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REPORT 13

Spatial analysis for investment targeting: **pilot tool**

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technical consortium
Building Resilience in the Horn of Africa
CGIAR

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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.

Purpose

2

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.

3

Review of **spatial baseline datasets**

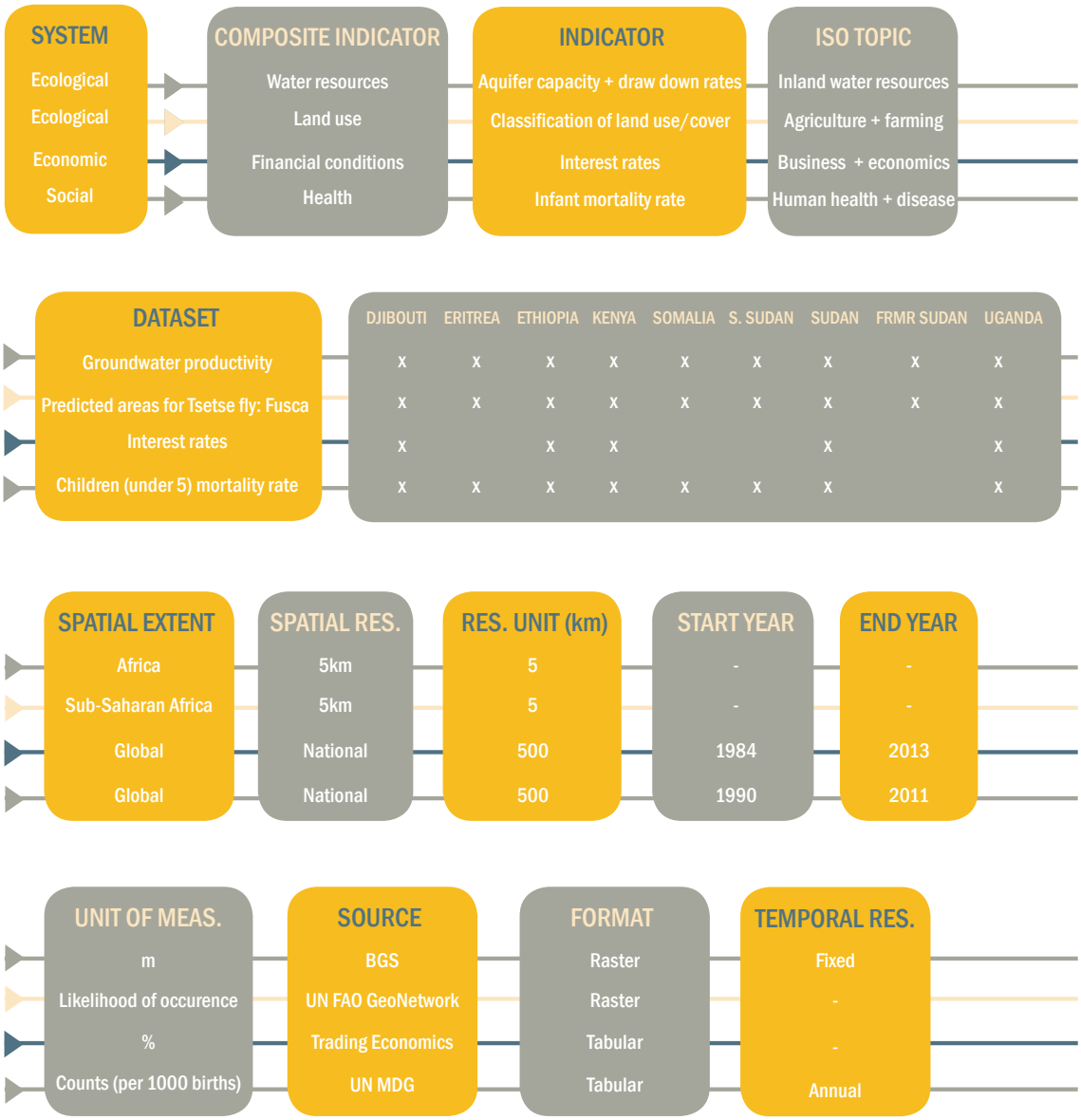
In order to represent vulnerability or susceptibility and time to recover, and as part of the Technical Consortium's work to establish catalogues containing baseline datasets for the IGAD member state countries, a data inventory for the region was carried out - paying particular attention to those datasets 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



4

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[3] 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).

[3] 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.

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).

