SUMMARY REPORT

Spatial analysis for investment targeting:

PILOT TOOL UNDER DEVELOPMENT

technical consortium
Building Resilience in the Horn of Africa

habitat INFO

ILRI
INTERNATIONAL LIVESTOCK RESEARCH INSTITUTE

Spatial analysis for investment targeting:
Pilot tool under development

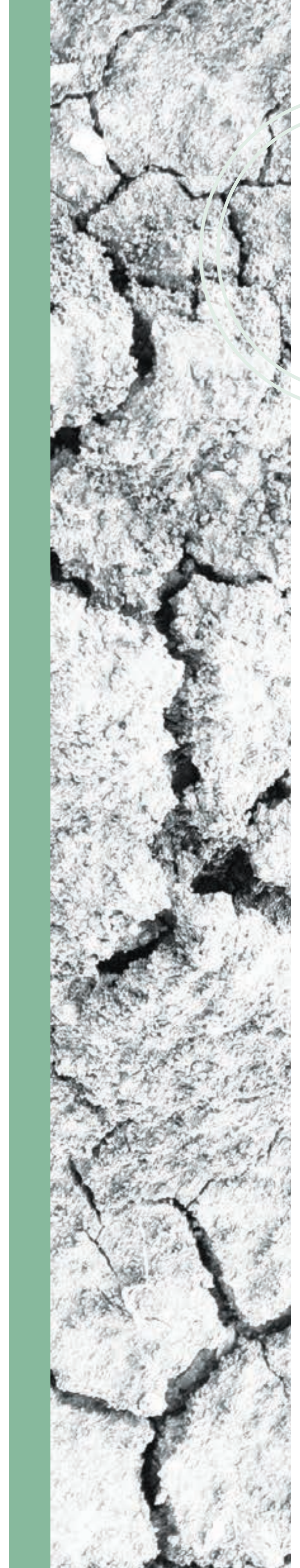
Concept developed by habitat INFO
Rob Davies, PhD and Tim Wroblewski

Report synthesised and edited by
Sabrina Chesterman and Katie Downie, PhD

Design and layout by
Jodie Watt Media

The Technical Consortium for Building Resilience
in the Horn of Africa is a project of the
Consultative Group on International Agricultural Research (CGIAR)
hosted at the International Livestock Research Institute (ILRI).

www.technicalconsortium.org



The nature of resilience

The term ‘resilience’ has gained significant traction within the agencies, governments, researchers and practitioners working across the development and humanitarian realm. Resilience is seen as a paradigm shift, away from short-term thinking and solutions to address vulnerability to hazards such as drought, toward interventions that, over a longer time, can enhance development and build capacity to deal with dynamic environmental and social challenges and enduring shocks and stresses. In response to this paradigm shift and following the humanitarian disaster caused by the 2010-2011 drought crisis in the Horn of Africa, the Summit of the Heads of State and Government convened in Nairobi in September 2011 to launch “Ending Drought Emergencies”. And, in the spirit of a new-found sense of optimism, the member states of the Intergovernmental Authority on Development (IGAD) committed to a program of work for which a significant outcome would be the enhanced resilience of populations residing in the drylands of the Horn of Africa. This initiative, after decades of the affected countries being overwhelmed by emergencies, manifested their commitment to end drought emergencies and vulnerabilities from the IGAD region once and for all.

Most definitions of resilience in development scenarios hinge upon the response of social, ecological and economic systems to shocks and stressors. It is, however, extremely difficult to quantify this response, as it is impossible to observe the full range of possible disturbances, hence assessments of system resilience normally fall short of providing comprehensive evaluations. In addition, as building resilience is rarely a linear, cumulative process that increases as each system component improves, the current linear and causal socio-ecological models used to measure resilience are inadequate to understand these micro, meso and macro interactions. For example, an overall loss of resilience may be caused by an increase in one variable producing a drastic reduction in another. Furthermore, resilience can be viewed over varying spatial scales such as individuals, households and communities, and over varying temporal scales such as seasons, annually or across a program lifespan, from immediate to long-term. This variance may make it necessary to continually update panel datasets.

The Resilience Measurement Technical Working Group[1] defines resilience as follows:

> *“Resilience is the capacity that ensures adverse stressors and shocks do not have long-lasting adverse development consequences.”*

One of the key features of this definition is that resilience is understood and measured according to the instrumental effects it exerts on targeted development outcomes that may be affected by stressors and shocks. Defining resilience as a capacity means that resilience is comprised of a set of *ex ante* attributes and supports that should positively shift the likelihood function that describes the relationship between shocks and development outcomes, such as food security[2].

[1] WFP. (2013). *Resilience Measurement Principles: Toward an agenda for measurement design.* Resilience Measurement Technical Working Group. Technical Series No. 1. FSIN. Rome.

[2] Barrett, C. & Constas, M. (2013). *Resilience to avoid and escape chronic poverty: Theoretical Foundations and Measurement Principles.* Paper presented at IFPRI, August 2013.

Resilience is seen as a paradigm shift, away from short-term thinking and solutions toward interventions that, over a longer time, can enhance development and build capacity to deal with dynamic environmental and social challenges.

Purpose

In order to better measure resilience, and to better understand and target investment that will enhance resilience, the Technical Consortium is developing a pilot spatial tool. The purpose of this resilience modeling tool is to assist IGAD member states in the Horn of Africa in identifying areas of high and low resilience to known hazards, initially focusing on resilience to drought specifically. This identification of relative levels of resilience geographically will provide an opportunity for better targeting of investment projects proposed in the drylands investment plans for the respective countries.

For the purposes of this model, resilience is understood as the ability of a population to recover from a shock. This ability is based on a calculation of the initial vulnerability at the time of the shock combined with the time it takes to recover from the impact of a hazard. This gives us a representation of overall resilience with low values indicating low resilience.

