A regional approach to drought index-insurance in Intergovernmental Authority on Development (IGAD) countries

Volume III: Technical feasibility assessment

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A regional approach to drought index-insurance in Intergovernmental Authority on Development (IGAD) countries

Volume III: Technical feasibility assessment

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Acronyms and abbreviations

eMODIS	EROS Moderate Resolution Imaging Spectroradiometer
FAO	Food and Agriculture Organization of the United Nations
IBLI	Index-based livestock insurance
IGAD	Intergovernmental Authority on Development
ISODATA	Iterative Self-Organizing Data Analysis Technique
MODIS	Moderate Resolution Imaging Spectroradiometer
NDVI	Normalized Difference Vegetation Index
TLU(s)	Tropical livestock unit(s)

1. Introduction

The following report describes the technical feasibility analysis conducted to assess areas that have appropriate agroecological and technical conditions for implementation of index-based livestock insurance (IBLI) solutions in the Inter-Governmental Authority on Development (IGAD) region. This desk study was conducted in the latter half of 2020 by the International Livestock Research Institute under the Drought Index Insurance for Resilience in the Sahel and Horn of Africa project, which has been commissioned by the United Kingdom Foreign, Commonwealth and Development Office. The study is conducted across eight IGAD countries: Djibouti, Eritrea, Ethiopia, Kenya, Somalia, South Sudan, Sudan and Uganda.

IBLI is an asset protection insurance coverage aimed at providing payouts when agricultural drought is detected[1] (i.e. at the end of a wet season) to support pastoralists in protecting their livestock. When relative forage availability over a certain insurance unit falls below a pre-defined threshold, insurance payouts are triggered. To assess the relative forage availability, the IBLI index is designed from time series of Normalized Difference Vegetation Index (NDVI) satellite imagery, which are obtained from 10-day composites at 250m spatial scale from the pre-processed EROS Moderate Resolution Imaging Spectroradiometer (eMODIS) data available since July 2002. NDVI is an indicator of vegetation greenness and can be used as a proxy for the amount of green forage available for livestock in rangelands. To obtain the seasonal forage availability index used for IBLI (henceforth in this document, the IBLI index), NDVI is aggregated over spatial units, averaged seasonally, and compared to long-term averages to assess seasonal anomalies (Vrieling et al. 2016).

This technical feasibility analysis aims at evaluating where the key conditions for designing the IBLI index are met. The design of the IBLI index is optimal when the agroecology and quality of the satellite signal meet certain criteria. Specifically, the following three major pre-conditions need to be considered.

1. **Dominance of rangelands.** Rangeland dominance is required to make sure that IBLI is appropriate for the location and that the satellite NDVI signal is not influenced by other land covers, such as crops or forests, that are not used for livestock herding.
2. **Sufficient forage production.** NDVI detects greenness, thus the land surface requires a minimum level of green vegetation during at least part of the season to obtain a meaningful signal. In this document this will be used interchangeably with the term 'valid areas' which include locations for which the vegetation characteristics (including vegetation abundance, and interannual variability) suggest that an NDVI based insurance product could be meaningful.
3. **Distinct seasonality to separate wet from dry seasons.** The temporal aggregation of NDVI relies on the definition of start and end dates for the vegetation seasonal cycle(s). In addition, these dates define the parameters of the insurance policy (i.e. coverage period, sales windows, time of payouts). In drylands, areas with limited intra-seasonal variability in NDVI normally correspond to evergreen forest, bare land or mixed land use. Such areas are not ideal targets for IBLI.

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[1] Agricultural drought refers to a period with below-normal soil moisture content and consequent crop/pasture production deficit without any reference to surface water resources (Mishra and Singh 2010). In the IBLI product, a satellite indicator of forage availability is used to detect agricultural drought.

This study presents a new methodology for an IBLI feasibility assessment at regional level, incorporating lessons learned from recent national-level feasibility studies conducted by the International Livestock Research Institute.

In recent technical assessments at national level (e.g. Fava et al. 2018; Kahiu and Fava, 2018), the NDVI data were first spatially aggregated to administrative units before the feasibility analysis was undertaken. However, this reduces flexibility of the approach to adapt to other unit definitions, which can be problematic given that the existing administrative units may not be optimal for effective insurance design. Therefore, the new methodology uses pixel-level analysis instead, which is more computationally intensive but improves the flexibility and makes the assessment more comparable between multiple countries (i.e. the way administrative units are defined changes between countries and can influence the result of the assessment). In fact, the pixel-level analysis can also provide valuable input for delineating the insurance units with local stakeholders, a critical step to be undertaken for design and implementation of the IBLI product in the region (Chelanga et al. 2017).

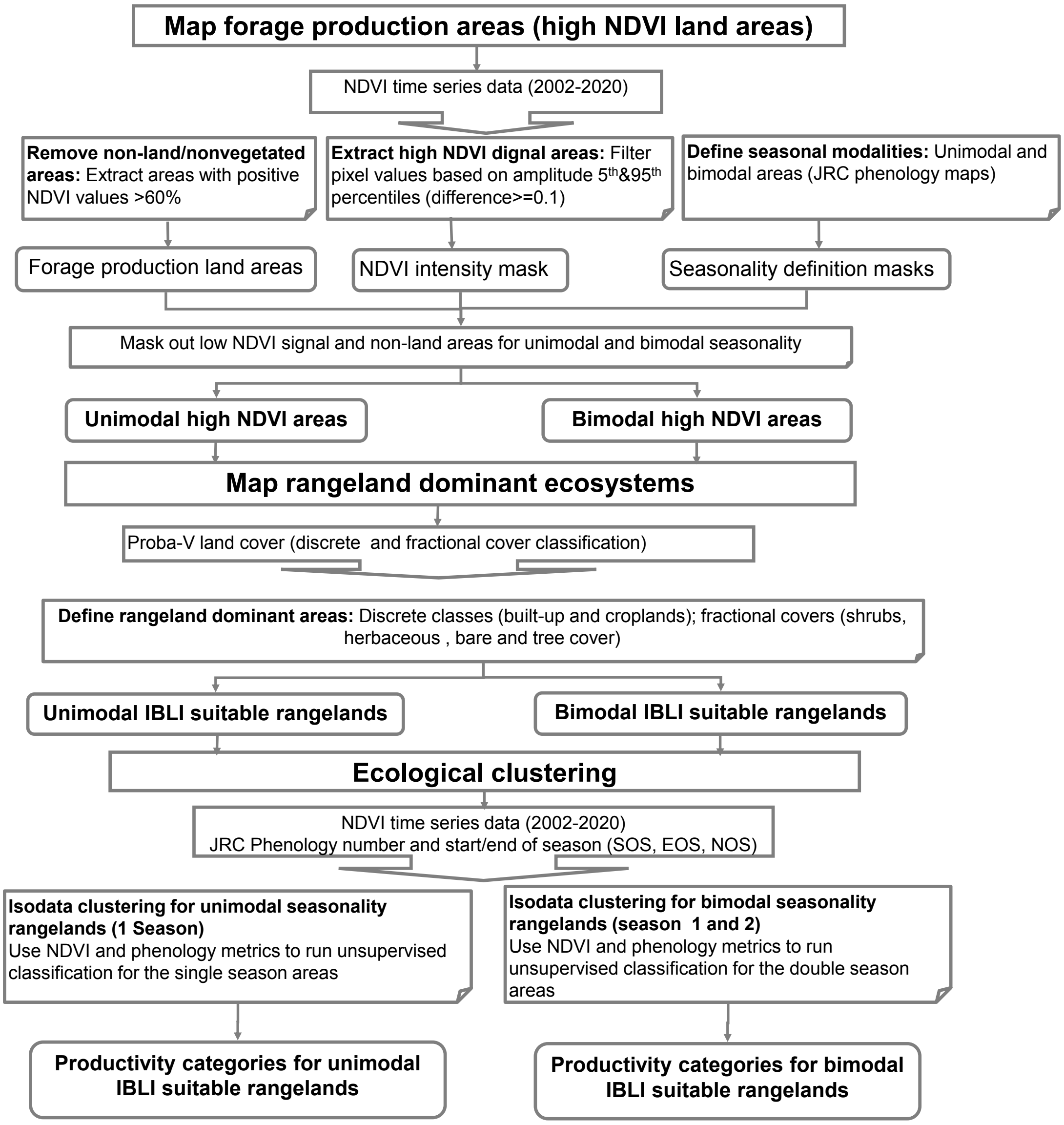
The new approach involves two critical steps: (i) the identification of areas where IBLI seems feasible to implement, and (ii) the characterization of the vegetation productivity and seasonality in these areas to better inform future product design. The methodology combines multiple indicators derived from satellite remote sensing and ancillary geospatial datasets. Pre-conditions for feasibility are determined using a rangeland cover map, phenology and NDVI intensity. Subsequently, stepwise classification and thresholding techniques are applied on multiple NDVI-based indicators (cumulative seasonal NDVI, NDVI amplitude, NDVI variability) for classifying the areas where the pre-conditions are met into broad clusters of vegetation production and phenology. Finally, spatial statistics are used to summarize the extent of the areas which are deemed feasible for IBLI and, based on an existing gridded livestock map, the livestock density within those areas is obtained. It should be noted that the feasibility analysis provides a preliminary assessment of areas where the IBLI product design could be potentially implemented. The assessment, however, needs to be followed by an in-depth review and discussion with local stakeholders during the early implementation stages of any initiative aimed at launching an IBLI product.

2. Methodology

2.1 Overview of the methodology

The identification of areas for which an IBLI product is deemed feasible is structured across three consecutive steps: (i) selection of areas where the NDVI signal is sufficient to design the IBLI index (i.e. high NDVI intensity thus valid forage production areas); (ii) extraction of areas dominated by rangelands; and (iii) clustering of the retained areas into classes of similar production and phenology. Figure 1 provides an overview of the methodology.

Figure 1: Overview of methods used to map out index-based livestock insurance feasible areas across the IGAD countries.



2.2 Datasets and pre-processing steps

The analysis combines multiple remote sensing and geospatial datasets. Table 1 provides details of the datasets used for the analysis, which are all freely accessible and publicly available. The dataset used for extracting the NDVI time series is similar to the one used for the IBLI product implemented in Kenya and southern Ethiopia. For land cover analysis, the Copernicus[2] land cover map was selected: the map is provided together with vegetation continuous field layers that provide fractional cover estimates for several land cover types including grass, shrubs, trees and bare soil. Although other land cover products exist, the merged Copernicus land cover discrete map with continuous field layers was selected due to its high temporal stability across years, higher spatial resolution compared to other products, good representation of rangeland ecosystems (based on our expert knowledge, and a key input in the analysis), as well as its relevance as an up-to-date product which will be available annually (Buchhorn 2020). The phenology metrics are extracted from freely available products distributed by the European Commission's Joint Research Centre.