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 2: Indicators under each system

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

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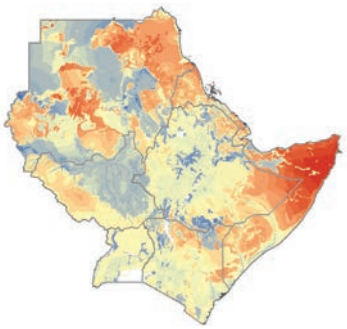
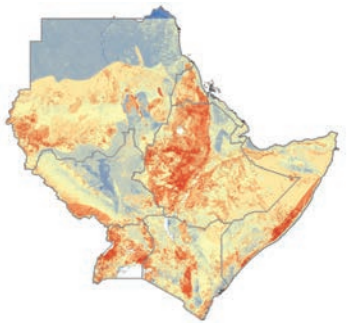
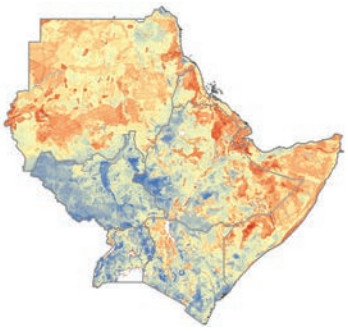
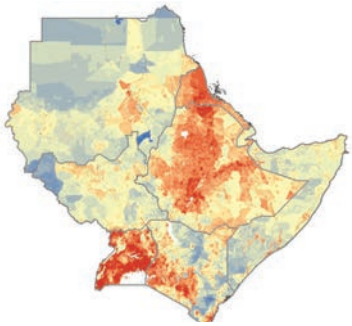
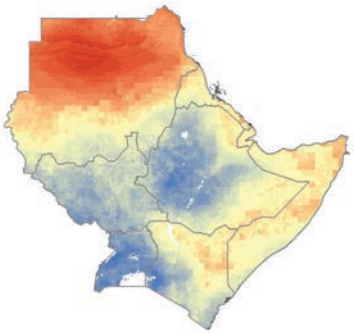
Composite indicators

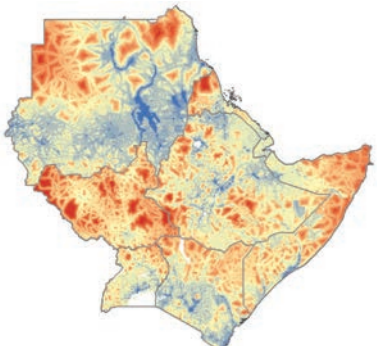
The indicators were then combined into composite indicators, in order to allow for multiple overlays, in line with GIS mapping capability. An ESRI Model Builder was used to assimilate these data into: six composite indicators for ecological/ environmental (water resources, land use, ecosystem services, 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.

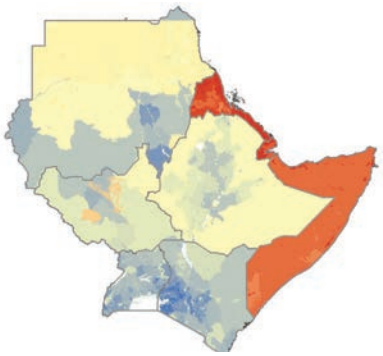
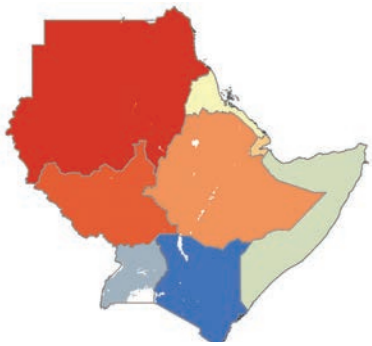
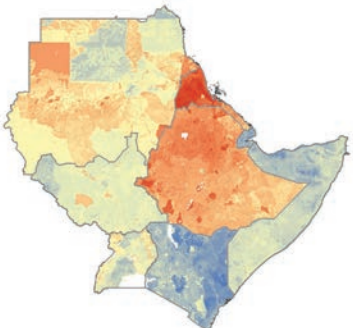
ECOLOGICAL SYSTEM