The tool overlays multiple data layers indicating linkages and dynamic interactions between key indicators in systems affecting resilience. The result is a mapped output depicting a region's relative resilience, derived from weighted indicators from three key systems: economic, social and ecological. The pilot development of the spatial tool will be trialed with various drought and environmental planning agencies in the IGAD member states to understand its utility in better enabling the targeting of investments and projects for the most impact in building resilience. Ultimately, it will allow governments in the Horn to host a sector-specific investment platform for improved planning and resource allocation.

Review of spatial baseline datasets

In order to represent vulnerability or susceptibility and time to recover, and as part of the Technical Consortium's work to establish catalogues containing baseline datasets for the IGAD member state countries, a data inventory for the region was carried out - paying particular attention to those datasets that could populate the indicators isolated in the systems review and indicator selection. Eventually these data catalogues will provide governments with meta-data on indicators that are generally agreed to contribute towards "resilience" to drought in the Horn of Africa.

Over a six-month period, a robust scoping for available datasets was undertaken, entailing extensive consultation with agencies, NGOs and governments in the Horn of Africa to collate available information on data sources. The data scoping resulted in 452 datasets being acquired and standardized in order to be comparable and scalable between values representing highest and lowest resilience. The systems framing these baseline datasets are designated as social, economic and ecological.

Figure 1 (below) provides an example of just four of the 452 datasets acquired – namely groundwater productivity, predicted areas of suitability for Tsetse fly, interest rates and the mortality rate of children under 5. It illustrates how each available dataset was arranged under a System, Composite Indicator, Indicator and ISO Topic. The availability of the relevant dataset in each of the IGAD member states (Djibouti, Eritrea, Ethiopia, Kenya, Somalia, South Sudan, Sudan, Former Sudan and Uganda) was noted, along with the dataset's spatial extent, spatial resolution, resolution unit, etc.

Various tests of the utility value of the datasets in terms of their scale, resolution, integrity and other attributes, were carried out. One of these tests involved the production of 10 maps at different scales (regional, national and subnational), looking at spatially representing basic indicators such as distance to water, livestock numbers, access to education and health etc. From this exercise, the limitations of the available spatial data were better understood and the requirements to generate more useful data were recognised.

FIGURE 1. Example of how the data catalogue is arranged

SYSTEM	COMPOSITE INDICATOR	INDICATOR	ISO TOPIC	DATASET	DJIBOUTI	ERITREA	ETHIOPIA	KENYA	SOMALIA	S. SUDAN	SUDAN	FRMR SUDAN	UGANDA
Ecological	Water resources	Aquifer capacity + draw down rates	Inland water resources	Groundwater productivity	x	x	x	x	x	x	x	x	x
Ecological	Land use	Classification of land use/cover	Agriculture + farming	Predicted areas for Tsetse fly: Fusca	x	x	x	x	x	x	x	x	x
Economic	Financial conditions	Interest rates	Business + economics	Interest rates	x		x	x			x		x
Social	Health	Infant mortality rate	Human health + disease	Children (under 5) mortality rate	x	x	x	x	x	x	x		x

SPATIAL EXTENT	SPATIAL RES.	RES. UNIT (km)	START YEAR	END YEAR	UNIT OF MEAS.	SOURCE	FORMAT	TEMPORAL RES.
Africa	5km	5	-	-	m	BGS	Raster	Fixed
Sub-Saharan Africa	5km	5	-	-	Likelihood of occurence	UN FAO GeoNetwork	Raster	-
Global	National	500	1984	2013	%	Trading Economics	Tabular	-
Global	National	500	1990	2011	Counts (per 1000 births)	UN MDG	Tabular	Annual

It is hoped that the model will prove useful as an early warning system for livestock mortalities in arid parts of Africa.

Addressing a data gap:

Simulating livestock population dynamics

As part of the development of decision support analysis tools to better equip governments for rational and inclusive decision-making, and to avert future livestock population crashes in the Horn of Africa, a model was developed to simulate livestock population dynamics in the region with which to inform food security early warning systems. As livestock population dynamics are not solely influenced by drought, the model uses the balance/imbalance between livestock numbers and the available rangeland forage in arid and semi arid lands (ASALs) in conjunction with rainfall patterns, to capture livestock populations for the region. The model also provides an understanding of the lower trophic interaction between herbivores (livestock) and their vegetation food base, in gauging future livestock populations.

Starting livestock populations were estimated from calculations of long-term carrying capacity based on rainfall, plant productivity and soil quality. Rainfall anomalies (difference from the long-term mean annual rainfall) were calculated on a cell-by-cell basis using rainfall estimate data from TAMSAT, available at 5km^2 resolution every 10 days for the whole of Africa from 1988 to present. Rainfall estimates from satellites (derived from cloud surface temperatures) were chosen over those from Normalized Difference Vegetation Index (NDVI), as the substrate signal used can be too strong in arid regions.

Based on the observations of Le Houerou *et al*. (1988)[4], plant production in an arid grassland over an average year amounts to 37.362% of phytomass and the variability of production is generally 1.5 times the variability in rainfall. The assumption is therefore that livestock will have 15% more food available than in a 'normal' year if rainfall is 10% above average. Thus, the start-point geographic distribution of above-ground net primary production (in gm^{-2}) was then calculated using a high spatial resolution dataset of rainfall from Worldclim[5] in the equation of Schuur (2003)[6] referred to by Yang *et al*. (2008)[7]. The rainfall dataset was first filtered to exclude all areas receiving > 1035mm rain per annum.

With this high resolution (1km^2) dataset of likely total above-ground primary production in a normal rainfall year, it was then possible to reverse-estimate the likely biomass or phytomass values for each grid cell using the observation of Le Houerou *et al*. (1988)[4] that production is normally equivalent to 0.3736 of biomass. Food supplies or carrying capacity for the livestock can then be calculated as all of the fresh growth plus 10% of the phytomass, assuming that one tropical livestock unit consumes 2500 kg DM per annum[8].