Because the data cover different geographical domains and have different spatial and temporal resolutions, they were first subset to the IGAD extent, and then resampled to a 5-km spatial resolution to reduce data dimensionality for easier processing.

Table 1: Satellite data products used in the study.

Data	Product	Description and Source
NDVI	eMODIS Normalized Difference Vegetation Index (NDVI)	A 10-day temporal smoothed NDVI product at 250 m spatial resolution covering the period July 2002 to July 2020 derived from the Moderate Resolution Imaging Spectroradiometer onboard the Aqua satellite by the United States Geological Survey.
Land cover	Copernicus Global Land Service: Land Cover 100m: collection 3: epoch 2019: Globe	A global near-real-time annual land cover product for 2019 at 100 m spatial resolution. The product is produced by the Copernicus Land Service derived from PROBA-V satellite observations and ancillary datasets. The global map includes a discrete classification, with 23 classes aligned with FAO's land cover classification system (Meroni 2018).
	Copernicus Global Land Service: Fractional covers for • grass • shrubs • trees • bare	100 m resolution land-cover fractions, i.e. fractional cover for the four main classes used in the analysis, centred around the year 2019.
Phenology	Phenological timings • number of growing seasons • start of season • end of season	Three products were used: number of growing seasons per year, start of season and end of season. The IGAD region has both unimodal and bimodal precipitation regimes thus each season has a start and end product. These metrics were derived by the European Commission's Joint Research Centre from long-term-average 10-day MODIS NDVI data, pre-processed by the University of Natural Resources and Life Sciences, Vienna at 1 km resolution for 2013 to 2016 (Klisch and Atzberger 2016).

Notes: FAO – Food and Agriculture Organization of the United Nations.

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[2] Copernicus is the European Union's Earth observation programme. The land cover map is obtained from Copernicus Global Land Service (https://land.copernicus.eu/) global/products/lc), described in table 1.

2.3 Technical feasibility assessment

2.3.1 Selection of areas with sufficient signal and definition of seasonality

The IBLI product design depends on a clear seasonal vegetation signal that can be observed by optical sensors onboard satellites to determine relative forage availability. Areas with limited NDVI variability correspond either to non-vegetated areas or evergreen forests, while negative NDVI values represent (temporal) waterbodies or submerged vegetation. Following Vrieling et al. (2016), we masked non-land areas if the smoothed NDVI time-series data comprised <60% positive NDVI values. In addition, to remove areas with limited NDVI signal and variability, we extracted per-pixel the 5th and 95th percentiles of the time-series data from July 2002 to July 2020. A pixel was masked out if the difference between the 95th and the 5th percentiles was <0.1. It should be noted that the IBLI coverage is designed to detect forage availability during the rainy season, when some forage is generally available unless in the case of severe drought. Areas excluded by this procedure are largely barren/unproductive lands of minimal importance for livestock nutrition. This does not necessarily imply that livestock are never present in those areas, because they might be crossed during migration.

The implementation of IBLI also assumes a clear seasonality in vegetation growth, with distinct dry and wet periods, a typical feature of rangelands in dryland areas. Seasonality is also critical in IBLI as it informs key design parameters of insurance policy, such as the coverage period, sales windows and timing of payouts. To assess seasonality, we used phenological metrics that were derived by the European Commission’s Joint Research Centre from MODIS satellite data, as described in Table 1. These included spatial layers for the number of growing seasons per year (Figure 16) and the start and end of the vegetation season (start of season and end of season, respectively).

2.3.2 Determination of areas dominated by rangelands

An important pre-condition for IBLI product implementation is the dominance of rangelands, comprising arid and semi-arid lands characterized by tree-shrub-grass systems. Rangelands are a key component of extensive pastoral livestock systems (i.e. the target of the IBLI product), and the dominance of rangelands is also important to avoid the NDVI signal being influenced by other land covers with no value for livestock herding.

To determine rangeland extent, the Copernicus discrete land cover (Figure 2) and fractional cover products for 2019, available at 100 m spatial resolution, were used. We did not use the fractional shrub and grasslands layers of the Copernicus product directly because, after summing them to produce a savanna layer, we found the extents were too restrictive for a definition of rangelands in the region based on our expert knowledge. Therefore, the discrete land cover classes were used coupled with the continuous field layers (i.e. proportional cover) of built-up area and croplands (here both referred to as human landscapes), tree and bare-land fractions, in a decision tree classification approach to create an ad-hoc rangeland layer (Figure 3). In the decision tree classification, we first defined the savanna areas from the discrete classes map by merging the shrubs, herbaceous vegetation and herbaceous wetland classes as savannas, then identified savanna areas with the following conditions for the fractional covers: human landscapes <=40%, tree cover <=25% and bare land cover <=20%. This resulted in a binary layer of rangeland and non-rangelands.

Figure 2: Discrete land cover for the IGAD region.

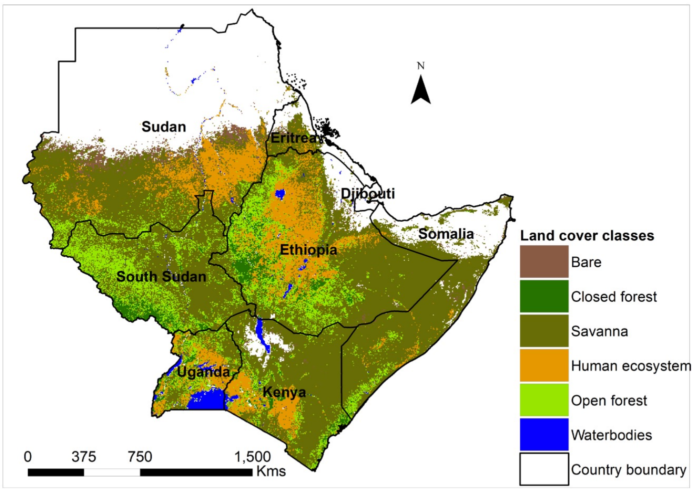
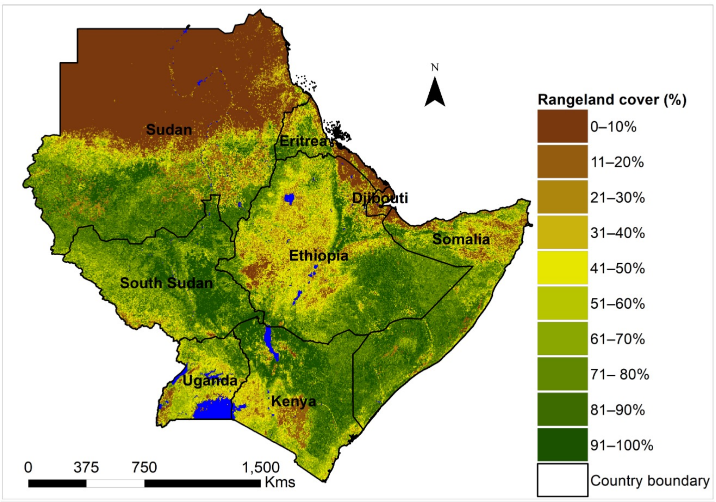


Figure 3: Rangelands fractional cover for the IGAD region comprising the sum of grass and shrub fractional covers.



2.3.3 Clustering of the feasible areas for IBLI

The retained pixels for which the NDVI signal and rangeland dominance were deemed sufficient for IBLI design were further classified into ecological strata by clustering pixels with similar NDVI-based long-term vegetation dynamics. Unsupervised classification using the commonly applied Iterative Self-Organizing Data Analysis Technique (ISODATA) algorithm was done to create land clusters according to their ecological characteristics. The ISODATA clustering technique uses the statistical differences or similarities of the image data to group pixels into discrete classes. The algorithm iterates until a convergence threshold is reached, resulting in the final discrete classes. Here, the ISODATA algorithm was applied in Python (Herranz and Tita 2013) with a predefined number of initial classes set at 1,000 for 200 iterations and 20 cluster pairs that could be merged, and a minimum number of 10 pixels in each cluster.

As input to the ISODATA classification, we extracted various metrics from the NDVI time series for the period July 2002 to December 2019 at the 5-km pixel level, each representing relevant information on vegetation characteristics for insurance purposes. These comprised the following:

(i) Cumulative NDVI as a measure of seasonal productivity (henceforth referred to as NDVI intensity). This was extracted from the 10-day-median NDVI profile integrated between the start and end of season using the European Commission's Joint Research Centre phenology metrics (Figure 4, Figure 5 and Figure 6).

(ii) NDVI amplitude as a measure of seasonal dynamics, calculated as the difference between the seasonal maximum NDVI and the NDVI at the start of season, based on the median dekadal NDVI profile (Figure 7, Figure 8 and Figure 9).

(iii) NDVI variability corresponding to seasonal vegetation cycles in response to precipitation, the principal limiting climatic factor in vegetation productivity in the tropics, thus informative of drought characteristics of an area. This was calculated by determining the multi-annual seasonal cumulative NDVI (from start of season to end of season) then extracting the multi-annual 20th percentile value divided by the 50th (median) percentile value (Figure 10, Figure 11 and Figure 12).

(iv) Length of the growing season, referring to the number of days when plant growth takes place, which can be used to determine the type of plants that can grow in an area and their productivity. The average length of growing season was determined by counting the number of dekads (10-day intervals) from start of season to the end of season (Figure 13, Figure 14 and Figure 15).

Figure 4: Multi-year average of cumulative NDVI used as input for the clustering of the IGAD area where IBLI is feasible – unimodal production regime in IGAD region countries.

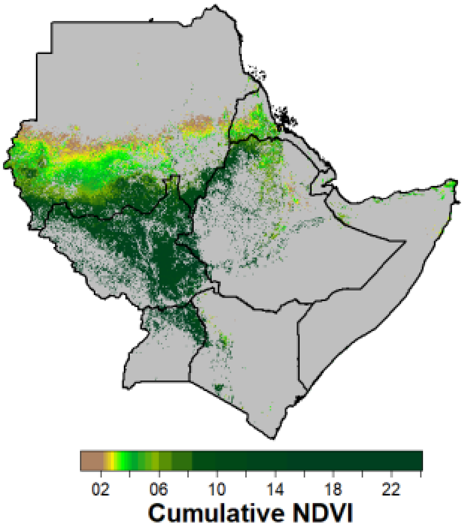


Figure 5: Multi-year average of cumulative NDVI used as input for the clustering of the IGAD area where IBLI is feasible – bimodal production regime for March–June in IGAD region countries.