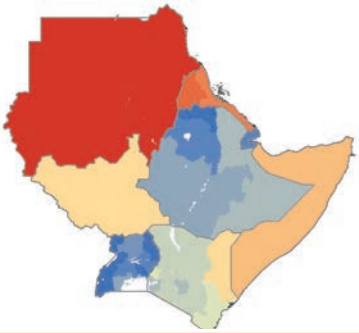
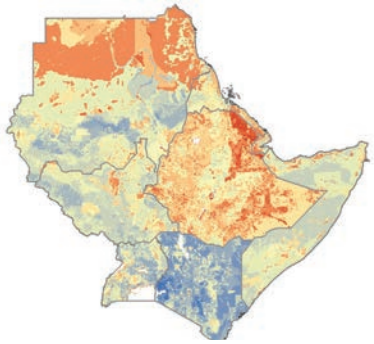
Composite indicator	Indicator	Dataset	Dataset no.	Source	Spatial output
Water resources	Aquifer capacity and draw down rates	Depth to groundwater	E1_001_001	BGS	
		Groundwater productivity	E1_001_002		
		Groundwater storage	E1_001_003		
	Water source distribution	Mean annual water discharge	E1_002_001	WWDRII	
		Lakes and wetlands	E1_002_002	WWF GLWD	
		Dams and capacity	E1_002_004	WRI African Data Sampler	
	Distance from water source	Distance to freshwater	E1_003_001	Kummu M, de Moel H, Ward PJ, Varis O (2011) How Close Do We Live to Water? A Global Analysis of Population Distance to Freshwater Bodies	
Land use	Deforestation	Forest Loss	E2_001_001	habitat INFO, OneWorld Group, WCMC, MODIS, GLCF	
	Slope	Digital Elevation Model (SRTM)	E2_002_001	NASA SRTM	
	Rangeland condition	Dynamic carrying capacity	E2_003_002	habitat INFO, see comments	
		Food balance between long-term carrying capacity and livestock numbers (GLW)	E2_003_003	habitat INFO, FAO GLW	
		Relevant phytomass (understorey)	E2_003_004	habitat INFO, see comments	
		Relevant phytomass (maximum)	E2_003_005	habitat INFO, see comments	
		Relevant phytomass (minimum)	E2_003_006	habitat INFO, see comments	
		Total plant biomass (estimate)	E2_003_007	habitat INFO, see comments	
		Phytomass for arid regions (understorey)	E2_003_008	habitat INFO, see comments	
	Classification of land use / cover	Land Use: Somalia	E2_007_001	SWALIM	
		Livestock production systems in Eastern Africa	E2_007_002	FAO GeoNetwork	
		Predicted areas of suitability for tsetse fly: Fusca	E2_010_001	UN FAO GeoNetwork	
		Predicted areas of suitability for tsetse fly: Palpalis	E2_010_002	UN FAO GeoNetwork	
		Predicted areas of suitability for tsetse fly: Morsitans	E2_010_003	UN FAO GeoNetwork	

Composite indicator	Indicator	Dataset	Dataset no.	Source	Spatial output
Ecosystem services	Levels of protection	Levels of protection	E3_001_001	habitat INFO, OneWorld Group	
		Habitat Transformation / Loss	E3_001_002	habitat INFO, OneWorld Group, WWF Ecoregions, GlobCover	
		Habitat Loss (including restricted)	E3_001_003	habitat INFO, OneWorld Group, WWF Ecoregions, GlobCover	
		Biodiversity Value	E3_001_004	habitat INFO, OneWorld Group, WWF Ecoregions, ZMUC	
	Forest resources	Forest Resources	E3_002_001	habitat INFO, OneWorld Group, MODIS, GLCF	
	Soil moisture/ depth/nutrients	Soil depth (DSMW)	E3_004_001	UN FAO DSMW	
		Easily available soil moisture (DSMW)	E3_004_002	UN FAO DSMW	
		Soil nutrient availability (HWSD)	E3_004_003	UN FAO HWSD	
	Food web complexity/species diversity	Vertebrate Taxa Richness	E3_005_001	habitat INFO, OneWorld Group, ZMUC, WWF Ecoregions	
Population & per capita resources	Rainfall per person on agricultural land	Precipitation: areas receiving less than 1036mm per annum (habitat INFO)	E4_001_001	habitat INFO, WorldClim	
		Precipitation: current (WorldClim)	E4_001_002	WorldClim	
		Precipitation: per person on agricultural land (habitat INFO)	E4_001_003	habitat INFO, UNEP, FAO IIASA GAEZ	
		Global Agro-Ecological Zones	E4_001_004	UN FAO IIASA GAEZ	
	Population density	Population density (GRUMP)	E4_002_001	SEDAC, CIESIN	
		Human Appropriation of NPP as a percentage of NPP	E4_002_002	SEDAC, CIESIN	
	Trends in urban population centres in the last decade	Urban residence (percentage of population)	E4_003_001	UN DESA	
		Urban population (annual rate of change)	E4_003_002	UN DESA	
Climate	Rainfall data from remote sensing	Precipitation: estimates from remote sensing (TARCAT)	E5_001_002	TAMSAT, TARCAT v.2	
	ENSO index	El Nino / Southern Oscillation Index	E5_002_003	Australian Bureau of Meteorology, 2005	
	Productivity	Length of growing period zones (FGGD)	E5_003_001	UN FAO FGGD	
		Net Primary Productivity (above ground)	E5_003_009	habitat INFO, see comments	
Natural resource shocks	Disasters	Disasters	E6_001_001	EM-DAT	