It is important to note that not all phytomass will be relevant to livestock; much will be inaccessible in trees for instance. Biomass values per grid cell were therefore multiplied by their % tree cover values (calculated from the MODIS Vegetation Continuous Fields product from NASA[9]) and then subtracted 90% of this 'tree biomass value' from the total biomass values. This revealed an estimate of understorey biomass at 0.5km^2 across the region. The model assumes that only 15% of total understorey biomass is relevant to livestock[10] as much of it will either harden/lignify without being consumed, be removed by insects or be overlooked by herbivores in favor of fresh green growth.

The model therefore provides a high spatial resolution representation of relevant phytomass or the plant building blocks for annual growth. In the ASALs, these 'building blocks' for fresh growth exist as woody or inedible rhizome material that persists as standing crop from one season to another. The building blocks are not fixed from year to year, but may accumulate in years of good rainfall or decline during drought. This separation of persistent phytomass and more variable fresh growth is analogous to the concepts of capital: winter phytomass = biomass = capital (which can appreciate or depreciate in value) and annual plant production = fresh growth = interest. The allowance for phytomass to appreciate over good years and depreciate during drought and for fresh growth to be a dynamic rainfall-related function on this changing phytomass offers a better approximation for long-term variation in the number of animals that can be supported on the land.

In order to allow these building blocks to appreciate or depreciate within realistic limits during consecutive good/bad years, an upper limit of 1.3 x relevant biomass and lower limit of 0.7 x relevant biomass was set. Phytomass at the end of a year was modified by a factor which varied between x 0.9 (driest years) and x 1.3 (wettest years). The value used was directly (linearly) interpolated from the rainfall anomaly. This created a rapid increase (by up to 30%) of the capital in wettest years and a steady decline in capital (by up to 10%) in the driest years. Rainfall was allowed to be the major driver of the increase in plant matter during good rainfall years and, in a further step, livestock were allowed to be the major driver of phytomass depletion during dry or overstocked years.

If prevailing food supplies for the year exceed total demand of livestock consumption, it was assumed that there was no depletion of capital due to livestock. If consumption exceeds food supplies, then the exact deficit (less

---

[4] Le Houerou, H.N., Bingham, R.L. & Skerbek, L.W. (1988). Relationship between the variability of primary production and the variability of annual precipitation in world arid lands. *J. Arid. Environ.* 15: 1-18.

[5] Hijmans, R.J., Cameron, S.E., Parra, J.L., Jones, P.G. & Jarvis, A. (2005). Very high resolution interpolated climate surfaces for global land areas. *International Journal of Climatology* 25: 1965-1978.

[6] Schuur, E.A.G. (2003). Productivity and global climate revisited: the sensitivity of tropical forest growth to precipitation. *Ecology* 84(5): 1165-1170.

[7] Yang, Y., Fang, J., Ma, W. & Wang, W. (2008). Relationship between variability in aboveground net primary production and precipitation in global grasslands. *Geophysical Research Letters* 35, L23710: 1-4.

[8] De Leeuw, P.N. & Tothill, J.C. (1990). The concept of rangeland carrying capacity in Sub-Saharan Africa – myth or reality? *Land Degradation and Rehabilitation* 29b. 19pp.

[9] Hansen, M., Defries, R., Townshend, J.R., Carroll, M. & Dimicelli, C. (2004). *500m MODIS Vegetation Continuous Field v.1.* University of Maryland, Maryland, USA.

[10] Davies, R.A.G. (1994). *Predation by Black Eagles on Rock Hyrax and other prey in the Karoo.* PhD thesis, University of Pretoria.

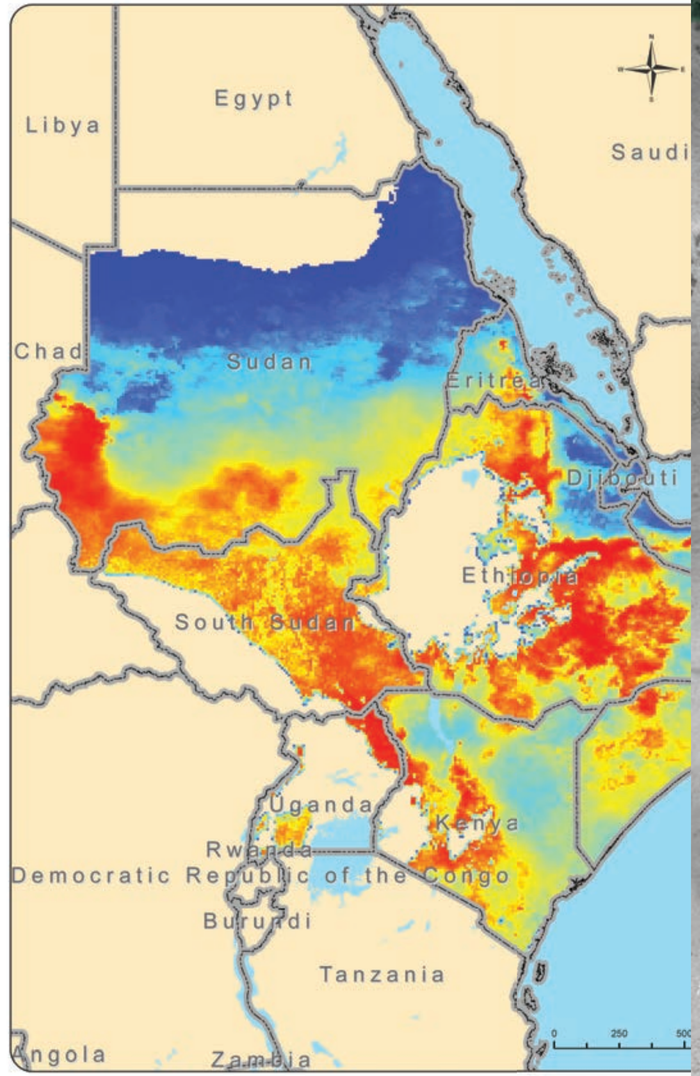
15% to be found elsewhere) was subtracted from capital.