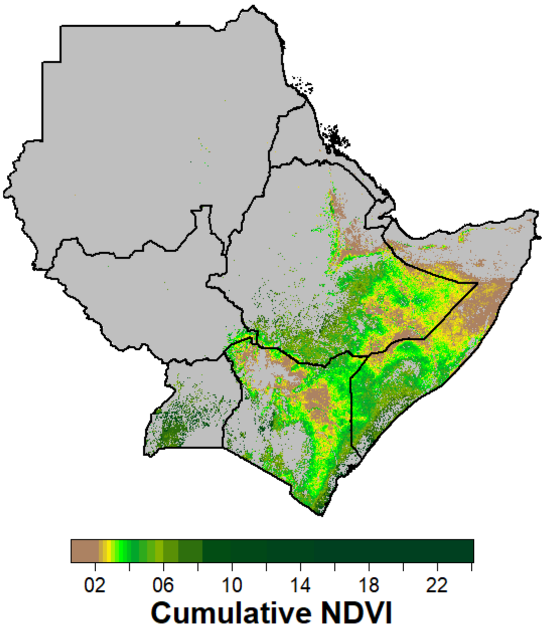


Figure 6: Multi-year average of cumulative NDVI used as input for the clustering of the IGAD area where IBLI is feasible – bimodal production regime for October–December/January in IGAD region countries.

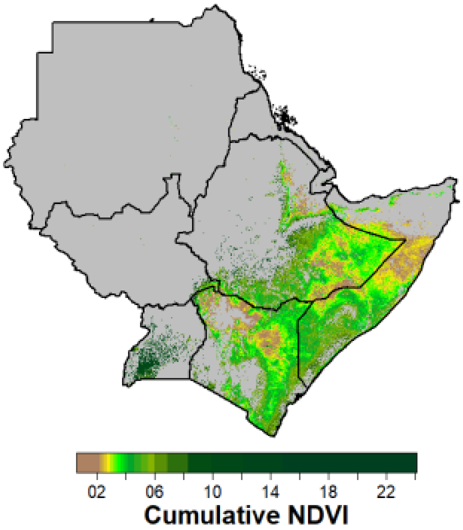


Figure 7: Multi-year average of NDVI amplitude used as input for the clustering of the IGAD area where IBLI is feasible – unimodal production regime in IGAD region countries.

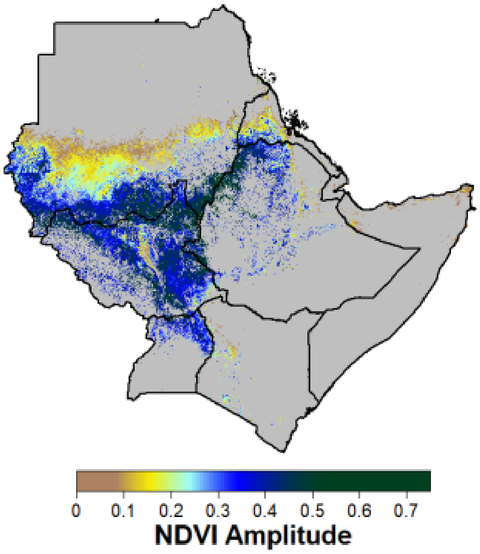


Figure 8: Multi-year average of NDVI amplitude used as input for the clustering of the IGAD area where IBLI is feasible -- bimodal production regime for March–June in IGAD region countries.

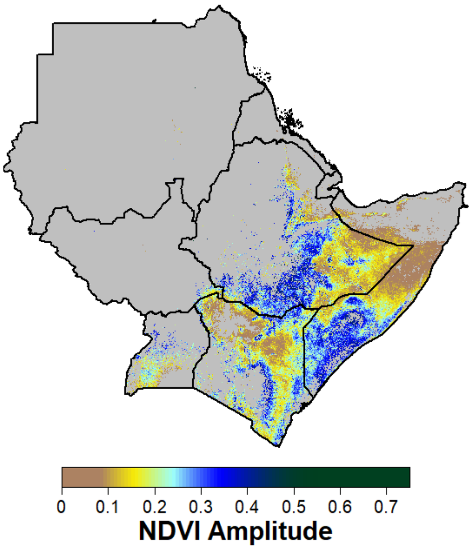
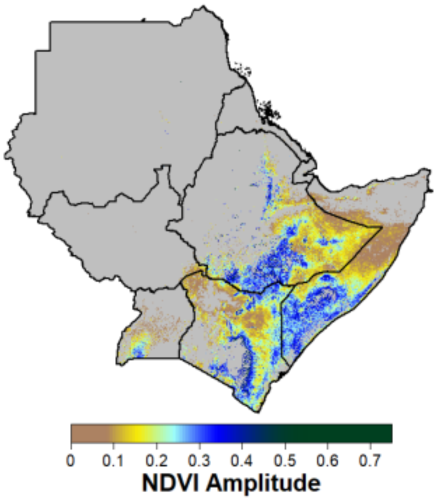


Figure 9: Multi-year average of NDVI amplitude used as input for the clustering of the IGAD area where IBLI is feasible -- bimodal production regime for October–December/January in IGAD region countries.



The ecological clustering was performed separately for unimodal and bimodal production regimes. As a result, the clustering for unimodal areas comprised four layers, while the one for bimodal areas, eight: four for each of the seasons.

Figure 10: Interannual variability of seasonally cumulated NDVI expressed as 20th percentile divided by the 50th (median) percentile used as input for the clustering of the IGAD area where IBLI is feasible – unimodal production regime in IGAD region countries.

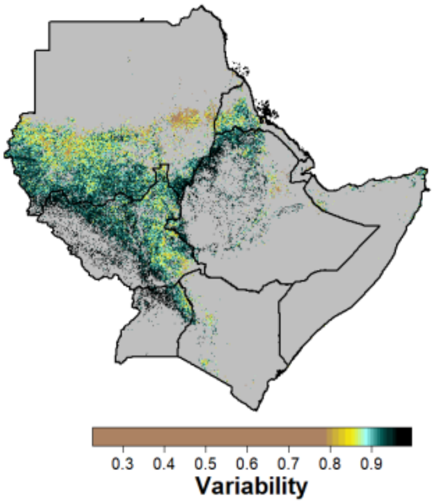


Figure 11: Interannual variability of seasonally cumulated NDVI expressed as 20th percentile divided by the 50th (median) percentile used as input for the clustering of the IGAD area where IBLI is feasible – bimodal production regime for March–June in IGAD region countries.

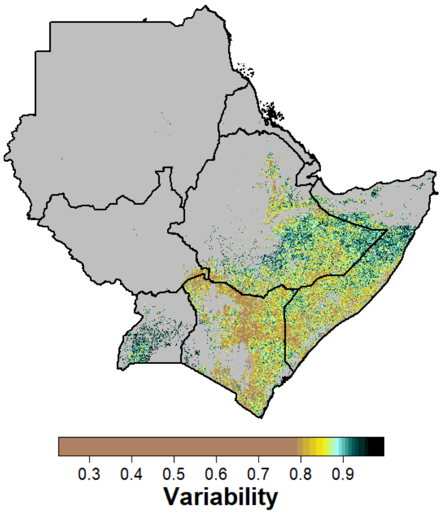


Figure 12: Interannual variability of seasonally cumulated NDVI expressed as 20th percentile divided by the 50th (median) percentile used as input for the clustering of the IGAD area where IBLI is feasible – bimodal production regime for October–December/January in IGAD region countries.

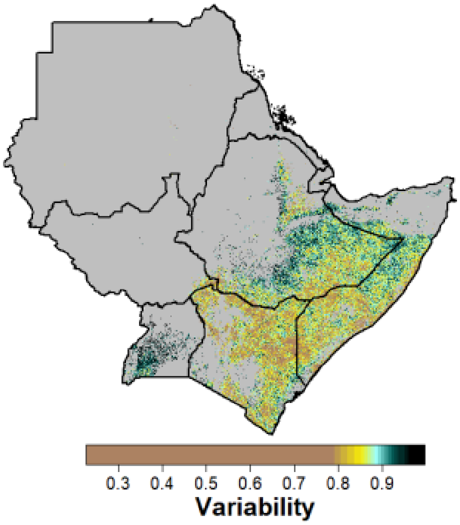


Figure 13: Average season length in 10-day periods (dekads) used as input for the clustering of the IGAD area where IBLI is feasible – unimodal production regime in IGAD region countries.

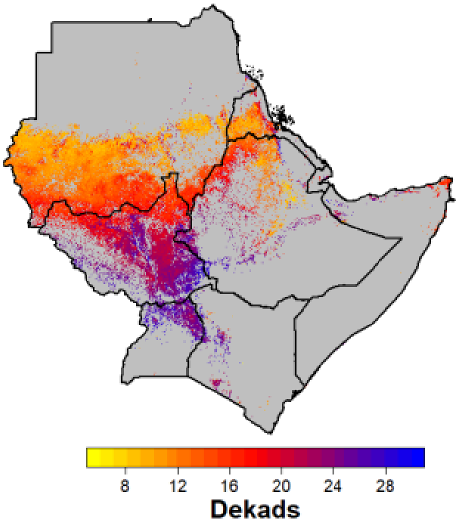


Figure 14: Average season length in 10-day periods (dekads) used as input for the clustering of the IGAD area where IBLI is feasible – bimodal production regime for March–June in IGAD region countries.

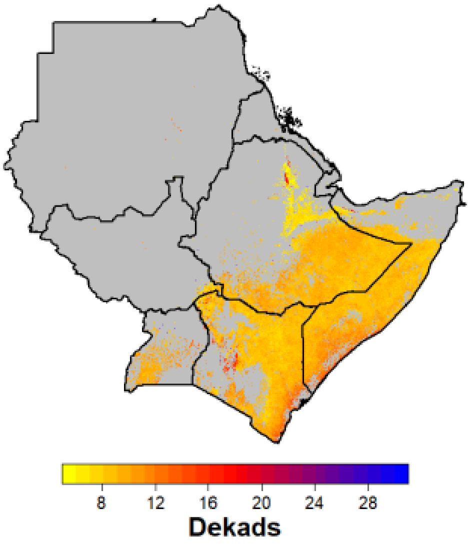
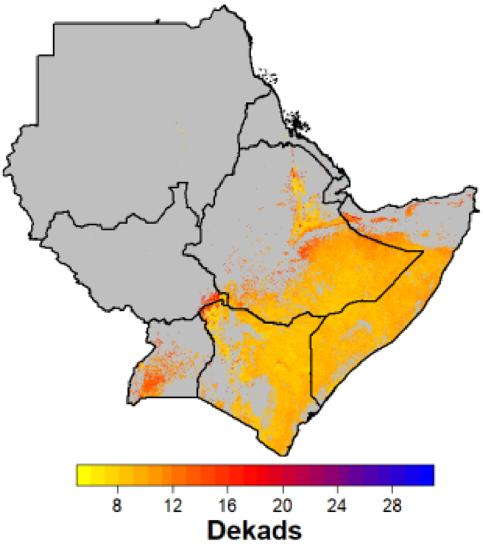


Figure 15: Average season length in 10-day periods (dekads) used as input for the clustering of the IGAD area where IBLI is feasible – bimodal production regime for October–December/January in IGAD region countries.