ECONOMIC SYSTEM

Composite indicator	Indicator	Dataset	Dataset no.	Source	Spatial output
Infrastructure	Lights at night infrastructure	Lights at night	F1_001_002	NOAA	
	Travel time to the nearest city	Travel time to nearest city	F1_002_001	European Commission	
	Road and rail infrastructure	Roads: Eritrea	F1_003_001	AfDB	
		Roads: Ethiopia	F1_003_002		
		Roads: Kenya	F1_003_003		
		Roads: Northern Sudan	F1_003_004		
		Roads: Southern Sudan	F1_003_005		
		Roads: Uganda	F1_003_006		
		Roads (primary): Somalia	F1_003_007	SWALIM	
		Roads (secondary): Somalia	F1_003_008		
	Distance to the nearest port	Average travel time to nearest port	F1_004_001	HarvestChoice, IFPRI	
	Communication (internet, cell phones, land lines, cell towers etc.)	Telephone possession: Eritrea	F1_005_001	Measure DHS	
		Telephone possession: Ethiopia	F1_005_002		
		Telephone possession: Kenya	F1_005_003		
		Telephone possession: Uganda	F1_005_004		
		Telephone lines	F1_005_005	The World Bank	
		Mobile cellular subscriptions	F1_005_006		
		Fixed broadband subscribers	F1_005_007		
	% land under irrigation	Irrigation areas	F1_007_001	UN FAO aquastat	
		Irrigation schemes (major): Somalia	F1_007_002	SWALIM	
		Irrigation schemes (major): Kenya	F1_007_003	World Resources Institute	
	Irrigation potential	Irrigation potential	F1_008_001	IFPRI	
	Electrical infrastructure	Power plants: Uganda	F1_009_001	AfDB	
		Power plants: Djibouti	F1_009_002		
		Power plants: Eritrea	F1_009_003		
		Power plants: Ethiopia	F1_009_004		
		Power plants: Kenya	F1_009_005		
		Power plants: Sudan	F1_009_006		
		Electricity transmission network: Uganda	F1_009_007	The World Bank AICD	
		Electricity transmission network: Ethiopia	F1_009_008		
		Electricity transmission network: Kenya	F1_009_009		
		Electricity transmission network: Sudan	F1_009_010		
		Household electricity: Eritrea	F1_009_011	Measure DHS	
		Household electricity: Ethiopia	F1_009_012		
		Household electricity: Kenya	F1_009_013		
		Household electricity: Uganda	F1_009_014		
	Distance to nearest airport	Airfields: Somalia	F1_010_001	SWALIM	
		Airports (VMap0)	F1_010_002	VMap0 (5th Edition)	
		Airports (Natural Earth)	F1_010_003	Natural Earth	
	Distance to nearest market	Livestock markets: Somalia	F1_011_001	SWALIM	
		Markets: Kenya	F1_011_002	World Resources Institute	
		Average travel time to nearest town (over 20k)	F1_011_003	HarvestChoice, IFPRI	

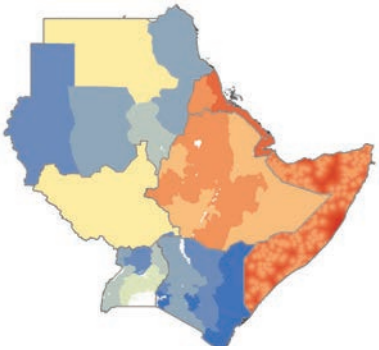
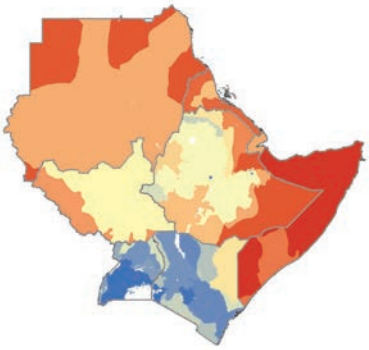
Composite indicator	Indicator	Dataset	Dataset no.	Source	Spatial output
Trade access	Status of trade regulations	Ease of doing business index	F2_001_001	The World Bank	
	Tax regulations	Tax regulation indicators (habitat INFO)	F2_002_001	habitat INFO, see comments	
	Livestock trade (exports, volume, value, milk, hides, skins etc.)	Value of production: cow milk	F2_003_001	ILRI	
		Value of production: cattle meat	F2_003_002	ILRI	
		Value of production: eggs	F2_003_003	ILRI	
		Value of production: goat meat	F2_003_004	ILRI	
		Value of production: goat milk	F2_003_005	ILRI	
		Value of production: sheep milk	F2_003_006	ILRI	
		Value of production: sheep meat	F2_003_007	ILRI	
		Value of production: small ruminants	F2_003_008	ILRI	
		Total value of production: cattle meat and milk	F2_003_009	ILRI	
		Total value of production: poultry meat and eggs	F2_003_010	ILRI	
		Agricultural raw materials exports	F2_003_011	The World Bank	
		Livestock production index	F2_003_012	The World Bank	
	Flexible exchange rate policy	Exchange rate policies	F2_004_001	IMF	
Financial services	Access to financial services	Financial Access	F3_001_001	IMF Financial Access Survey	
		Strength of legal rights index	F3_001_002	The World Bank	
Wealth	Tourism (conservancies and NP)	International tourism (number of arrivals)	F4_002_001	The World Bank	
	GDP (national, agriculture, industry)	GDP (current US$)	F4_003_001		
		Agriculture: value added (% of GDP)	F4_003_002		
		Industry: value added (% of GDP)	F4_003_003		
	GDP high resolution (income)	Estimated total economic activity (from lights at night)	F4_004_001	NOAA	
	Household assets	Household possessions: Eritrea	F4_005_001	Measure DHS	
		Household possessions: Ethiopia	F4_005_002		
		Household possessions: Kenya	F4_005_003		
		Household possessions: Uganda	F4_005_004		
	Agricultural assets	Agricultural machinery	F4_006_001	The World Bank	

