RESEARCH HIGHLIGHTS

CLIMATE CHANGE AND FUTURE CROP SUITABILITY IN ANGOLA

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Research Highlights – Climate Change and Future Crop Suitability in Angola

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BACKGROUND AND CONTEXT

The Adaptation for Smallholder Agriculture Programme (ASAP) is a flagship programme within the International Fund for Agricultural Development's (IFAD's) portfolio of activities aimed at channelling climate and environmental finance to smallholder farmers, and which allows IFAD country programmes to design projects which integrate considerations of the impacts of climate change on smallholder farmers. To support the integration of climate information and improved knowledge of climate related risks to the smallholder agriculture sector, IFAD commissioned a Climate Risk Analysis to assess the potential impacts of climate change on several crops and commodities in Angola.

The full Climate Risk Analysis report (accessible via the IFAD Country page [1]) provides an analysis of inter alia i) the current and future climate characteristics of Angola; ii) the potential change in the suitability of various crops under projected climate changes; and iii) potential risks and economic impacts related to climate change, as well as potential adaptation options and opportunities to increase climate resilience. The following report provides a brief summary of highlighted results for Angola, including: i) projected changes to temperature and precipitation as a result of climate change; and ii) impacts of climate change on the future suitability of several major crops and resulting impacts on production across each of the country's 18 provinces.

AGRICULTURE IN ANGOLA

Angola's agricultural production is characterised by moderately low productivity of a wide selection of staple crops, a diverse variety of annual and perennial horticultural products, and cash crops. Rainfed agriculture, practiced by smallholder farmers, accounts for the vast majority of the planted area. In addition to rainfed production of staple crops, there are complex mixed farming practices that include various fruit trees adjacent to households (bananas, avocado, mango, coconut, papaya and other), mixed kitchen-scale gardens for production of diverse vegetable crops, and grazed production of cattle and small ruminant livestock.

1 https://www.ifad.org/en/web/operations/country/id/Angola

SUMMARY RESULTS

The likely effects of climate change are not fully consistent between each of Angola's 18 provinces or the crops assessed, however, several general observations can be made. For example, all Provinces in the study area are predicted to experience increasing temperatures throughout the year, indicated by increased average monthly 'Mean Temperature' as well as average 'Minimum Temperature'. Furthermore, all provinces are predicted to experience increasing delays or inconsistencies in the onset of rainfall, and an overall decrease in the annual and seasonal precipitation between the present day and the 'Mid-Century' future (defined by the period 2040–2069). Average monthly rainfall is predicted to decrease in all Provinces, including during the months of October-December which are considered to be the start of the rainy season. These results may be indicative of a delay in the onset of the traditional rainy seasons, or alternatively a decrease in the effective duration of the rainy season. The overall effect of these reductions in monthly precipitation throughout the rainy season is to reduce the total seasonal rainfall for the period October–April by 8.5 %, from 765 mm/season to 700 mm/season. The total estimated change in annual rainfall between the Historical and Future periods is 84mm per year.

The full study includes analyses of the predicted effect of climate change on various crops, particularly cereals (maize, sorghum), legumes (beans, groundnuts), and root crops (cassava) in each of Angola's 18 provinces. The combined effects of reduced precipitation during the traditional growing seasons and increased temperatures will result in a complex matrix of positive and negative effects on the crops assessed. The annual production of critical staple crops such as beans, maize and sorghum is expected to be negatively impacted by increased temperatures and reduced or delayed rainfall, thereby causing a reduction in the extent of suitable production areas as well as reducing the productivity of remaining areas. Conversely, certain climate resilient species such as cassava and groundnuts are comparatively less affected by the predicted climate changes and experience mild positive effects on crop suitability in certain provinces. Arid southern provinces such as Namibe, Huila, Huambo, Cunene are predicted to experience negative impacts on virtually all crops – the latter areas are likely to require extensive support and capacity-building to manage the impacts of climate change on agricultural production and food security.

The climate-related risks to agricultural households in each Province are a function of both the impact of climate change on crop production, as well as the adaptive capacities of each community to manage and respond to climate risks. It is important to note that the following analyses are based on consideration of a narrow range of modelled variables and the resultant effects on crop suitability. Consequently, this study cannot account for local-level factors such as differences in performance, climatic suitability and yield potential between local land races or improved cultivars. This study cannot account for indirect effects of climate change on crop production, such as increased vulnerability to pests and disease, soil degradation or flooding/ waterlogging. However, the study does find that climate change is likely to result in multiple negative effects on smallholder farmers in the study area, through disruption of familiar seasonal trends, increased water and heat stress and reduced growing season. In the absence of adequately detailed socio-economic data, this study was unable to undertake a rigorous assessment of the adaptive capacities of farming households in each province – it is anticipated that the finalisation of Angola's next agricultural census study will contribute useful data that will support future initiatives focused on adaptive capacity and vulnerability to climate change.