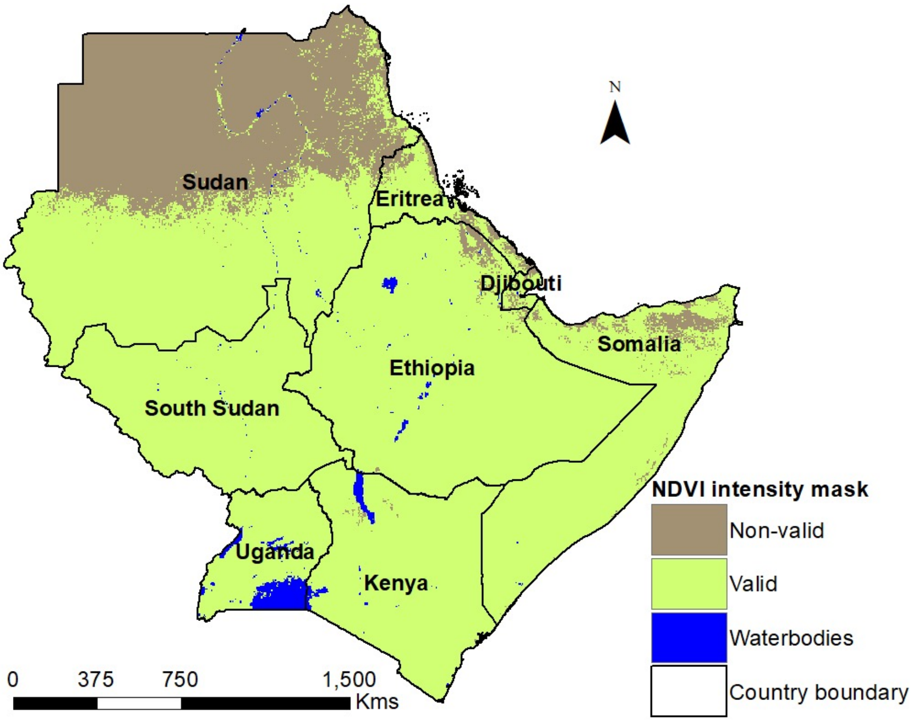


3. Results

3.1 Selection of valid areas, rangeland dominance and seasonality

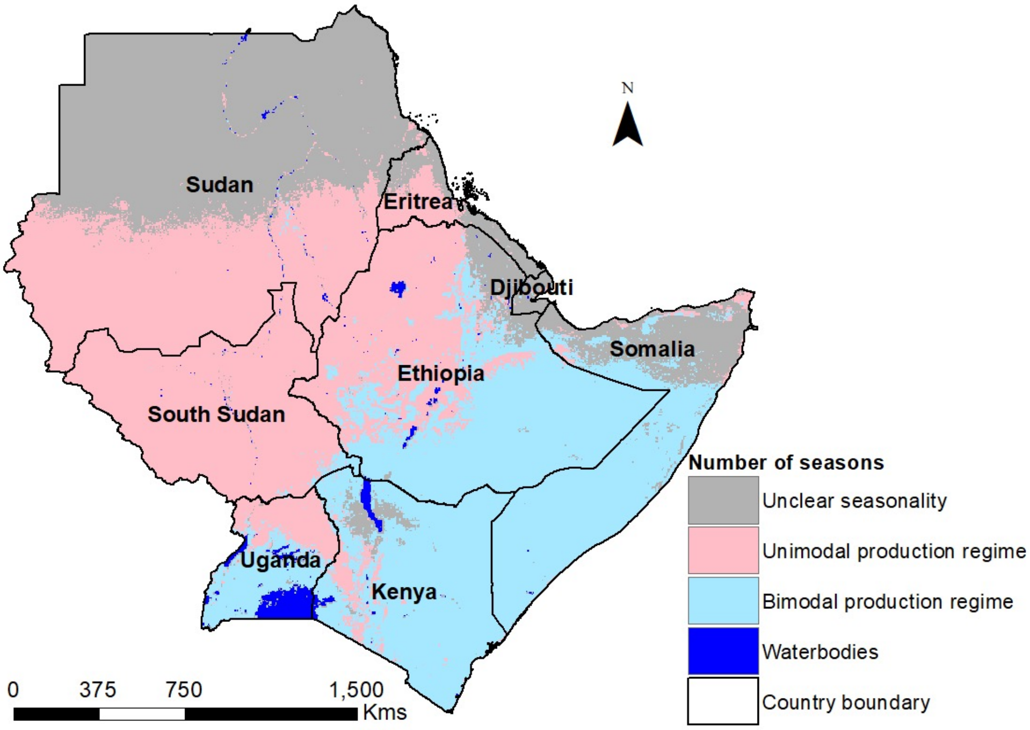
In the southern parts of the IGAD region, the NDVI amplitude was sufficiently large to discern a clear seasonal vegetation signal except for some locations with low vegetation production in northern Kenya (Marsabit and Turkana). In the north, the NDVI amplitude becomes too small – i.e. in the Sahara Desert (mainly in Sudan) as well as in some areas of northern Somalia, Djibouti and Eritrea (Figure 16) – consistent with the rangeland map.

Figure 16: Forage production areas shown by NDVI validity in IGAD region countries.



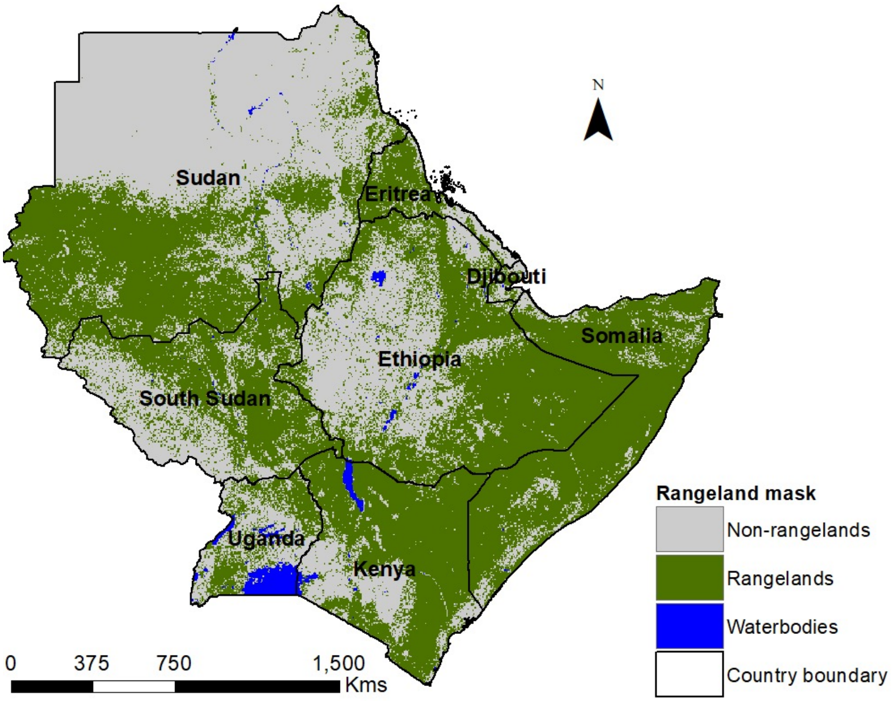
The IGAD region is characterized by both bimodal and unimodal precipitation regimes (Figure 17), thus resulting in two distinct vegetation growth seasons in most of the region. The southeast of the IGAD region mainly experiences a bimodal vegetation growth pattern with two distinct wet and dry seasons every calendar year, whereas the northwestern areas towards the Sahara Desert have a unimodal vegetation growth pattern. Large parts of low-productivity rangelands in northern Somalia, Djibouti and central/southern Eritrea are indicated to have limited seasonality in the European Commission's Joint Research Centre seasonality mask. However, from a qualitative review of the mask with local mapping products, several areas used by pastoralists were identified. As such, if for a given pixel both the validity and rangeland maps indicated feasible condition, the area was considered feasible even if the phenology layer suggested otherwise.

Figure 17: Vegetation growth regimes shown by number of seasons in IGAD region countries.



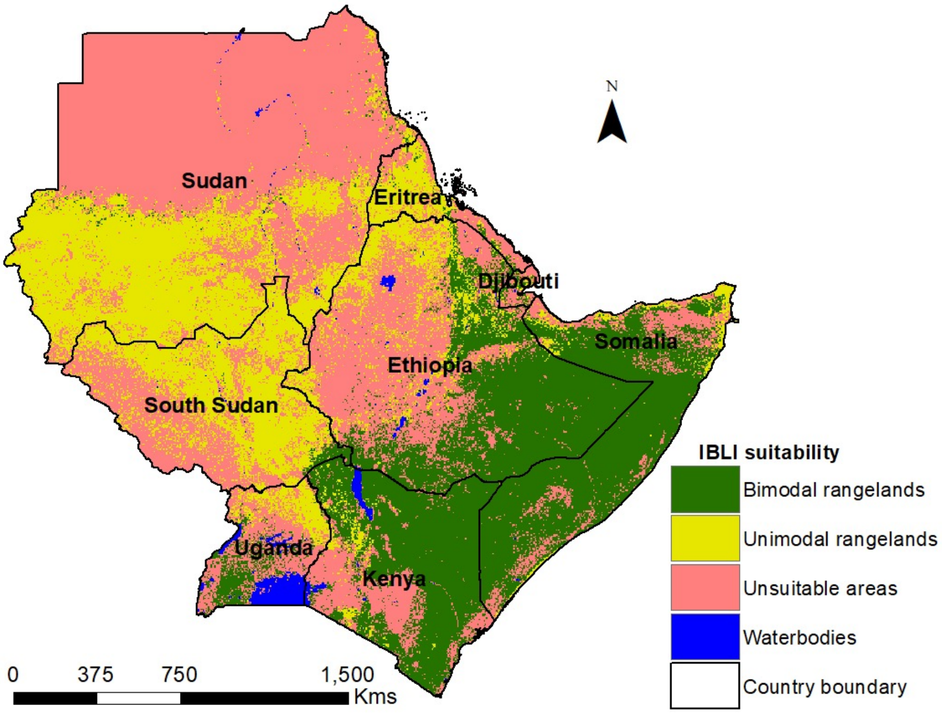
Based on the rangeland map, rangelands dominate the eastern and southern parts of Kenya and Ethiopia, southern part of Sudan, northeastern South Sudan and Uganda, northwestern Eritrea and almost all of Somalia (Figure 18). Only small portions of Djibouti within the central areas of the country have scattered rangelands, while bare lands dominate the country.