For each grid cell, livestock numbers at start (P) are compared with the carrying capacity (K), where K or carrying capacity is not a fixed long-term stocking rate but a highly dynamic measure that realistically represents prevailing food conditions based on rainfall for that year and cell. The P:K ratio is then used to scale both livestock recruitment and livestock mortality in a linear fashion ranging between the extremes of worst case scenario and best case scenario and values for a 'normal' year. The assumption is that mortality rates will be maximum and recruitment rates minimum when large livestock populations are stressed by drought; and that mortality rates will be minimum and recruitment rates maximum when small livestock populations experience good rains.

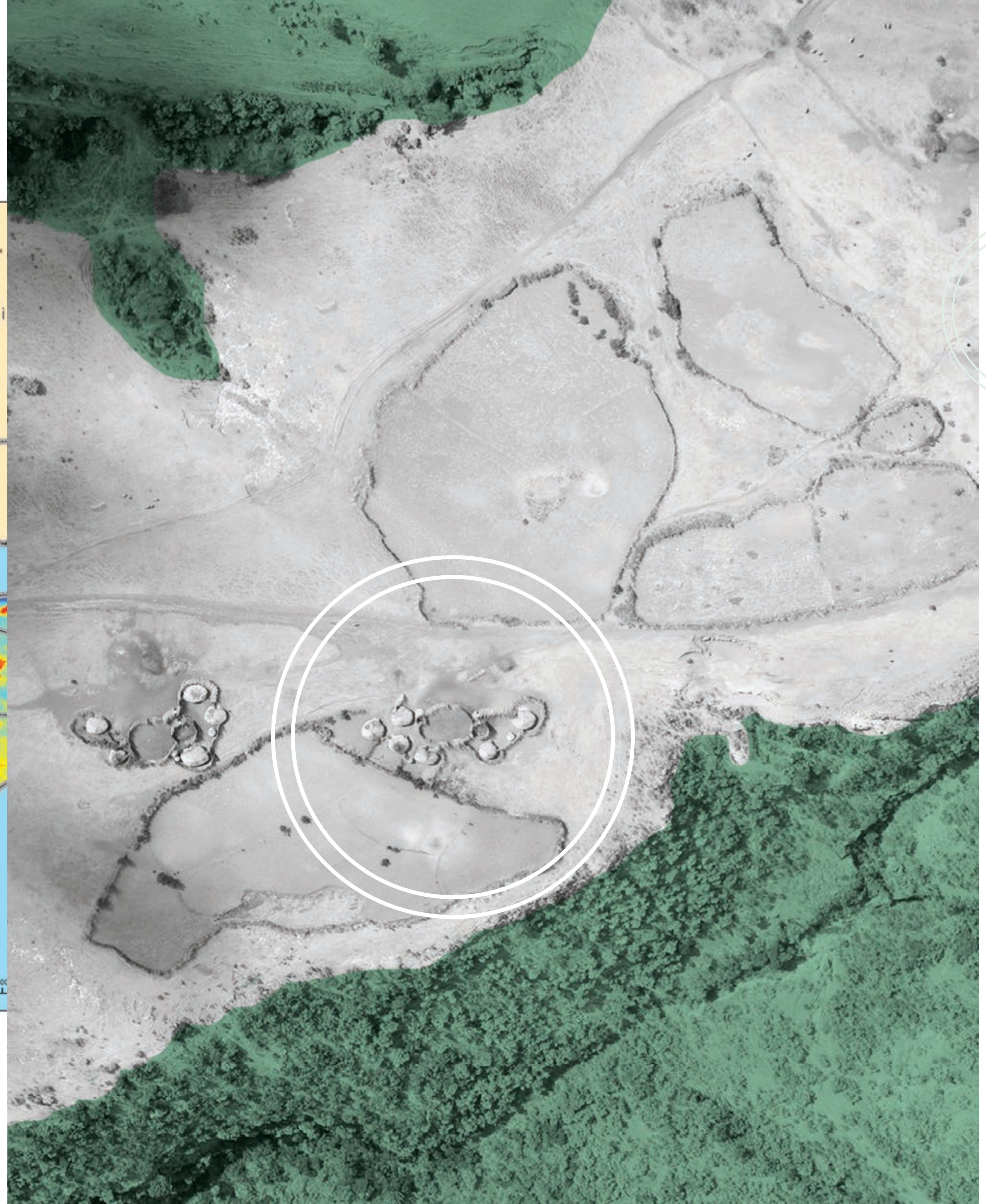
Map outputs were produced for phytomass and production in an average year. The coefficient was calculated of the variation of livestock mortality rate to highlight which parts of IGAD arid regions regularly face the most dramatic increases and decreases of livestock numbers due to rainfall patterns. This was used in the environmental sensitivity layer along with the expected mortality rate for 2014 (based on average rainfall pattern) and a measure of livestock overhead going into 2014. Animations were also produced to visualise the pattern of change in model parameters over the 30 years of rainfall data. Output layers were checked for particular grid cells from one year to the next to ensure the calculations were made correctly.

It is hoped that the model will prove useful as an early warning system for livestock mortalities in arid parts of Africa. For 2014, an input of rainfall data in a 'normal' year can forecast mortality patterns if rainfall follows an average course. The rainfall patterns have also been determined from strong El Nino and La Nina years, which can be fed into the model if sea surface temperatures in the Indo-Pacific indicate one of these patterns is imminent. There is thought to be a nine-month advance warning from these indicators. The model is in its pilot development stage, with ground truthing and expert consultation on its parameters still required as part of a larger validation of the spatial tool.

Figure 2: **Pastoral drought risk - Projected livestock mortalities 2014.**



Total livestock mortalities is an output of the livestock mortalities model developed by habitat INFO.



Review of systems, selection of indicators

The next step in developing the spatial tool was to synthesise the system indicators. As mentioned previously, in order to represent vulnerability or susceptibility and time to recover, spatial datasets were grouped into three systems: ecological, social and economic. The ecological system refers to the natural resources that we use and depend on, that are provided by nature as opposed to being human-engineered. The social system is defined as the level of community/social support, or the level of access to 'human capital', while the economic system is defined as access to material wealth.