METHOD AND APPROACH

The analyses presented in this study are intended to provide an illustrative comparison of the potential effects of future climate change on production of economically important crops, as well as the differential impacts of climate change on agricultural households in each of Angola's 18 provinces. For each of the crops considered in this study (maize, sorghum, beans, groundnuts and cassava) the relative impacts of climate change on crop production are considered at the Province level, aiming to identify those Provinces which are likely to be most or least vulnerable to climate change impacts on the given crop.

IMPACTS

The **Impacts (I)** of climate change on crops were estimated by projecting the likely future changes to Angola's climate, and then analysing the effects of those projected climate changes on economically important crops. Firstly, the potential future changes to Angola's climate were computed through analysis of 29 General Circulation Models (GCMs) downloaded from the AgMERRA dataset [2], based on the methods described by Ramirez-Villegas et al (2013) [3]. Future climate changes were computed assuming the scenario of 'RCP 8.5' (where 'RCP 8.5' refers to one of four hypothetical scenarios for future global greenhouse gas emissions proposed by the Intergovernmental Panel on Climate Change). This analysis was used to generate predictions of the effect of climate change across Angola, comparing the historical baseline (the average climate for the period 1980–2010) to the Mid-Century future (2050, the average climate for the period 2040–2069). In particular, the analysis compares the climatic variables of *Mean Monthly Precipitation* (i.e. the average precipitation for each month), *Monthly Mean Temperature* and *Monthly Minimum Temperature* (Tmin).

2 https://data.giss.nasa.gov/impacts/agmipcf/agmerra/

3 Ramirez-Villegas J, Jarvis A, Laderach P 2013 Empirical approaches for assessing impacts of climate change on agriculture: The EcoCrop model and a case study with grain sorghum. Agricultural and Forest Meteorology 170(15):67-78

Analyses of current and future crop suitability were generated using the Food and Agriculture Organisation's EcoCrop Suitability model[4] combined with the most recent statistics available for annual crop production and demographics. The EcoCrop model estimates the suitability of a given crop to the defined environmental conditions based on the known preferences of each crop such as: i) minimum, optimum and maximum temperature; ii) minimum, optimum and maximum monthly rainfall; and iii) minimum and maximum growing period. Therefore, EcoCrop defines the area of suitability for a given crop based on whether there are adequate climatic conditions (temperature and precipitation) within the growing season and calculates the climatic suitability of the resulting interaction between rainfall and temperature. Readers are referred to the full project report and the work of Ramirez-Villegas et al (2013) for detailed description of methodology.

A suitability index score, ranging from 0 – 1, indicates the relative suitability of a given area for each of the crops assessed (where a suitability score of 0 is considered to be totally unsuitable, a score of 1 is considered excellent, with a continuous spectrum of marginal, moderate and good suitability types in between). In this study, analyses of the distribution of suitable areas for a given crop allows for the estimation of the total suitable production area, as well as the average suitability index score, within each of Angola's 18 provinces. The EcoCrop approach also allows for map-based visualisations of crop suitability zones across the country. The use of colour-coded maps to depict the distribution of various categories of crop suitability index scores can be used to demonstrate the distribution of crop-suitable areas, as demonstrated in Figure 1.

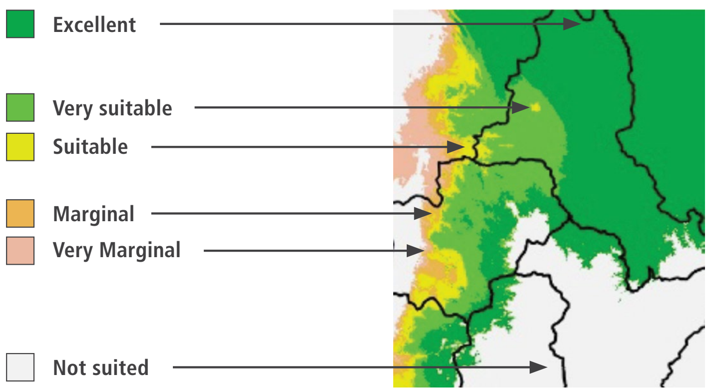
The comparison of maps of 'Historical' and 'Future' distribution of crop suitability can be used to estimate the potential changes to the size and relative productivity of crop-suitable areas. In addition, this approach allows for the identification of specific areas which are likely to undergo positive or negative changes (anomalies) as a result of climate change, and may be used to inform decision-making such as identification of climate-vulnerable areas and value chains to be prioritised for additional support. The potential impacts of climate change on each crop were estimated based on:

- the changes to total suitable area (km^2) and average suitability index score between the historical baseline and 'mid-century' future[5];
- and estimated historical crop production in each Province, derived from national agricultural production statistics [6].