Figure 18: Rangeland dominant areas in IGAD region countries.



Based on NDVI validity (forage production areas) and rangelands dominant maps, we classified the region into areas suitable and unsuitable for implementation of IBLI (Figure 19). The suitable class comprises areas that meet the IBLI conditions of seasonality, NDVI intensity and rangeland dominance. This class is further subdivided into unimodal and bimodal suitable rangelands . The unsuitable class comprises areas lacking sufficient NDVI signal and where rangelands are not dominant.

Figure 19: IBLI suitability classification within the IGAD region based on seasonality for both unimodal and bimodal vegetation production regimes.



3.2 Mapping of areas feasible for IBLI

The unsupervised ISODATA classification resulted in 25 main clusters for both the unimodal (Figure 20) and bimodal (Figure 21) vegetation growth patterns. An assessment of variations in forage production levels was used to merge these clusters into three main classes. Within the unimodal vegetation pattern, clusters 0–5 corresponded to low forage production areas along desert fringes, classes 6–10 to moderate forage production areas, and classes 11–20 to high forage production areas, as also evidenced by high mean annual precipitation (Figures 1–4 in the appendix). Classes 21–24 contained <=5 scattered pixels and thus were discarded at the merging stage.

Figure 20: Resulting ecological clusters from ISODATA clustering for unimodal vegetation growth regimes in the IGAD region.

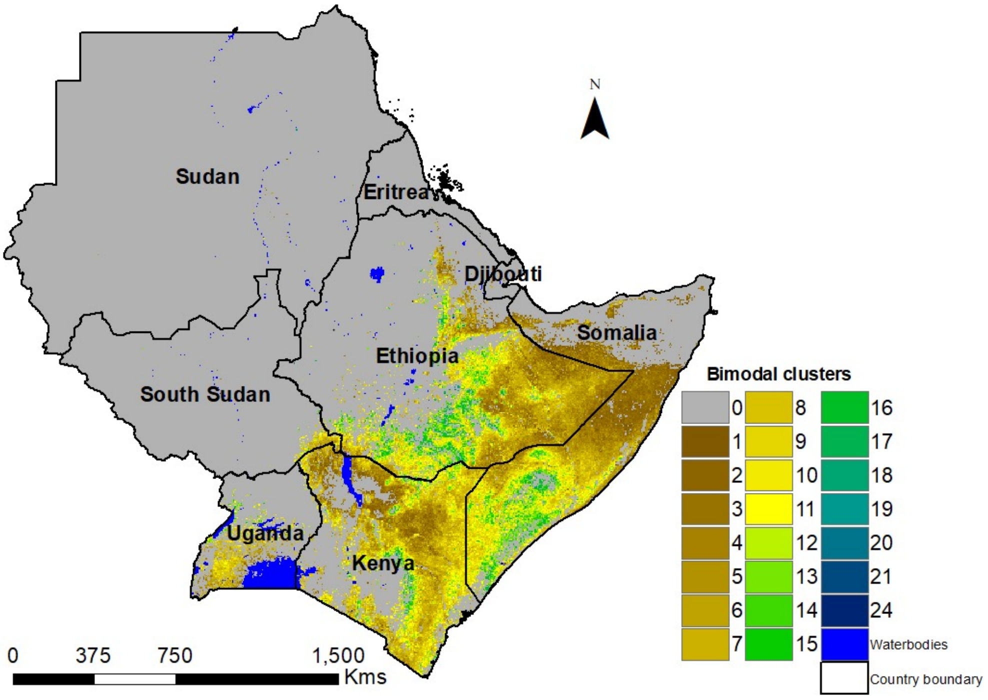
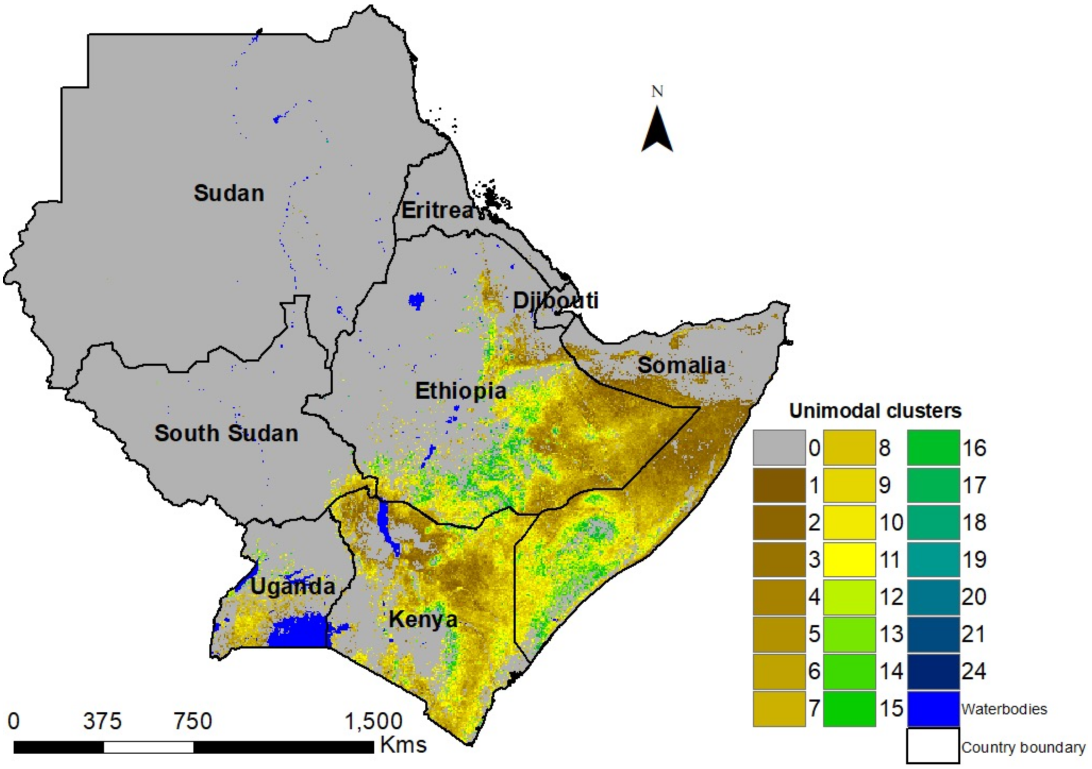
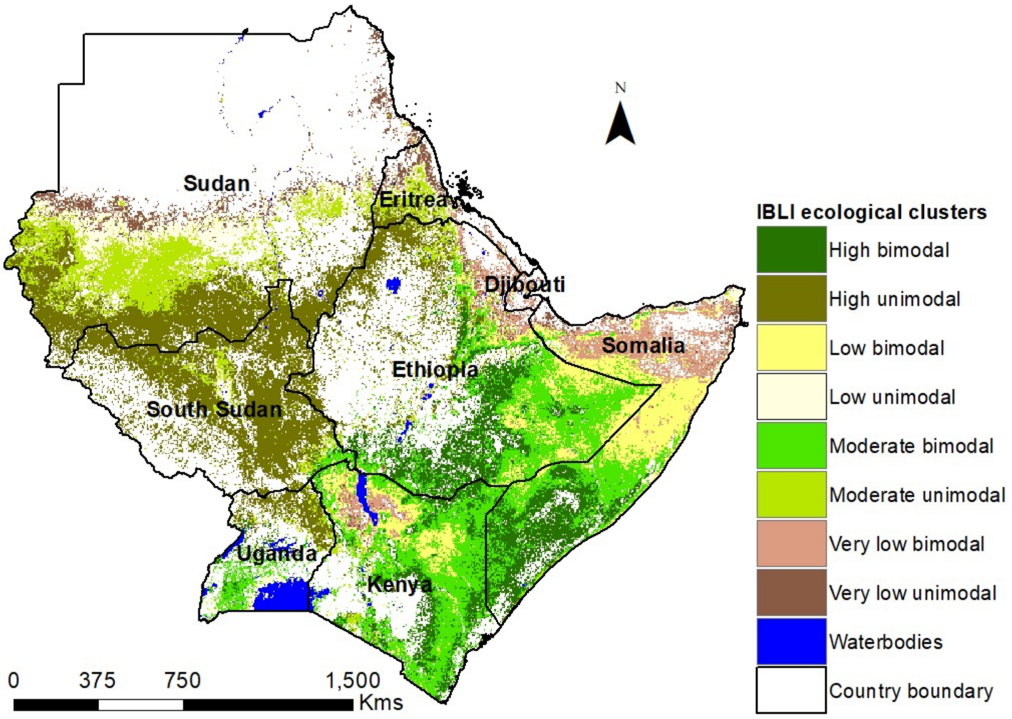


Figure 21: Resulting ecological clusters from ISODATA clustering for bimodal vegetation growth regimes in the IGAD region.



A similar approach was adopted for the bimodal clusters, whereby classes 0–4 were low forage production areas, 5–9 were moderate production and 10–20 were high production classes (Figure 22 and Figures 5–8 in the appendix). A fourth class which includes the very low production areas for unimodal and bimodal regimes was defined using the rangeland and valid NDVI masks only (see Section 3.1 and Figure 16, Figure 17 and Figure 18). These areas need to be carefully reviewed during the product design stage to confirm that they are effectively used by pastoralists and that seasonality could be defined by alternative approaches.

Figure 22: Classification of IBLI suitability based on different forage production levels (i.e. very low, low, moderate, high).



3.3 Country statistics

Overall, for 53.8% of the land area of the IGAD region, conditions are favourable for IBLI product design (Table 2). Sudan has the largest area suitable for IBLI across the IGAD region (12.7%), closely followed by Ethiopia (12.4%). At national level, Sudan has the least country area fraction suitable for IBLI (35.4%), followed by Djibouti and Uganda (both 40.5%). On the other hand, Somalia has the largest area suitable for IBLI (82.5%), followed by Kenya (72.9%), Eritrea (62%) and South Sudan (59.1%) (Table 2). It is noteworthy that for the very low production areas (Figure 22), although included in the statistics, there is need for further analysis to ascertain if their forage production characteristics allow for effective pastoral use. These areas form a significant portion of the rangelands for countries such as Djibouti, Eritrea and Somalia, as shown in Figure 22 and Table 2.

Table 2: Fraction of country areas where IBLI product design is feasible for the IGAD region.