From the pool of datasets, 165 indicators were selected that best represent resilience in these three key systems. The 165 resilience indicators were selected[11] using the following underlying criteria:

- relevance to the region's resilience,
- data quality and
- availability of the data on a regional and national level.

The indicators were then divided amongst the three systems: social (51), economic (73) and ecological (41) (see Figure 3 on following page).

[11] This selection of indicators and the datasets to populate them has to date been based largely on expert opinion. More validation of the weighting will take place within the next six months.

ECOLOGICAL SYSTEM

- Water discharge
- Irrigation potential
- Distance from water
- Rainfall per person on agricultural land
- Rainfall data from remote sensing
- ENSO index
- Crowding on agricultural land
- % people in water stress
- Human appropriation of net primary productivity
- Population density
- Projected population growth
- Biodiversity value
- Forest resources
- Deforestation
- Slope
- Length of the growing period
- Net primary productivity
- Soil degradation
- Available soil moisture
- Rangeland condition
- Livestock mortality data
- Invasive plant occurrence
- Food web complexity
- Tsetse fly occurrence

SOCIAL SYSTEM

- Conflicts
- Governance
- Change in leaders
- Crime rates
- Displacement migration
- Circular migration
- Policing
- Community management
- Availability of support networks
- Representation in parliament
- Property rights + legal indicators
- Agricultural system
- Own food production
- Access to improved water
- Life expectancy
- Orphans
- Infant mortality
- Disease metrics (malaria, HIV etc)
- % expenditure on health
- Distance to health centres
- Education
- Equitable society indicators
- Inclusivity indicators
- Role and participation of women
- Access to info - early warning
- Access to info - crop prices etc.
- Sustainability of heating etc.

ECONOMIC SYSTEM

- Lights at night infrastructure
- Travel time to nearest city
- Road and rail infrastructure
- Distance to nearest port
- Electrical infrastructure
- Distance to nearest airport
- Distance to nearest marketplace
- Telephone infrastructure
- Cell phone users per 1000 people
- Access to internet
- Price stability
- Flexible exchange rate policy
- Integration with other markets
- Trade regulations/trade openness
- Tax regulations
- Access to credit, savings and insurance
- Access to local enterprises
- Access to development projects
- Tourism
- Interest rates
- Inflation rate
- GDP national
- National debt
- GDP household (income)
- Household assets
- Livelihood diversity
- Crop diversity
- Livestock diversity
- Agricultural assets
- Agricultural inputs
- Crop storage facilities
- Agriculture as % GDP
- % reliance on cash crops
- Industry trade as % GDP
- % land under irrigation
- Water withdrawals
- Poverty (infrastructure)
- Malnourishment
- Calories per person per day
- Protein consumption per person per day
- Diet diversity
- Employment-to-population ratio (male & female)

Figure 3: Indicators under each system

KEY: Positive influences at high values are in white; negative influences at high values are in black.

Rationale behind methodology

Systems and indicators were separated to better measure and assess the influence on resilience that each may have.

Ecological conditions (such as rainfall and population density) define the susceptibility of a particular location to the impact of a shock, such as severe drought. Assessing the ecological/environmental system indicators of an area is the first step in evaluating that area's resilience.

Social (non-material) conditions and economic (material) conditions affect the adaptive capacity of a particular location/community to bounce back from the environmental shock once it has occurred. Therefore, social system indicators (good governance, inclusivity in decision-making, access to good healthcare) and economic system indicators (road and rail infrastructure, access to market, GDP per capita) form an important means of evaluating the time a community needs to rebuild or bounce back after the shock has occurred.

While in many cases variables may be relevant both during and after a shock, it was expedient for the purposes of developing the tool to allocate ecological or environmental indicators in a first step to evaluate susceptibility to the shock; and to allocate social or economic indicators in a second step, which could evaluate time to rebuild following a shock. These steps are later combined in evaluating overall resilience so they are still included whether considered during or after the shock.

Weighting of indicators

Once the indicators were separated into the three systems, careful consideration was then given in assigning weights to each indicator in order to compose an overall index of resilience. Each indicator was weighted using an ArcGIS Model Builder, which allows for easy changing of weightings at two classification levels for future sensitivity analysis.

The method of combining these datasets involved standardizing the scale of each to vary in integer values ranging from 1 to 9, and then a simple summation of the layers could take place. However, datasets which were considered to be more crucial to vulnerability, from a more reliable source, and at sufficient geographical resolution, were allowed to have more influence on the final summary layers (weighted up to *3) than datasets which were considered to be less crucial, less reliable, and of a crude resolution (weighted * 1).

While in many cases variables may be relevant both during and after a shock, it was expedient for the purposes of developing the spatial tool to allocate ecological or environmental indicators in a first step to evaluate susceptibility to the shock, and to allocate social or economic indicators in a second step to evaluate the relative time required to rebuild following a shock.

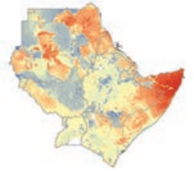
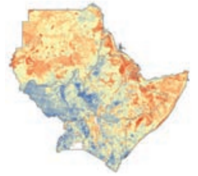
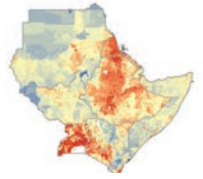
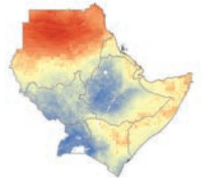
Composite indicators

The indicators were then combined into composite indicators, in order to allow for multiple overlays, in line with GIS mapping capability. An ESRI Model Builder was used to assimilate these data into: six composite indicators for ecological/ environmental (water resources, land use, ecosystem services, per capita resources, climate and natural resource shocks); four composite indicators for social (health, education, governance and social shocks); and seven composite indicators for economic (infrastructure, trade access, financial services, wealth, financial conditions, livelihood/income diversification and economic shocks).