The potential impacts of climate change on each crop can be quantified in several ways, for example, in terms of changes to "production per capita", "production per household" and "production per Province". It should be emphasised that no further calibration or validation of EcoCrop analyses was carried out in support of this study and that results should be considered as indicative guidelines only, to inform additional local-level decision-making and further research.

FIGURE 1. DEMONSTRATION EXAMPLE OF THE DISTRIBUTION OF CROP SUITABILITY INDEX.

GENERATED USING ECOCROP



[4] https://ecocrop.fao.org/ecocrop/srv/en/home

[5] Total suitable area was calculated as the sum of all areas with a suitability index score higher than 0, and average suitability index score is calculated as the average score of all areas with a suitability index score higher than 0

[6] Derived from the most recent national statistics available - *Relatório 1ªEpoca Campanha Agrícola* 2018-2019, for the season 2017-2018. Figures for sorghum were obtained from the CountrySTAT web portal (2014)

CLIMATE PROJECTIONS

PROJECTED CHANGES TO TEMPERATURE IN ANGOLA BY 2050

The predicted changes in Mean Monthly Temperature (TMean) during the period from 'Historical' to 'Future 2050' timepoints indicate that climate change will result in consistent increases in Mean Temperature across spatial and temporal dimensions in Angola. A common prediction across each of the country's provinces is that TMean will increase in all provinces during the period from 'Historical' to 'Future 2050' timepoints by at least 1.5°C. The hottest months of October and November are predicted to increase by 2.1–2.4°C, relative to a Historical average of 24°C. Similar increases of 1.8–2.3°C are predicted for all other months of the year, including the peak summer months that support the rainfed agricultural season (up until March/ April) as well as the colder winter months of May–August.

The overall effect of increased temperatures is likely to result in complex impacts on the agricultural sector, particularly when considered in combination with the predicted decreases and delayed timing of rainfall. The large increases in temperature (2.1–2.4°C) in the months of September–November will increase crop water demand and evapotranspiration losses of water from agricultural soils, coinciding with the reduced rainfall predicted for the same months. This effect is likely to increase the risks of crop failure as a result of inadequate or erratic rainfall during the establishment of rainfed crops. Furthermore, the increased average temperatures are likely to include increased frequency or severity of heat waves and unusually hot days, further contributing to evapotranspirative losses of water and crop stress.

A possible additional effect of the increase in winter temperatures may be to increase the feasibility and productivity of irrigated agriculture during the dry, cooler winter (particularly in high altitude areas). Increased winter temperatures may result in suitably warm conditions for off-season irrigated production of staples such as maize and beans, as well as various horticultural crops such as tomatoes and other assorted vegetables.

Taken cumulatively over the entire growing season, the combination of reduced rainfall and increased temperatures are likely to reduce agricultural production, either as a result of decreased yield or outright crop failure, particularly in the case of heat- and drought-sensitive crops such as maize.

TABLE 2. PROJECTED INFLUENCE OF CLIMATE CHANGE ON MEAN MONTHLY TEMPERATURE (°C) IN ANGOLA AT HISTORICAL AND MID-CENTURY PERIODS, AND MONTHLY ANOMALIES BETWEEN THE TWO TIME PERIODS [7]

Tmean (°C)	**MONTH**											
	J	F	M	A	M	J	J	A	S	O	N	D
Historical	23.5	23.5	23.5	23.2	21.7	19.7	19.3	21.3	23.4	24.4	24.0	23.5
Future	25.3	25.3	25.4	25.1	23.9	21.8	21.5	23.4	25.7	26.7	26.1	25.5
Anomaly	**1.8**	**1.8**	**1.9**	**2.0**	**2.2**	**2.1**	**2.2**	**2.1**	**2.3**	**2.4**	**2.1**	**1.9**

[7] Historical temperature based on the average of the period 1980-2010, and projected Mid-Century temperature for the period 2040-2069. Anomalies are defined as the total change between Historical and Mid-Century projections

CLIMATE – PROJECTED CHANGES TO RAINFALL IN ANGOLA BY 2050

The predicted changes in mean monthly precipitation from the historical baseline to the mid-century (2050) future indicate that climate change will result in complex changes in rainfall across Provinces and months (see Table 3). Province-level summaries of predicted monthly changes in precipitation can be found in the supplementary Appendix.