	Djibouti	Eritrea	Ethiopia	Kenya	Somalia	South Sudan	Sudan	Uganda	Total
Country fraction									
Total land mass (thousand km^2)	22	120	1,129	586	633	628	1,870	241	5,230
Percentage of total land suitable (%)	40.5	62.0	57.4	72.9	82.5	59.1	35.4	40.5	--
Percentage of land suitable – unimodal rainfall regime (%)	29.3	92.0	25.5	5.4	6.3	96.9	98.2	47.4	42
Percentage of land suitable – bimodal rainfall regime (%)	70.7	8.0	74.5	94.6	93.7	3.1	1.8	52.6	52
IGAD fraction									
Total suitable (%)	0.17	1.43	12.39	8.17	9.98	7.10	12.67	1.87	53.8

We also assessed livestock distribution and total tropical livestock units (TLUs)[3] within the areas suitable for IBLI by country (Table 3). Here we used Food and Agriculture Organization of the United Nations (FAO) 2015 ruminant TLUs data (Gilbert et al. 2018) for livestock distribution; while for total TLUs we used the most recently available FAO statistics (FAOSTAT 2020). Although these data must be read with caution given the potential inaccuracy in the livestock distribution map, they provide a general overview of the proportion of the livestock herds that can be potentially covered by IBLI.

Table 3: Total TLUs per country, and proportion and number of total TLUs suitable for IBLI within the IGAD region

	Total TLUs	Proportion of total TLUs suitable for IBLI (%)	No. of TLUs suitable for IBLI
Djibouti	499,000	35.9	179,141
Eritrea	3,100,000	75.1	2,328,100
Ethiopia	70,800,000	38.0	26,904,000
Kenya	28,800,000	50.8	14,630,400
Somalia	17,100,000	84.5	14,449,500
South Sudan	15,100,000	61.6	9,301,600
Sudan	45,300,000	52.4	23,737,200
Uganda	17,600,000	43.4	7,638,400
Total IGAD Region	198,299,000	50.9	99,168,341

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[3] 1 TLU is equivalent to one head of cattle with a body weight of 250 kg. One sheep = 0.1 TLU, one goat = 0.1 TLU and one cow = 1 TLU.

In IGAD rangelands, different livestock types are reared: poultry, cattle, sheep, pigs, goats, horses, donkeys, mules and camels. However, only goats, sheep, cattle and camels are included in the analysis as these are the only ruminants covered by IBLI products. At the regional level, around 51% of the livestock population is found within IBLI-suitable areas. At the national level, Somalia has the largest number of livestock falling within IBLI-suitable areas, at 85% of the national livestock tally, while Eritrea is second at 75%.

4. Conclusions

This study assesses the technical feasibility for IBLI solutions in the IGAD region. To adapt the assessment to a regional (and potentially continental) level analysis, a new methodology has been developed. The methodology combines multiple remote sensing datasets in a sequential classification approach to (i) define the overall suitability or non-suitability for IBLI solutions at a 5-km spatial resolution, and (ii) characterize the suitable areas based on agroecological criteria (i.e. production and phenology). The main advantage of the newly proposed method compared to previous technical feasibility studies for IBLI is that no prior spatial aggregation to administrative units is required, but the analysis is performed at the NDVI pixel level, making the assessment more flexible. The choice of the insurance units can therefore be made during the product design and customization stages, with country stakeholders benefiting from the rangeland characterization made during this assessment, which could inform the customization of product design for the target location.

The overall results indicate that IBLI product design is feasible in about 54% of the IGAD region, and that about 51% of the total livestock in these countries could be covered. With reference to the IGAD land area, Ethiopia and Sudan have the highest proportion of suitable area (23% and 24%, respectively) followed by Somalia (18%) and Kenya (15%). In absolute terms, the same countries have the largest number of TLUs that could be covered, with Ethiopia first (26.9 million TLUs) and then Sudan (23.7 million TLUs). However, in terms of the proportion of the national herd that could be covered by IBLI, Somalia has the largest share (85%), followed by Eritrea (75%) and South Sudan (62%) (Table 3).

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Appendix

Vegetation growth profiles for IBLI-suitable clusters

The classification of IBLI-suitable areas into clusters with similar productivity and phenological characteristics across the IGAD region resulted in eight classes, four in each of the two seasonal regimes (unimodal and bimodal): very low, low, moderate and high production areas. These areas show similar growth patterns and intensity of NDVI across varying precipitation ranges, as shown in Figures 1–8. The very low productivity areas in both seasonal regimes have non-uniform profiles in most of the areas (see Figures 1 and 5).

Unimodal seasonality rangeland profiles

Figure 1: Unimodal vegetation growth patterns for areas with very low productivity shown with varying mean annual precipitation ranges.

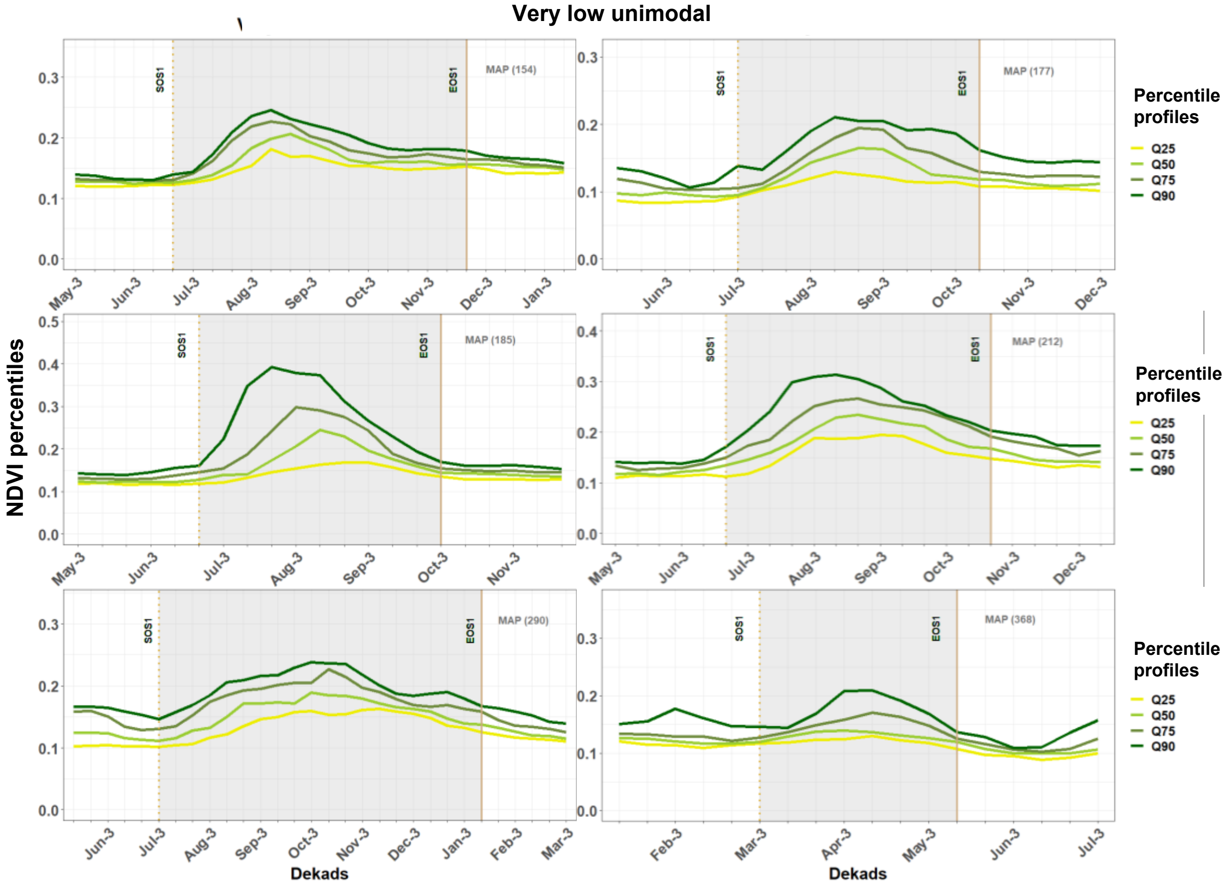


Figure 2: Unimodal vegetation growth patterns for areas with low productivity shown with varying mean annual precipitation ranges.

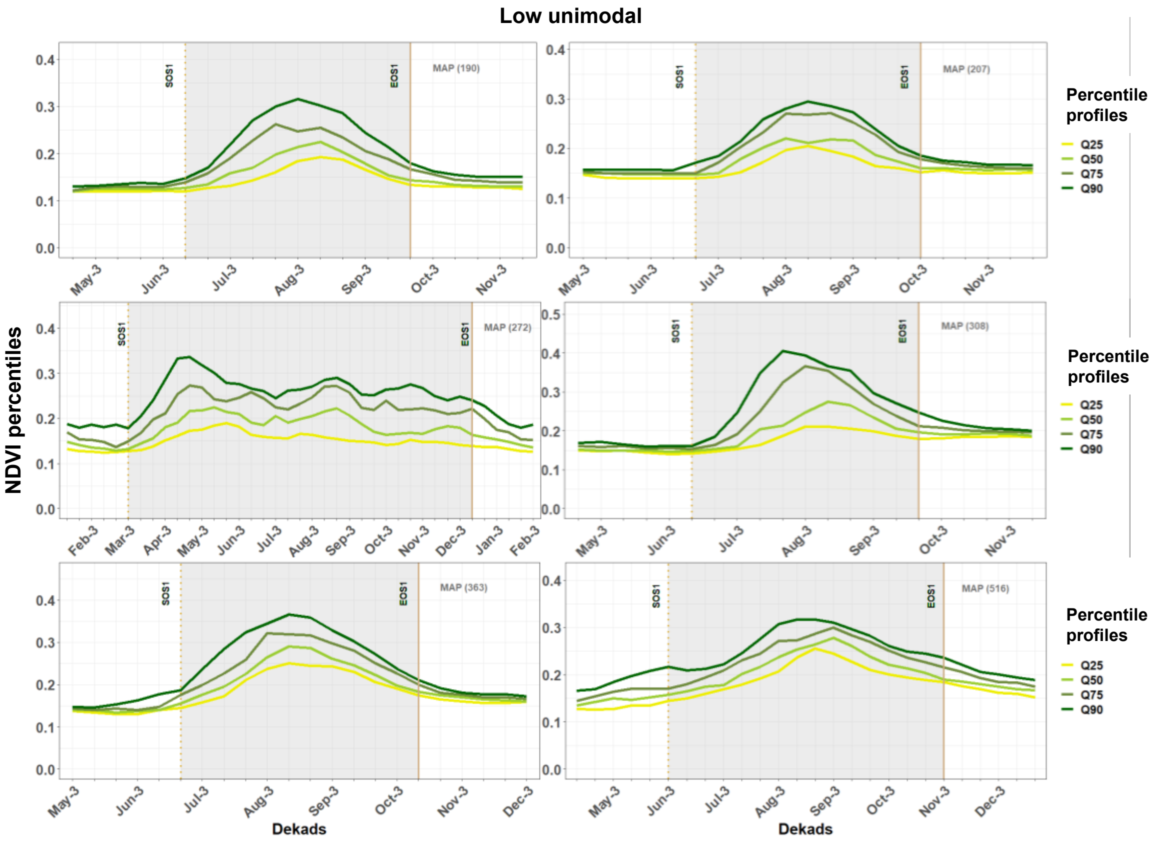


Figure 3: Unimodal vegetation growth patterns for areas with moderate productivity shown with varying mean annual precipitation ranges.