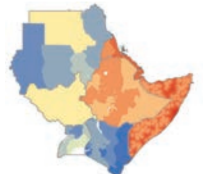
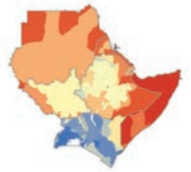
The composite indicators are illustrated over the next three pages.

On the opposite page:

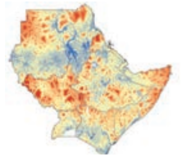
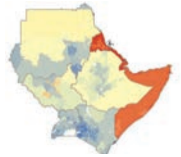
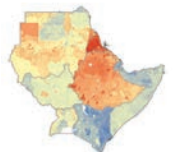
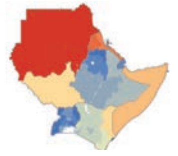
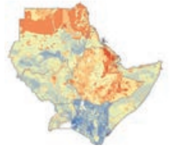
Figure 4: Overview of the composite indicators within the spatial tool

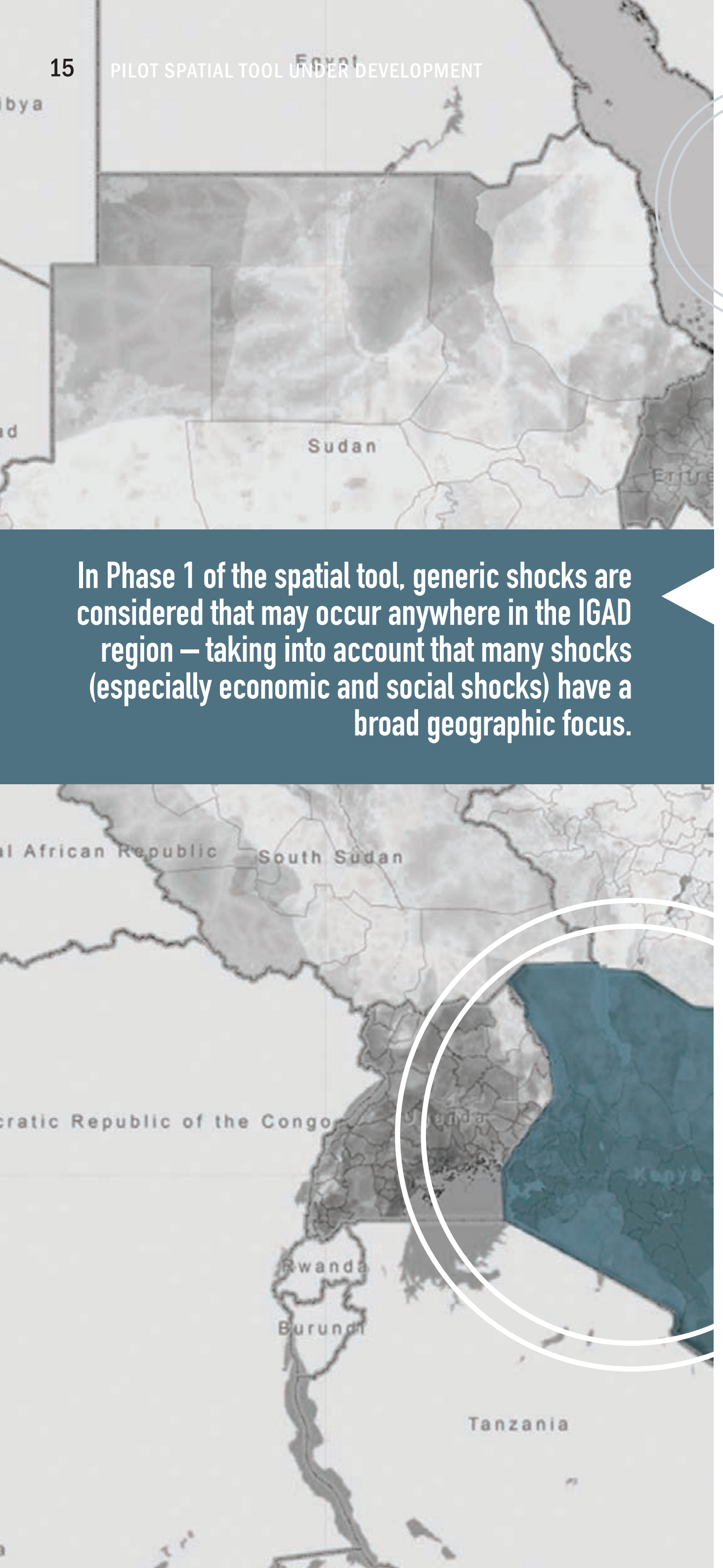
	COMPOSITE INDICATOR	INDICATORS	SPATIAL OUTPUT
ECOLOGICAL SYSTEM	WATER RESOURCES	• Aquifer capacity and draw down rates • Water source distribution • Distance from water source	
	LAND USE	• Deforestation • Slope • Rangeland condition • Livestock mortality data • Soil degradation • Invasive plant occurrence • Classification of agricultural systems • Habitat transformation • Livestock mobility and migratory patterns • Livestock related disease outbreaks (5 yrs) • Livestock birth and death rates • Net primary productivity • Circular migration	
	ECOLOGICAL SERVICES	• Levels of protection • Forest resources • Wetlands • Soil moisture/depth/nutrients • Food web complexity/species diversity	
	POPULATION DENSITY + PER CAPITA RESOURCES	• Rainfall per person on agricultural land • Population density • Trends in urban population centres in the last decade • Per capita water use • Population growth	
	CLIMATE	• Rainfall data from remote sensing • El Niño–Southern Oscillation index • Length of the growing period • Bi-seasonal or uni-seasonal growing periods • Aridity • Climate change • Potential evapotranspiration (PET) • Temperature	
	NATURAL RESOURCE SHOCKS	• Disasters	