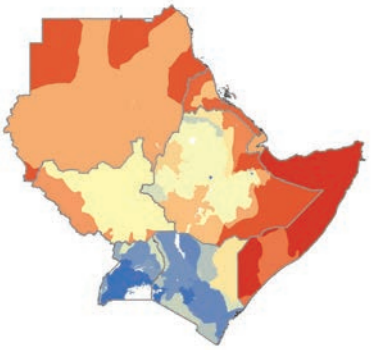
Composite indicator	Indicator	Dataset	Dataset no.	Source	Spatial output
Wealth	Diet (calories, protein, diversity)	Dietary consumption: energy, protein, fat	F4_008_001	UN FAO	
		Protein consumption	F4_008_002	OneWorld, habitat INFO, RCCP Food Economy Analysis	
		Diet diversification index	F4_008_003	OneWorld, habitatINFO, FAO	
	Poverty infrastructure	Poverty: infrastructure poverty	F4_010_001	NOAA	
	Malnutrition	Child malnutrition	F4_011_001	SEDAC, CIESIN	
	Aid activity	NGO activity: Horn of Africa	F4_012_001	NGO Aid Map	
Financial conditions	Interest rates	Interest rates	F5_002_001	Trading Economics	
	Inflation rates	Inflation and other economic indicators	F5_003_001	IMF WEO	
	Employment rates (male and female)	Employment (female): Eritrea	F5_004_001	Measure DHS	
		Employment (female): Ethiopia	F5_004_002	Measure DHS	
		Employment (female): Kenya	F5_004_003	Measure DHS	
		Employment (female): Uganda	F5_004_004	Measure DHS	
Income diversification	Livestock diversity/ numbers/types	Global sheep density	F6_002_001	UN FAO Gridded Livestock of the World	
		Global cattle density	F6_002_002	UN FAO Gridded Livestock of the World	
		Global goat density	F6_002_003	UN FAO Gridded Livestock of the World	
		Global pig density	F6_002_004	UN FAO Gridded Livestock of the World	
		Global poultry density	F6_002_005	UN FAO Gridded Livestock of the World	
		Cattle distribution: Ethiopia	F6_002_007	ILRI, IFAD	
		Camel distribution: Kenya	F6_002_008	ILRI, GTZ	
		Cattle density: Kenya	F6_002_009	ILRI, MALDM	
		Livestock distribution: Ethiopia	F6_002_010	ILRI, IFAD	
		Exotic chicken, turkey and geese density: Uganda	F6_002_011	ILRI, Uganda Bureau of Statistics	
		Total poultry and duck density: Uganda	F6_002_012	ILRI, Uganda Bureau of Statistics	
		Livestock distribution: Kenya	F6_002_013	World Resources Institute	
	Crop area/yield/ irrigated yield/ diversity/reliance on cash crops	Crop yield: Banana/plantain	F6_003_001	HarvestChoice MapSpaM	
		Crop yield: Barley	F6_003_002		
		Crop yield: Bean	F6_003_003		
		Crop yield: Sugar cane	F6_003_004		
		Crop yield: Maize	F6_003_005		
		Crop yield: Cotton	F6_003_006		
		Crop yield: Groundnut	F6_003_007		
		Crop yield: Cassava	F6_003_008		
		Crop yield: Coffee	F6_003_009		
		Crop yield: Millet	F6_003_010		