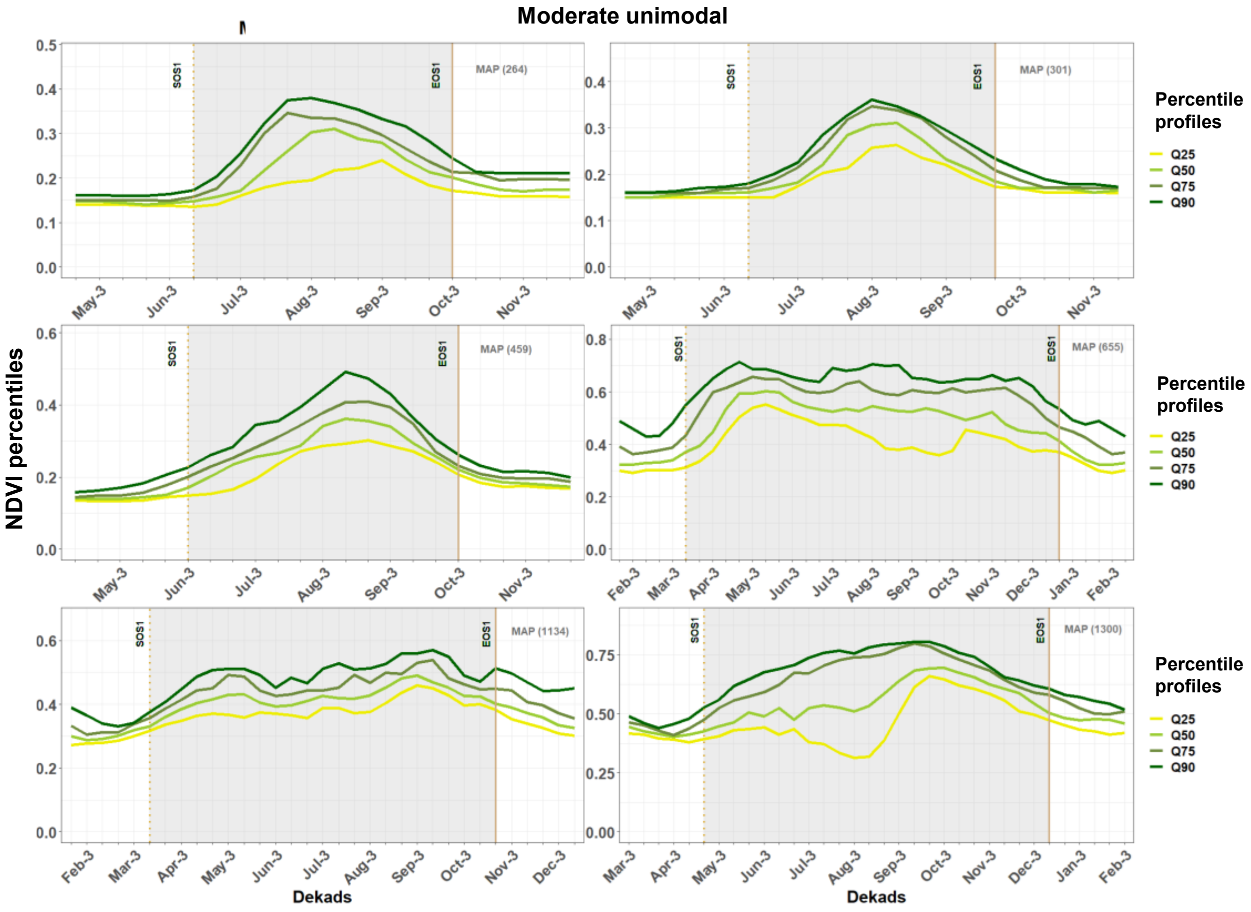
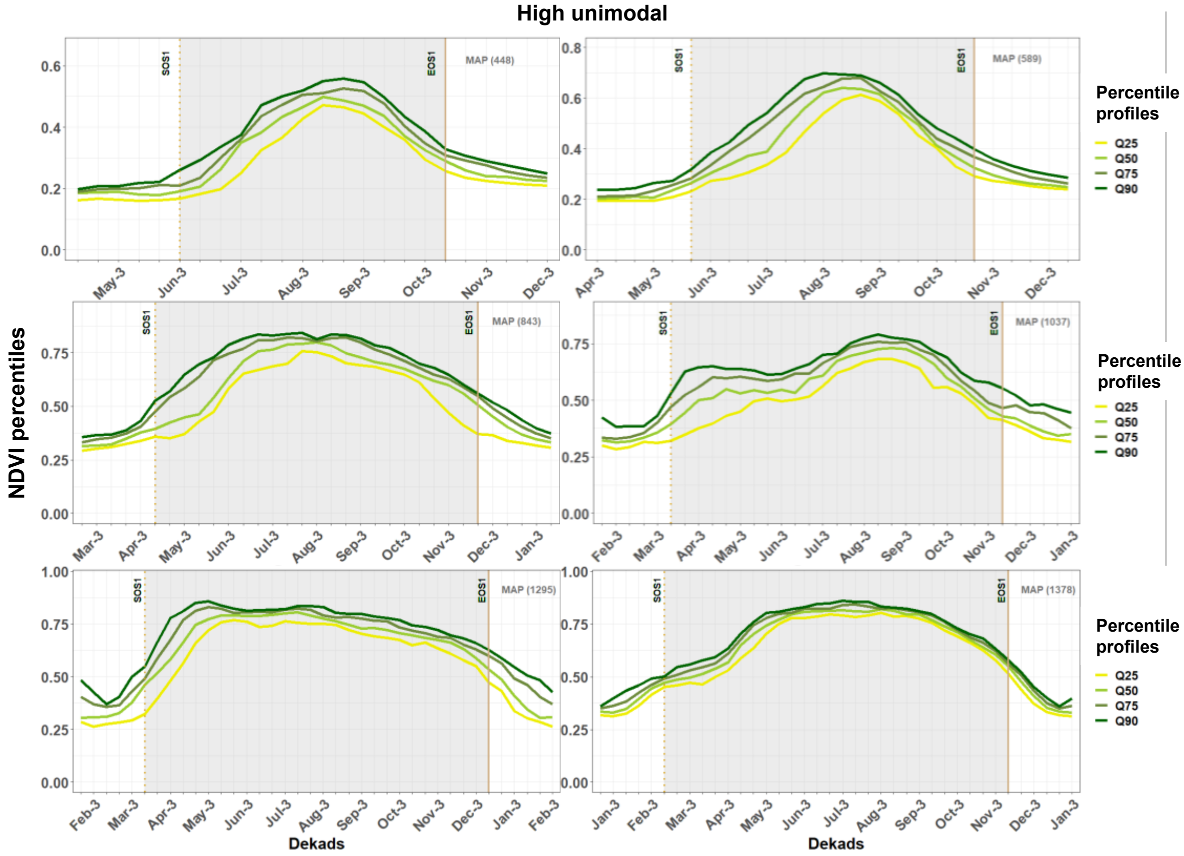


Figure 4: Unimodal vegetation growth patterns for areas with high productivity shown with varying mean annual precipitation ranges.



Bimodal seasonality rangeland profiles

Figure 5: Bimodal vegetation growth patterns for areas with very low productivity shown with varying mean annual precipitation ranges.

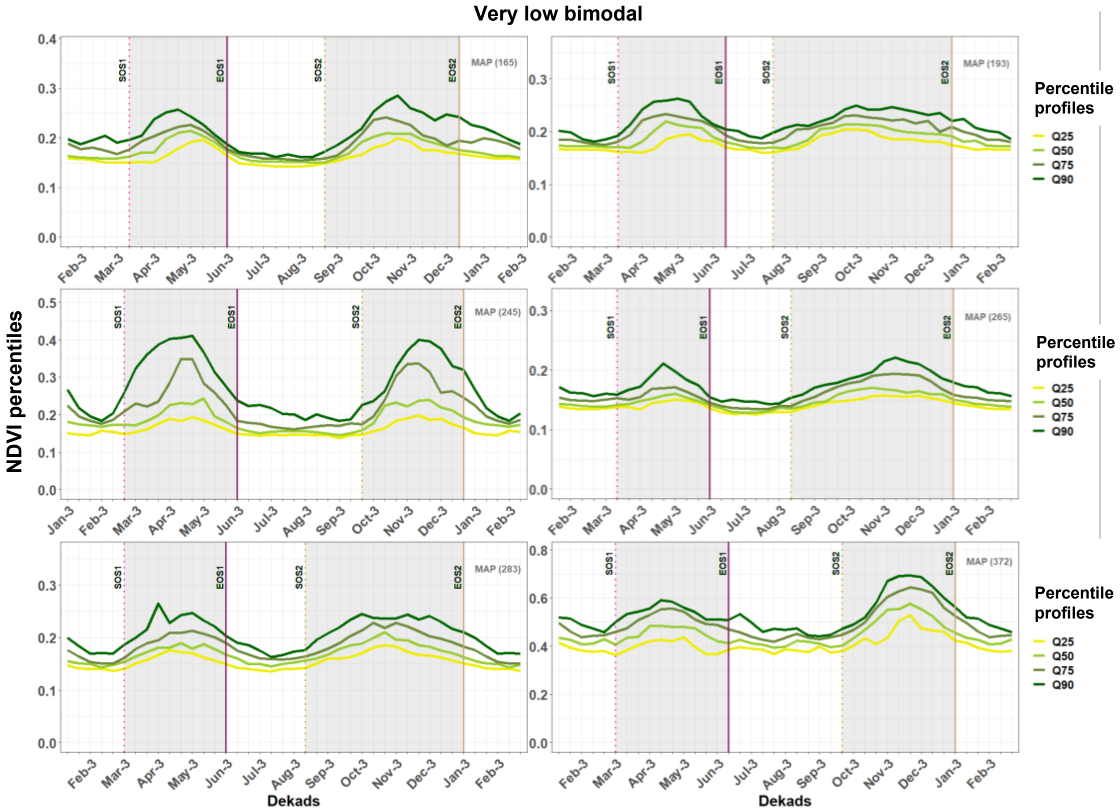


Figure 6: Bimodal vegetation growth patterns for areas with low productivity shown with varying mean annual precipitation ranges.