SOCIAL SYSTEM

COMPOSITE INDICATOR	INDICATORS	SPATIAL OUTPUT
LAND USE SUPPORT	• Status of sanitary and photosanitary (SPS) protocols • Access to veterinary services – agro vets, community animal healthcare workers (CAHWs), vets etc • Agricultural extension services (training) • Extension services	
COMMUNITY SUPPORT	• Community management • Availability of support networks	
INFORMATION	• Access to info - early warning • Access to info - crop prices etc.	
HEALTH	• Access to improved water & facilities • Life expectancy • Orphan health • Infant mortality • Disease metrics (malaria, HIV etc.) • % expenditure on health • Distance to health centres/number of health centres • Antenatal care • Child nutrition • Maternal mortality	
EDUCATION	• Education (schools, literacy rates, gender) • Number of schools • Health education	
GOVERNANCE	• Crime rates • Representation in parliament • Representation in county level administration • Property rights and legal indicators • Equitable society indicators & orphan care • Role and participation of women • Inclusivity indicators • National level governance • Change in leaders • Governance below national level • Policing	
SOCIAL SHOCKS	• Conflicts • Displacement migration	

ECONOMIC SYSTEM

COMPOSITE INDICATOR	INDICATORS	SPATIAL OUTPUT
INFRASTRUCTURE	• Lights at night infrastructure • Travel time to the nearest city • Road and rail infrastructure • Distance to the nearest port • Communication (internet, cell phones, land lines, cell towers etc.) • Agricultural inputs • % land under irrigation • Irrigation potential • Electrical infrastructure • Distance to nearest airport • Distance to nearest market • Crop storage facilities • Air infrastructure	
TRADE ACCESS	• Status of trade regulations • Tax regulations • Livestock trade (exports, volume, value, milk, hides, skins etc.) • Flexible exchange rate policy • Integration with other markets • Trade routes	
FINANCIAL SERVICES	• Access to financial services • Access to insurance	
WEALTH	• Access to development projects • Tourism (conservancies and NP) • GDP (national, agriculture, industry) • GDP household (income) • Household assets • Agricultural assets • Diet (calories, protein, diversity) • Access to local enterprises • Poverty infrastructure • Malnutrition • Aid activity • Poverty	
FINANCIAL CONDITIONS	• Price stability • Interest rates • Inflation rates • Employment rates (male and female)	
INCOME DIVERSIFICATION	• Livelihood diversity • Livestock diversity/numbers/types • Crop area/yield/irrigated yield/diversity/reliance on cash crops	
ECONOMIC SHOCKS		



In Phase 1 of the spatial tool, generic shocks are considered that may occur anywhere in the IGAD region – taking into account that many shocks (especially economic and social shocks) have a broad geographic focus.

Spatial outputs

The spatial tool analyzes the resilience layers for each of the administration districts that are submitted in the query and produces a summary table containing the following information:

1. **AREA** of the administration district
2. **POPULATION** of the administration district (calculated from AfriPOP 2010 adjusted UN)
3. **SUSCEPTIBILITY/IMPACT:** mean value of the ecological or environmental system layer (as indicated by the weighting of its ecological indicators). Low impact equates to high resilience, while high values of impact equates to low resilience, at the time of the environmental shock. Values are relative; they are not interpreted in any other way.
4. **TIME TO RECOVER:** We took the mean value of the socio-economic systems layer (as indicated by the weighting of its social and economic indicators) and we inverted these values so that high socio-economic capacity represented an expected shorter time to recover following a shock. Short recovery time values equate to a high resilience, while long recovery time values equate to low resilience. Values are relative; they are not interpreted to actual time.
5. **OVERALL RESILIENCE:** calculated by combining susceptibility with measures of recovery time (this is computed as socio-economic capacity for recovery divided by environmental-sensitivity or susceptibility to the shock). Areas with high capacity for quick recovery and low susceptibility to the shock are accorded highest resilience; while areas poor in capacity for recovery and highly susceptible to the shock are accorded lowest resilience.

The output is then illustrated as a regional map *(see graphic on right)*, showing locations where environmental shocks are expected to have a higher impact and affected communities will take a long time to recover (highlighted in red), and areas where shocks have a lower impact and communities will be quicker to recover (highlighted in blue).

SPATIAL TOOL OUTPUT 1: SUMMARY TABLE

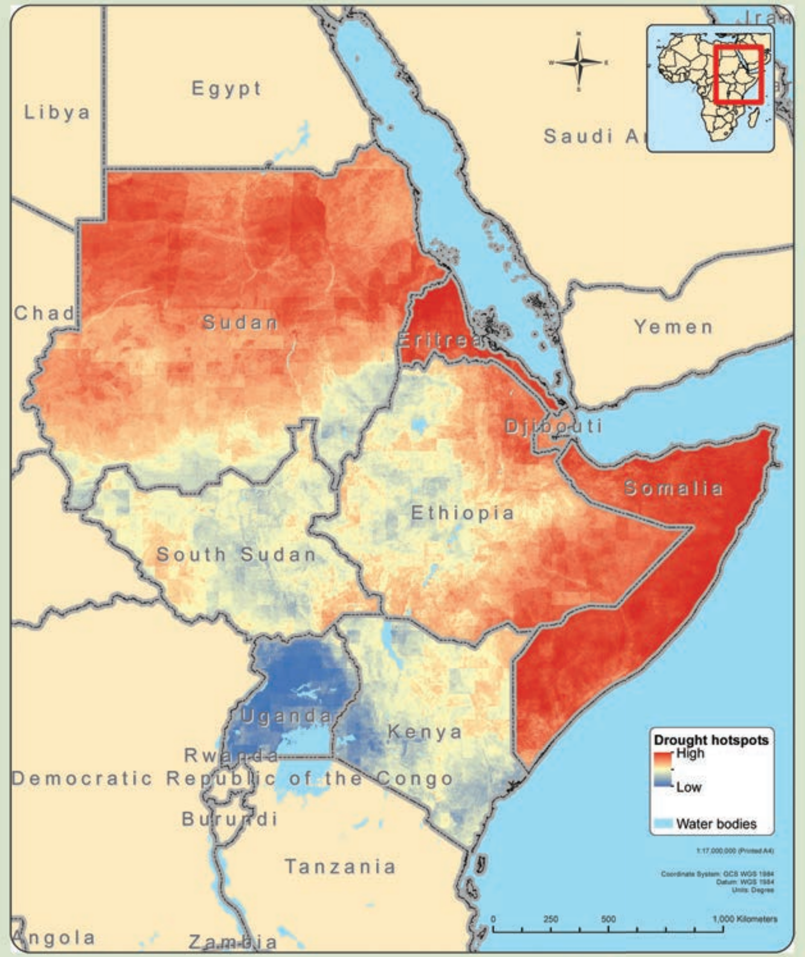
AREA	POPULATION	SUSCEPTIBILITY/ IMPACT:	TIME TO RECOVER:	OVERALL RESILIENCE:
of the administration district.	of the administration district (calculated from AfriPOP 2010 adjusted UN).	mean value of the ecological system layer. Low impact = high resilience to shock.	mean value of the socio-economic systems layer. Short recovery time = high resilience to shock.	calculated by combining susceptibility with recovery time. Low valu = low resilience.

