas, population density and inaccessibility; the soil qualities layer (combining nutrients, moisture and depth) is considered very important but is let down by coarse resolution. Vertebrate taxa richness is an inadequate indicator for food web complexity. The wetlands and forest data are useful but other habitats e.g. natural pasture should be considered for inclusion in future versions. The ranking of types of wetlands from the GLWD database (WWF) is simplistic. Ideally this layer should include flow rates and measures for efficiency of water retention and filtration. Consideration of the InVest toolset is recommended to calculate monetary value of ecosystem services (replacement cost if they are lost) for highlighting their importance. Improving the resolution of soil quality data would represent a major improvement to this layer. There is an urgent need for an indicator to represent food web complexity, and perhaps this can be a natural indicator of ecosystem health e.g. monitoring of certain species. The recently launched African Raptor Databank, a pan-African citizen science project, may provide future indication of ecosystem health. An abundance and diversity of raptors invariably signals a largely undisturbed ecosystem supporting an abundance of other wildlife (Ian Newton in litt.). But arid areas such as the Horn of Africa may require other carefully chosen indicator species.

Population and *per capita* resources	The spatial data on population and per capita resources are very good for drawing broad- and fine-scale comparisons at grid-square resolution (1km^2). Strong data sets within this composite are considered to be rainfall per person and people living in water stress (although the latter is patchy); other data such as AfriPOP and agglomeration are at high resolution but they indicate high density or likely high growth zones rather than people who are actually limited by resources. Human appropriation of NPP (Net Primary Productivity) is used as a proxy for people in relation to food resources. But these data are very crude and make unrealistic assumptions. The major improvement possible for this critical composite layer is a detailed analysis of food consumption, food supply and food distribution. A fuller understanding of the geographic process of agglomeration (movement into cities) would be very relevant to the relationship of people to natural resources in the Horn of Africa.
Climate data	The spatial data on climate are good for drawing broad- and fine-scale comparisons at grid-square resolution (1km^2). This layer readily indicates the most amenable climates for the Horn of Africa that are evidently the most populated (previous composite). Futures analysis, involving the expected changes in extreme conditions and shrinking of the growing period would be a valuable inclusion to the next version. Future versions could include spatial data on energy use efficiency but this is considered to be a minor contribution to global climate resilience rather than a significant local factor. Efficient use of energy infrastructure can be included in material assets (economic sector).

SOCIAL COMPOSITE INDICATORS

Health	The spatial data on health are good for drawing broad-scale comparisons at provincial resolution and for some countries at a higher resolution. This layer readily indicates areas that are good or bad for human health in the Horn of Africa. Access to health care is based on distance to health centres for Somalia and Kenya, on problems accessing healthcare to province level for Uganda, Ethiopia and Eritrea, and on hospitals per 100k population at national levels except for Sudan and South Sudan. Any indicators of health care for the latter are an obvious gap and ideally we would want distribution data on health centres for all countries. Access to improved water is considered of vital importance to human health, yet only sub-national data is available for this in Uganda. Getting these data to provincial or administration district level for the remaining countries would be a very important addition to the layer. Ideally there should be maps available showing the exact distribution of access to improved water to 1km^2 resolution.
Education	The spatial data on education are adequate for drawing broad-scale comparisons at provincial level. This layer indicates the broad areas that are good or bad for education across the Horn of Africa. Literacy level was available for all countries but only at national scale – this could be improved to sub-national if the data are found. The proportions of male and female lacking education was available sub-national for Kenya, Uganda, Ethiopia, Eritrea and North Sudan (females only). Comparable data are needed for Somalia, Djibouti and South Sudan. Evidently this layer could be markedly improved to a finer geographic level, preferably by administration district. In the absence of census data for certain countries e.g. South Sudan, the best way of improving geographic resolution on education would be digitising schools as per Somalia. This ought to be combined with some measure of the quality of education.
Governance	The spatial data on governance are good for drawing broad-scale comparisons at provincial level for most countries. This layer indicates best and worst governance regions across the Horn of Africa. This composite attempts to represent the inclusivity of different elements of society. Where there is census data this representation is good for gender issues and income brackets. Countries lacking census information are Djibouti, Somalia and South Sudan (North Sudan is available from 1989). The treatment of transboundary communities involves the assumption that communities split across borders will not be best represented in national government and is simplistic. Ideally all society groups should have a measure of representation in each parliament. Social shock data (conflicts, disorder, displacement migration) are to be handled separately to assess likelihood of social shocks.