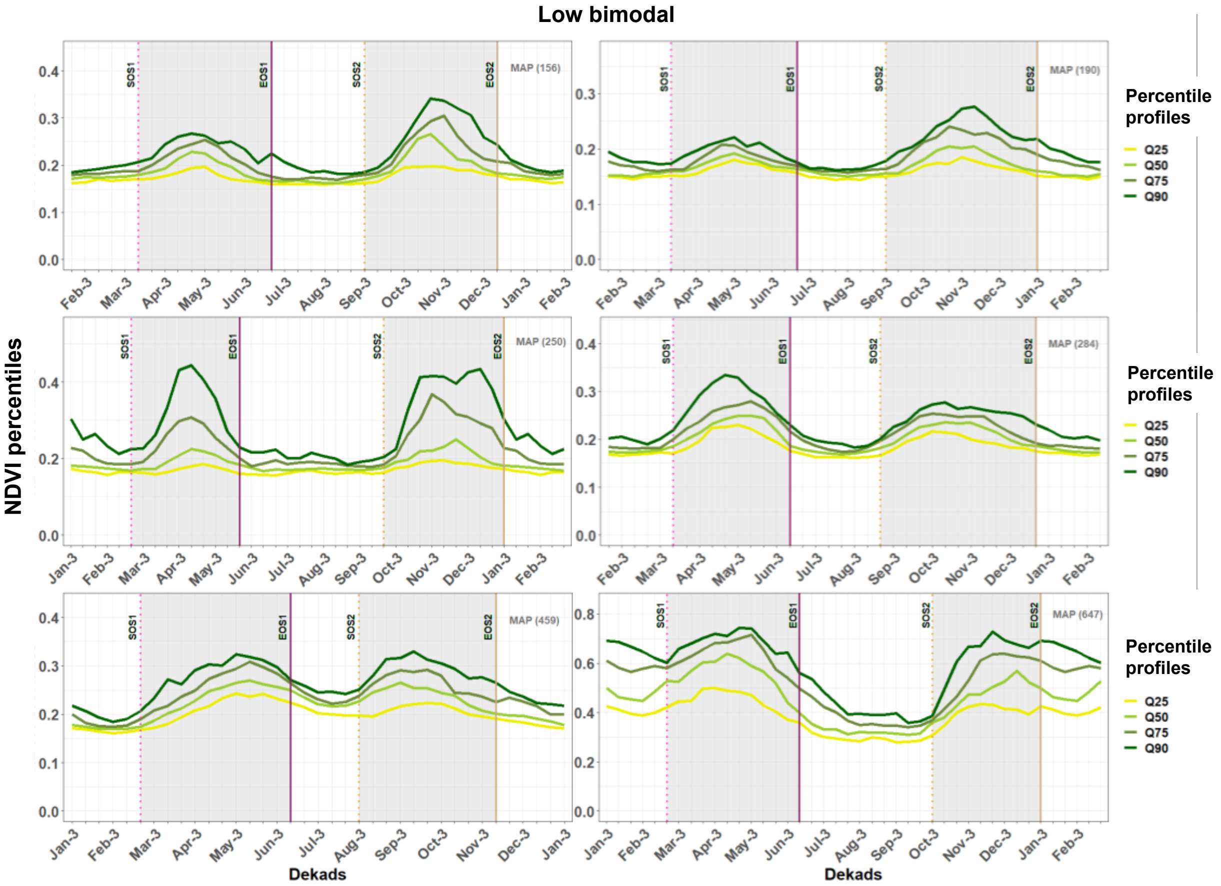


Figure 7: Bimodal vegetation growth patterns for areas with moderate productivity shown with varying mean annual precipitation ranges.

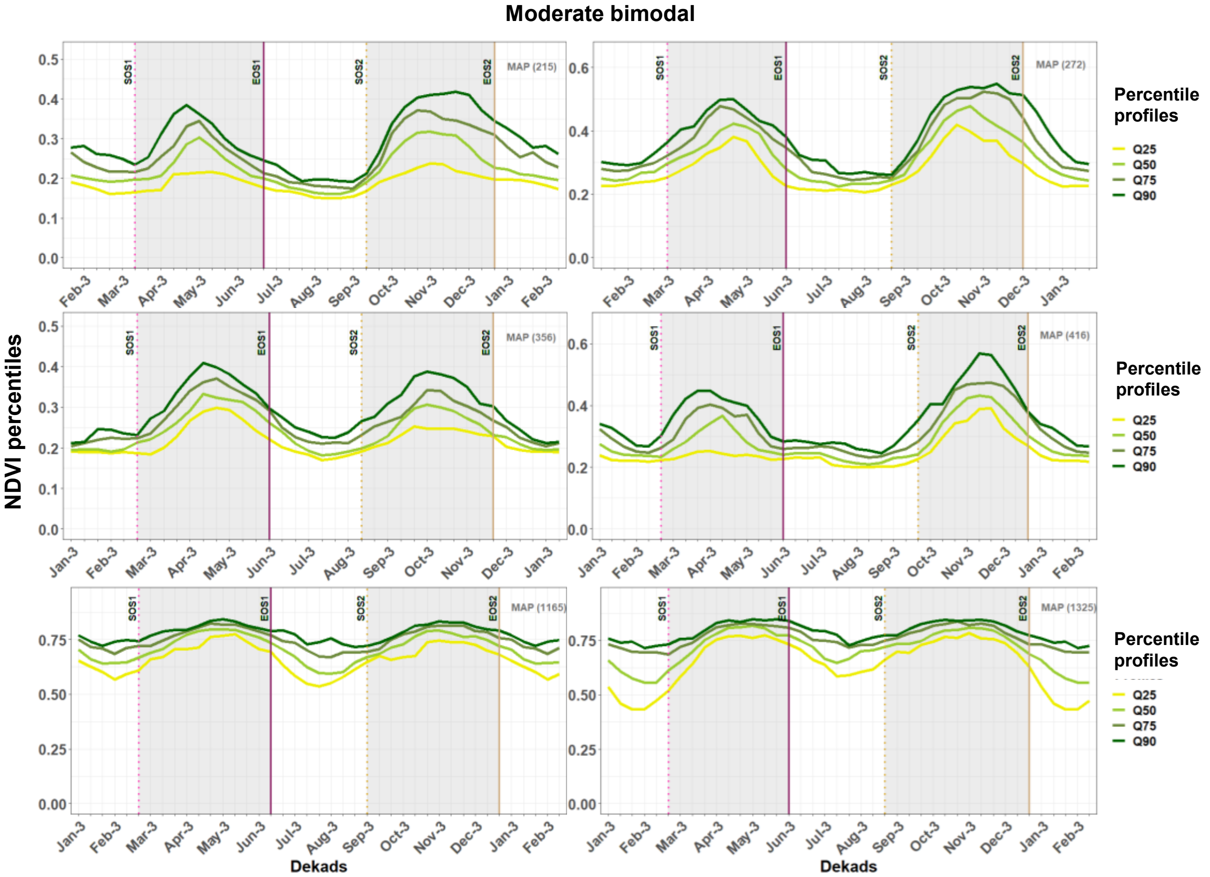
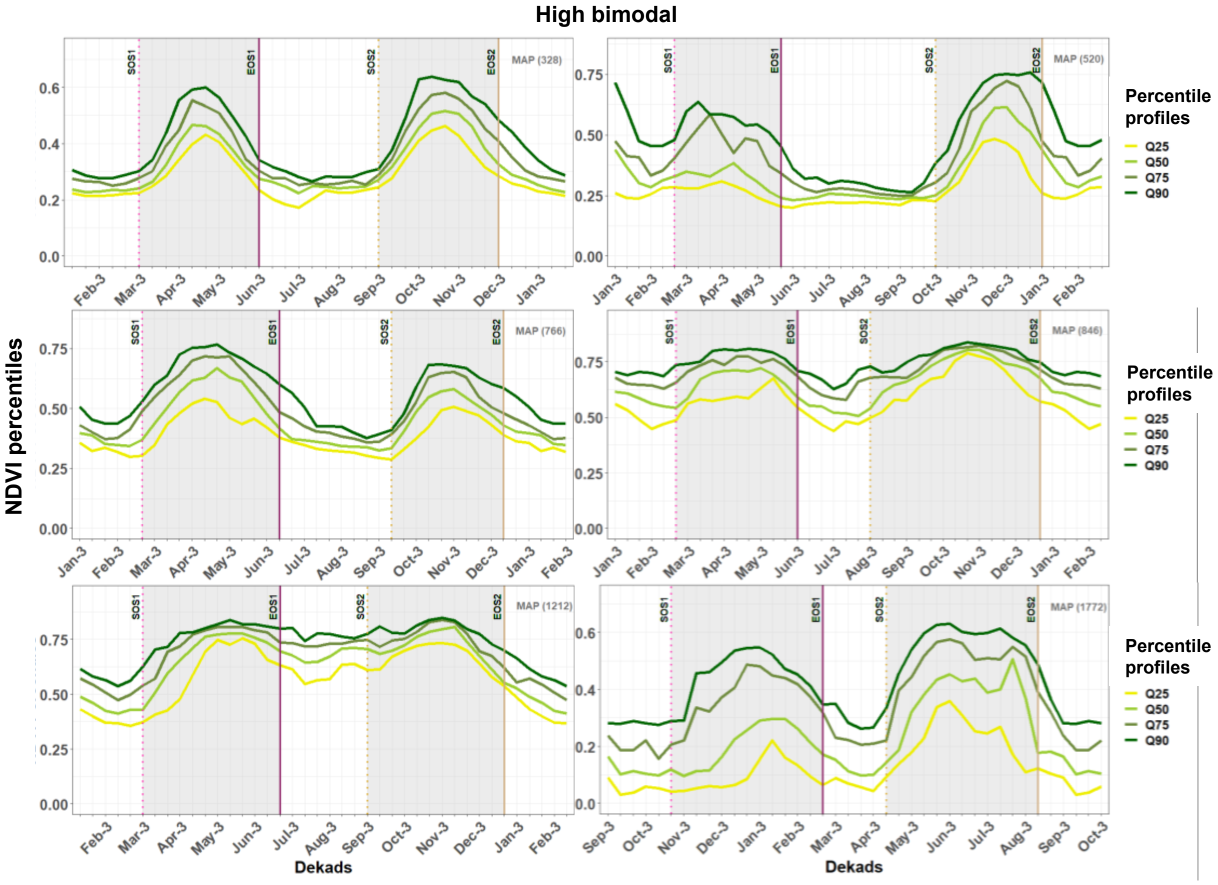


Figure 8: Bimodal vegetation growth patterns for areas with high productivity shown with varying mean annual precipitation range.



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