Composite indicator	Indicator	Dataset	Dataset no.	Source	Spatial output
Income diversification	Crop area/yield/ irrigated yield/ diversity/reliance on cash crops	Crop yield: Other fibres	F6_003_011	HarvestChoice MapSpaM	
		Crop yield: Other oils	F6_003_012	HarvestChoice MapSpaM	
		Crop yield: Other pulses	F6_003_013	HarvestChoice MapSpaM	
		Crop yield: Potatoes	F6_003_014	HarvestChoice MapSpaM	
		Crop yield: Rice	F6_003_015	HarvestChoice MapSpaM	
		Crop yield: Sorghum	F6_003_016	HarvestChoice MapSpaM	
		Crop yield: Soy bean	F6_003_017	HarvestChoice MapSpaM	
		Crop yield: Sweet potato/yam	F6_003_018	HarvestChoice MapSpaM	
		Crop yield: Wheat	F6_003_019	HarvestChoice MapSpaM	
		Crop yield (irrigated): Barley	F6_003_020	HarvestChoice MapSpaM	
		Crop yield (irrigated): Bean	F6_003_021	HarvestChoice MapSpaM	
		Crop yield (irrigated): Coffee	F6_003_022	HarvestChoice MapSpaM	
		Crop yield (irrigated): Cotton	F6_003_023	HarvestChoice MapSpaM	
		Crop yield (irrigated): Groundnut	F6_003_024	HarvestChoice MapSpaM	
		Crop yield (irrigated): Banana/ plantain	F6_003_025	HarvestChoice MapSpaM	
		Crop yield (irrigated): Maize	F6_003_026	HarvestChoice MapSpaM	
		Crop yield (irrigated): Millet	F6_003_027	HarvestChoice MapSpaM	
		Crop yield (irrigated): Other pulses	F6_003_028	HarvestChoice MapSpaM	
		Crop yield (irrigated): Potatoes	F6_003_029	HarvestChoice MapSpaM	
		Crop yield (irrigated): Rice	F6_003_030	HarvestChoice MapSpaM	
		Crop yield (irrigated): Sorghum	F6_003_031	HarvestChoice MapSpaM	
		Crop yield (irrigated): Soy bean	F6_003_032	HarvestChoice MapSpaM	
		Crop yield (irrigated): Sugar cane	F6_003_033	HarvestChoice MapSpaM	
		Crop yield (irrigated): Sweet potato/yam	F6_003_034	HarvestChoice MapSpaM	
		Crop yield (irrigated): Wheat	F6_003_035	HarvestChoice MapSpaM	

SOCIAL SYSTEM

Composite indicator	Indicator	Dataset	Dataset no.	Source
Health	Access to improved water & facilities	Access to improved water	S4_001_001	WHO / UNICEF JMP
		Water sources: Kenya	S4_001_002	ILRI, ACT
		Water sources (bore holes): North Uganda	S4_001_003	WE Consult
		Water sources: Somalia	S4_001_004	ILRI, FSAU
		Water sources: Somalia	S4_001_005	SWALIM, SWIMS
		Safe water coverage by subcounty: Uganda	S4_001_007	World Resources Institute
		Water sources: North Kenya	S4_001_008	ILRI, GTZ
		Access to water (household characteristics): Eritrea	S4_001_009	Measure DHS
		Access to water (household characteristics): Ethiopia	S4_001_010	
		Access to water (household characteristics): Kenya	S4_001_011	
		Access to water (household characteristics): Uganda	S4_001_012	
	Life expectancy	Life expectancy and mortality	S4_002_001	WHO World Health Statistics 2013
	Orphan health	Orphans: Eritrea	S4_003_001	Measure DHS
		Orphans: Ethiopia	S4_003_002	
		Orphans: Kenya	S4_003_003	
		Orphans: Uganda	S4_003_004	
	Infant mortality	Infant mortality	S4_004_001	WHO World Health Statistics 2013
	Disease metrics (malaria, HIV etc.) Disease metrics (malaria, HIV etc.)	Malaria distribution	S4_005_001	Malaria Atlas Project
		Causes of death among children <5 years	S4_005_002	WHO World Health Statistics 2013
		Number of reported cases: Cholera	S4_005_003	
		Number of reported cases: Malaria	S4_005_004	
		Prevalence of HIV	S4_005_005	The World Bank
		Number of reported cases of cholera	S4_005_006	WHO Global Health Observatory Data Repository
		Number of reported deaths from cholera	S4_005_007	WHO Global Health Observatory Data Repository
		HIV prevalence by background characteristics: Ethiopia	S4_005_008	Measure DHS
		HIV prevalence by background characteristics: Kenya	S4_005_009	Measure DHS
		HIV prevalence by background characteristics: Uganda	S4_005_010	Measure DHS
		Age-standardized mortality rates by cause	S4_005_011	WHO World Health Statistics 2013
		Kenya DHS 2008	S4_005_012	Measure DHS
		Uganda DHS 2006	S4_005_013	Measure DHS
		Ethiopia DHS 2005	S4_005_014	Measure DHS
		HIV prevalence by age and sex: Ethiopia	S4_005_015	Measure DHS
	Disease metrics (malaria, HIV etc.)	HIV prevalence by age and sex: Kenya	S4_005_016	Measure DHS
	% Expenditure on health	Total health expenditure	S4_006_001	WHO Global Health Expenditure Database
	Distance to health centres / number health centres	Healthcare facilities	S4_007_002	WHO World Health Statistics 2013
		Healthcare access: Eritrea	S4_007_003	Measure DHS
		Healthcare access: Ethiopia	S4_007_004	
		Healthcare access: Uganda	S4_007_005	