RESILIENCE =

SOCIO-ECONOMIC CAPACITY	/	ENVIRONMENTAL SENSITIVITY
If inverted, this measure represents the ability of the district to recover following the shock, as a relative time value.		This measure represents environmental susceptibility at the time of the shock (= impact).

SPATIAL TOOL OUTPUT 2: MAP

Relative resilience to drought:
Drought hotspots in the Horn of Africa



Drought hotspots (likelihood of occurrence and lack of resilience) is a product of likelihood of drought occuring and susceptibility to drought divided by the inverse of time to revover after a drought.

Produced by habitat INFO, 03/14

Future developments of spatial tool

In Phase 1 of the spatial tool, generic shocks are considered that may occur anywhere in the IGAD region – taking into account that many shocks (especially economic and social shocks) have a broad geographic focus. However, the tool has been designed to accommodate a likelihood of occurrence maps for shocks that occur in specific areas. These values will be calculated in Phase 2 of the spatial tool, which focuses on drought as the primary hazard.

The Horn of Africa is predominantly comprised of arid or semi-arid lands, and is a naturally drought-prone region. With increasing pastoral or agro-pastoral land use, the environment and pastoral communities in this region are progressively susceptible to severe drought. In particular, heavy stocking of the land and consequent overgrazing will extend existing droughts, while denuded vegetation is the primary cause of further desertification and an increase in future droughts. This imbalance of livestock requirements and pasture availability results in livestock mortalities and food security issues.

It is therefore imperative that such pastoral communities be resilient to an environmental shock such as severe drought, in order to sustain food security in terms of livestock (where resilience applies to the conditions that affect the impact of the shock and the ability of a community to timely recover following the shock). Measuring the resilience to drought of pastoral communities within the Horn of Africa is therefore key to ameliorate or avert further livestock losses in this region, and to support the much-needed paradigm shift from relief to region- and community-specific development.

There are currently two versions under development of the new drought module to sit within the spatial tool. Version 1 identifies geographical areas in the Horn of Africa with respect to their relative resilience across multiple sectors using medium to long-term data on drought exposure risk. It is based on a new drought exposure layer, based on longer-term datasets, a subset of relevant environmental sensitivity layers, and the existing time to recover layer. It is envisaged that Version 1 will be useful to potential investors considering a variety of sectors e.g. water management, early warning information systems, conflict reduction.

Version 2 highlights pastoral and agro-pastoral localities where farmers and dependents may be at risk of significant livestock mortalities in the short-term. It is based on short-term rainfall estimates at high geographic resolution and encompasses the outputs of the livestock-vegetation model developed for the Horn of Africa Resilience Project. These outputs are confined to the pastoral and agro-pastoral land use regions.

Version 2 will include a new, high-resolution drought exposure layer; the existing time to recover layer; and a modified environmental sensitivity layer. It is envisaged that this version will be used to target those areas in which investments, such as the promotion of stock movement and reduction, will achieve optimal impact.

The Technical Consortium is collaborating with model developers at Colorado State University, to combine elements of their G-Range model[12], which simulates and forecasts rangeland ecosystem processes with this spatial tool, aiming to ground truth and validate data and to enhance the rigour of the model and capacity for interrogation at finer scale.

Both versions will combine population estimates with the calculation of resilience in order to focus potential investments on those areas that will see the biggest impact in terms of people helped. The outputs will be similar to those already produced by the spatial tool; a summary map and spreadsheet.

Version 2 may be developed into an early warning system for livestock farmers if the datasets are updated and with possible linking to the Southern Oscillation Index (SOI). Discussions are in place regarding the possibility of a 'futures analysis' that can factor in projected climate change, loss of cropland etc.

[12] G-Range is a global model that simulates generalized changes in rangelands through time, created with support from the ILRI. Spatial data and a set of parameters that control plant growth and other ecological attributes in landscape units combine with computer code to represent ecological process such as soil nutrient and water dynamics, vegetation growth, fire, and wild and domestic animal offtake. The model is spatial, with areas of the world divided into square cells. Those cells that are rangelands have ecosystem dynamics simulated. A graphical user interface allows users to explore model output.

For more information regarding G-Range, please contact Rich Conant, PhD at rich.conant@colostate.edu.

Application and value to the member states

The advance overlay functionality of GIS and the resulting spatial outputs will form an integral aspect for both the rational targeting of investment and the building of capacity and baselines from which to measure the impact. Historic and recent datasets were provided as benchmarks, which may then be tracked through time for the early detection and identification of anomalies or thresholds, the crossing of which may precipitate regime shift to a less favorable state.

Summary and other datasets have been supplied for each member state to augment and integrate with existing regional environmental information systems with the purpose of informing high spatial resolution decisions about land use and resilient development for populations within the ASALs.

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. technicalconsortium.org

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. 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. cgiar.org