A common prediction across each of the country's 18 Provinces is that mean monthly precipitation and total annual precipitation will be reduced in all Provinces during the period from 'baseline' to 'Future 2050' timepoints. Total rainfall at the onset of the rainy season in the months of September and October is predicted to be reduced from 21 to 15 mm/month and 71 to 49 mm/month (total reduction of rainfall of 6 mm and 22 mm, respectively). Further reductions in monthly precipitation are predicted for the summer rainy season months from November–March ranging from 5 to 15 mm/month. The overall effect of these reductions to monthly precipitation throughout the rainy season is to reduce the total seasonal rainfall for the period October–April by 8.5 %, from 765 mm/season to 700 mm/season.

An additional effect, which is likely to vary on an interannual basis as well as spatially within each season, is the effective timing of the onset of rainfall at the start of the growing season. The average reduction in national rainfall predicted for the start of the rainy season is likely to vary between provinces and Angola's agro-ecological zones but in some cases may result in inadequate rainfall to support effective establishment of crops during the period which is traditionally associated with the start of the growing season.

These analyses indicate that climate change may delay the onset of rainfall relative to the traditional agricultural calendar, in turn resulting in changes to the timing of various agricultural activities such as field preparation and sowing of seed. The majority of the rainfed agricultural growing season is characterised by monthly rainfall deficits and is likely to result in fundamental changes to local crop choices and agricultural practices by the year 2050.

TABLE 3. PROJECTED INFLUENCE OF CLIMATE CHANGE ON MEAN MONTHLY PRECIPITATION (MM/MONTH) IN ANGOLA AT HISTORICAL AND MID-CENTURY PERIODS, AND MONTHLY ANOMALIES BETWEEN THE TWO TIME PERIODS [8]

MM/MONTH	MONTH												TOTAL
	J	F	M	A	M	J	J	A	S	O	N	D	
Historical	151	142	165	95	15	2	1	5	21	71	135	148	950
Future	146	135	153	89	11	1	1	3	15	49	121	143	866
Anomaly	**-6**	**-7**	**-11**	**-6**	**-4**	**-1**	**0**	**-2**	**-6**	**-22**	**-15**	**-5**	**-84**

[8] Historical precipitation based on the average of the period 1980-2010, and projected Mid-Century precipitation for the period 2040-2069. Anomalies are defined as the total change between Historical and Mid-Century projections. Province-level summaries of predicted monthly changes in precipitation can be found in the supplementary Appendix).

CLIMATE CHANGE AND ITS EFFECT ON BEANS

BROAD CONTEXT

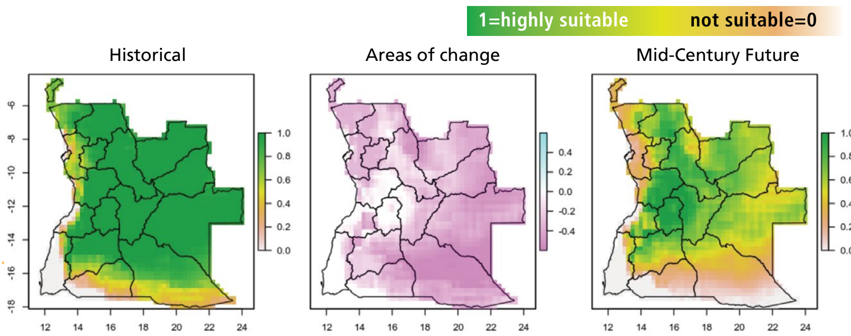
Beans are widely grown as a staple subsistence crop across most of Angola's provinces, with widespread areas of moderate, good or excellent suitability, and the spatial extent of suitability is only limited by the arid southern and coastal borders.

Climate change is projected to result in a reduction in total area suitable for bean production, as well as a reduction in the average suitability index scores across most of Angola. Most provinces are likely to undergo a transition from moderate/ good suitability to marginal/very marginal suitability for beans. The provinces worst affected are likely to include Luanda, Cunene and Cuando Cubango, where the future suitability scores are projected to be reduced to marginal or very marginal. Other provinces that are likely to experience significant reductions in area suitable for beans include Bengo and Namibe.

PRODUCTION OF BEANS IN ANGOLA[9].