ECONOMIC COMPOSITE INDICATORS

Infrastructure	The spatial data on climate are very good for drawing broad- and fine-scale comparisons at grid-square resolution (1km^2). This layer readily indicates locations where people can benefit from high investments in infrastructure and contrast these with areas where there is little supporting infrastructure. The layer could be improved when doing an analysis of food distribution by incorporating infrastructure for food or crop storage (silos); and by incorporating more detailed resolution for the irrigation layers. Distribution centres for other agricultural inputs (fertiliser) could be included as agricultural infrastructure. Measures for the efficient use of the energy infrastructure could be included if data are made available.
Trade access	The spatial data on trade access are informative for drawing broad-scale comparisons across countries and, for livestock trade, ascertaining differences at district scale. This layer readily indicates locations of high trade. This layer is biased to measures of livestock trade rather than other agricultural trade and would benefit from incorporation of the latter. But livestock trade is considered to be most relevant to pastoralists inhabiting drought stricken regions. The layer could be improved by digitising / incorporating strong trade routes and livestock migration routes (currently handled in environmental: land use). Ease of doing business data are not yet available for Somalia and South Sudan. Information on tax regulations was too scant to be incorporated into a meaningful data layer. Projections on the expected loss of cropland with climate change could be used to inform how this pattern may be expected to change in the future.
Financial servces	The spatial data on financial services are coarse and, aside from one known data source for Kenya, only available at national scale. This layer provides some comparison of which countries offer more services across the Horn of Africa but data were consistently absent for Somalia and mostly absent for Eritrea and South Sudan. Average values for missing data were computed that are not likely to be appropriate. This composite indicate layer requires major overhaul and needs incorporation of an indicator for access to insurance.
Wealth	The spatial data on wealth are excellent for drawing broad- and fine-scale comparisons at grid-square resolution (1km^2). This layer readily discerns the most wealthy areas of the Horn of Africa from poverty-stricken areas. The best indicator of poverty (malnourishment) has been allowed to have the most influence. This is already sub-national. The composite benefits from some very high resolution analyses of GDP and people living without lights. Logarithms are used to stretch the lower value scale that is relevant to rural areas. Otherwise, urban variation dominates the scale. Rural patterns of wealth / poverty are revealed by this but the assumption that agricultural GDP may be downscaled by population (Landscan) is simplistic. This layer does not discern the relative wealth of rural communities. An indication of this is obtained by including livestock per capita which is based on GLW. This appears to work well for most countries but the density of livestock in GLW appears inflated for Somalia resulting in strong boundary effects which may not be real. Validation of the livestock density layer for Somalia is recommended. The tourism, agricultural assets and diet are all national data only and exclude Somalia and South Sudan. As a result of these effects the relative wealth of Somalia may be somewhat inflated and needs validation. All of these national datasets ought to be improved to sub-national. Aid activity is largely national, excludes Djibouti, Eritrea and North Sudan, but includes some good subnational data as well (Somalia). It could be greatly improved by study of NGO and international agency investments (dashboard study). Wealth / Poverty is considered to be of critical importance to resilience and the ability of communities to bounce back from shocks. There is a lot of additional work that could be done on this layer as outlined but we would not expect it to radically alter the observed pattern.
Financial conditions	The spatial data on financial conditions are poor for drawing broad- scale comparisons only across the region with exceptions. This layer provides a crude indication of good and bad regions for financial conditions across the Horn of Africa but figures are missing for South Sudan and Somalia. The only subnational data included employment rates for women and covered Eritrea, Ethiopia, Uganda and Kenya. Excluding this, all data is national and average values were filled in for missing value. South Sudan is bereft for financial conditions data followed by Somalia. Data gaps include: For price stability Somalia and South Sudan; for wider employment rates Djibouti and South Sudan; for interest rate South Sudan, Somalia and Eritrea; for inflation rate South Sudan and Somalia.

Income/livelihood diversification	The spatial data on diversification of livelihoods are adequate for drawing broad- and fine-scale comparisons at sub-national resolution (5km^2). This layer readily discerns locations where different species / breeds of livestock are mixed and where many types of crop can be grown from locations which are limited in both. However, livestock data are empirical (GLW) whereas crop data are model predictions of likely yield. The assumptions of diversity behind both require examining. The livelihood diversity indicator layer is very crude national data, based on percent population employed outside agriculture (services and industry) and is lacking for Sudan, South Sudan, Eritrea, Djibouti and Somalia. Alternate forms of earning a living off the land or from society must be a vital form of resilience during and after a shock. So this composite is clearly important and warrants improvement based on empirical subnational data.

The International Livestock Research Institute (ILRI) works to improve food security and reduce poverty in developing countries through research for better and more sustainable use of livestock. ILRI is a member of the CGIAR Consortium, a global research partnership of 15 centres working with many partners for a food-secure future. ILRI has two main campuses in East Africa and other hubs in East, West and Southern Africa and South, Southeast and East Asia. www.ilri.org

CGIAR is a global agricultural research partnership for a food-secure future. Its science is carried out by 15 research centres that are members of the CGIAR Consortium in collaboration with hundreds of partner organizations. www.cgiar.org

The Technical Consortium for Building Resilience in the Horn of Africa provides technical support to IGAD and member states in the Horn of Africa on evidence-based planning and regional and national investment programs, for the long-term resilience of communities living in arid and semi-arid lands. It harnesses CGIAR research and other knowledge on interventions in order to inform sustainable development in the Horn of Africa. www.technicalconsortium.org