Composite indicator	Indicator	Dataset	Dataset no.	Source	Spatial output
Health	Distance to health centres / number health centres	Unmet need for family planning	S4_007_006	WHO World Health Statistics 2013	
		SPAs: Kenya	S4_007_007	Measure DHS	
		Health facilities: Somalia	S4_007_008	SWALIM	
Education	Education (schools, literacy rates, gender)	Educational attainment by age and sex: Eritrea	S5_001_001	Measure DHS	
		Educational attainment by age and sex: Ethiopia	S5_001_002		
		Educational attainment by age and sex: Kenya	S5_001_003		
		Educational attainment by age and sex: Sudan	S5_001_004		
		Educational attainment by age and sex: Uganda	S5_001_005		
	Number of schools	Location of schools: Somalia	S5_002_001	SWALIM	
	Health education	Adult literacy rates	S5_003_003	UNDP	
Governance	Crime rates	Homicide count and rate	S6_001_001	UN ODC	
	Property rights and legal indicators	Legal indicators and property rights	S6_004_001	Ibrahim Index of African Governance	
		CPIA property rights and rule-based governance rating	S6_004_002	The World Bank	
	Equitable society indicators & orphan care	Wealth quintiles: Ethiopia	S6_005_001	Measure DHS	
		Wealth quintiles: Kenya	S6_005_002	Measure DHS	
		Wealth quintiles: Uganda	S6_005_003	Measure DHS	
	Role and participation of women	Women's participation in decisionmaking: Eritrea	S6_006_001	Measure DHS	
		Women's attitude toward wife beating: Eritrea	S6_006_002	Measure DHS	
		Women's participation in decisionmaking: Ethiopia	S6_006_003	Measure DHS	
		Women's attitude toward wife beating: Ethiopia	S6_006_004	Measure DHS	
		Women's participation in decisionmaking: Kenya	S6_006_005	Measure DHS	
		Women's attitude toward wife beating: Kenya	S6_006_006	Measure DHS	
		Women's participation in decisionmaking: Uganda	S6_006_007	Measure DHS	
		Women's attitude toward wife beating: Uganda	S6_006_008	Measure DHS	
		Gender equality indicators (Ibrahim Index)	S6_006_009	Ibrahim Index of African Governance	
		Women in national parliament	S6_006_010	The World Bank	
		Gender Parity Index in primary level enrolment	S6_006_011	UN MDG	
		Gender Parity Index in secondary level enrolment	S6_006_012	UN MDG	
		Gender Parity Index in tertiary level enrolment	S6_006_013	UN MDG	
		Gender Parity Index as ratio of literacy rates	S6_006_014	UN MDG	

Composite indicator	Indicator	Dataset	Dataset no.	Source	Spatial output
Governance	Role and participation of women	Seats held by women in national parliament	S6_006_015	UN MDG	
		Seats held by women in national parliament (percentage)	S6_006_016	UN MDG	
	Inclusivity indicators	Digitised map of ethnic groups	S6_007_001	Murdock, G.P. (1959) Africa, its peoples and their cultural history	
		Geo-referencing of ethnic groups	S6_007_002	GREG	
	National Level Governance	Governance indicators (Ibrahim Index)	S6_008_001	Ibrahim Index of African Governance	
	Policing	Presence of peace keepers (no. of troops, police and military observers in mandate)	S6_011_001	The World Bank	
		Number of police: South Sudan	S6_011_002	UN Police Magazine	
		Number of police: Kenya	S6_011_003	Interpol	
Social shocks	Conflicts	Armed Conflict Location and Event Dataset (ACLED): Djibouti	S7_001_001	ACLED	
		Armed Conflict Location and Event Dataset (ACLED): Eritrea	S7_001_002	ACLED	
		Armed Conflict Location and Event Dataset (ACLED): Ethiopia	S7_001_003	ACLED	
		Armed Conflict Location and Event Dataset (ACLED): Kenya	S7_001_004	ACLED	
		Armed Conflict Location and Event Dataset (ACLED): Somalia	S7_001_005	ACLED	
		Armed Conflict Location and Event Dataset (ACLED): South Sudan	S7_001_006	ACLED	
		Armed Conflict Location and Event Dataset (ACLED): Sudan	S7_001_007	ACLED	
		Armed Conflict Location and Event Dataset (ACLED): Uganda	S7_001_008	ACLED	
		Conflict dataset (PRIO)	S7_001_009	PRIO	
	Displacement migration	Displacement indicators (migration rates and reasons): Eritrea	S7_002_001	Measure DHS	
		Migration and Displacement Statistics (UNHCR)	S7_002_002	UNHCR Population Statistics Database	

Spatial outputs

6

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 Figure 4)*, 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).

Figure 3: Spatial tool output 1 - summary table

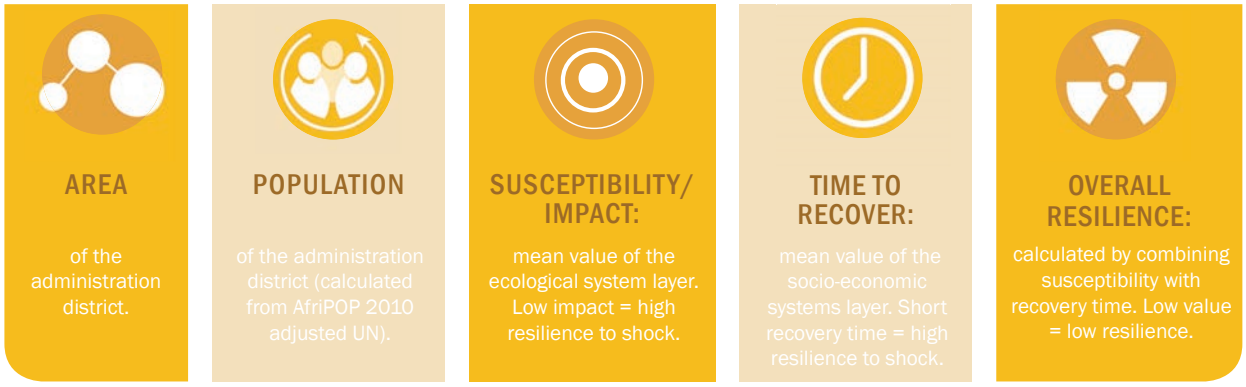
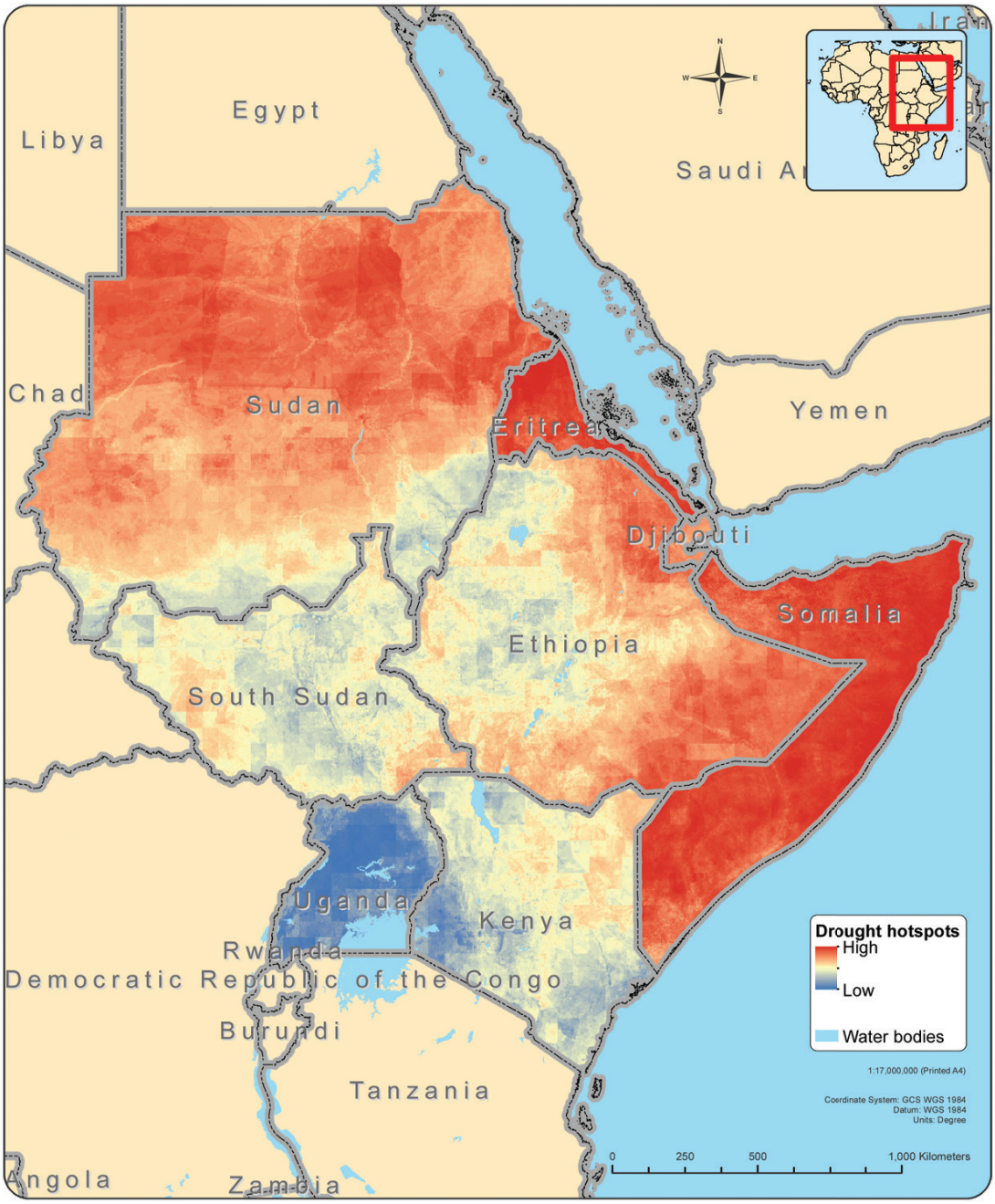


Figure 4: Spatial tool output 2 - Map.
Relative resilience to drought: Drought hotspots in the Horn of Africa



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.

Future development of spatial tool

7

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[4], 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.

[4] 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

8

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 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