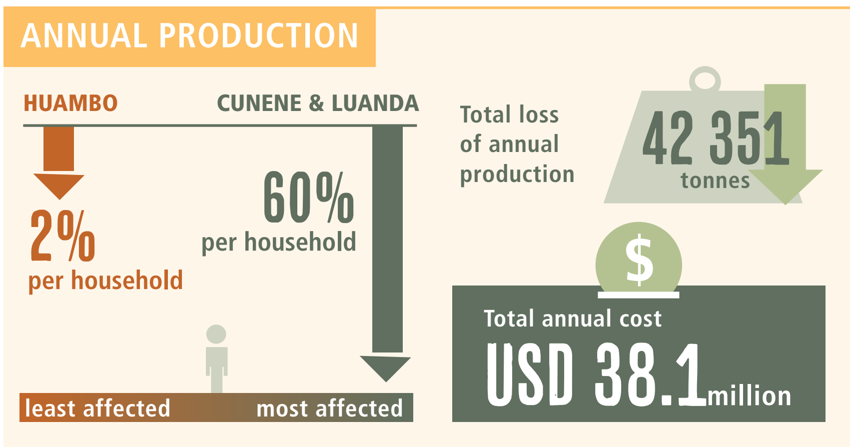
PROVINCE	PRODUCTION AREA		ANNUAL PRODUCTION	
	TOTAL (HA)	% NATIONAL TOTAL	TOTAL (TONNES)	% NATIONAL TOTAL
Bengo	12,561	1.3	5,371	1.3
Benguela	194,010	20.7	82,965	20.7
Bié	176,906	18.8	75,651	18.8
Cabinda	13,688	1.5	5,853	1.5
Cuando Cubango	6,762	0.7	2,892	0.7
Cuanza Norte	21,293	2.3	9,106	2.3
Cuanza Sul	120,425	12.8	51,498	12.8
Cunene	4,785	0.5	2,046	0.5
Huambo	139,783	14.9	59,776	14.9
Huíla	93,060	9.9	39,795	9.9
Luanda	553	0.1	236	0.1
Lunda Norte	2,593	0.3	1,109	0.3
Lunda Sul	3,169	0.3	1,355	0.3
Malanje	51,465	5.5	22,008	5.5
Moxico	20,524	2.2	8,777	2.2
Namibe	4,631	0.5	1,980	0.5
Uige	65,085	6.9	27,832	6.9
Zaire	7,598	0.8	3,249	0.8
Total	**938,891**		**401,499**	

PROJECTED EFFECT OF CLIMATE CHANGE ON DISTRIBUTION OF SUITABILITY FOR BEANS IN ANGOLA



HOUSEHOLD- AND PROVINCE-LEVEL IMPACTS

In terms of %change production per person, it is predicted that households will experience a decrease in annual production ranging from -2% in Huambo, up to -60% in Cunene and Luanda (relative to a very low baseline production in the latter provinces). In terms of the total impact of climate change on the annual production of agricultural households, the predicted decrease in annual production may range from 0.05 kg



9 Relatório 1ªEpoca Campanha Agrícola 2018-2019, for the season 2017-2018

10 Assuming a wholesale replacement cost of USD 900/tonne

up to 15 kg per household in most provinces. The provinces anticipated to be most negatively impacted by total reduced production at the household level include Namibe, Bie, Bengo and Moxico (resulting in lost production ranging from 20-50 kg per household per annum).

At the provincial level, the greatest losses of production are predicted in Benguela, Huíla and Bié, each province may experience shortfalls of over 6,000 tonnes each. In total, it is estimated that the annual production of beans across all provinces will be reduced by 42,351 tonnes, representing a significant loss of household income and staple food production. The total replacement cost for lost production of beans, at a national level, is estimated to be USD 38.1 million[10].

CLIMATE VULNERABLE PROVINCES AND HOUSEHOLDS

Table. Impact of predicted climate changes on the future production area (ha) and total annual production (tonnes/annum) of Beans (*Phaseolus vulgaris*) in each province of Angola at Baseline (Historical) and future Mid-Century periods, and resultant changes to annual production per capita, per household and per province[11]

PROVINCE	PREDICTED IMPACTS			
	% CHANGE PRODUCTION PER CAPITA	TOTAL CHANGE PER PERSON (KG)	TOTAL CHANGE PRODUCTION PER HOUSEHOLD (KG)	TOTAL CHANGE PRODUCTION PER PROVINCE(TONNES)
Bengo	-37	-6	-23	-1 976
Benguela	-8	-3	-14	-6 680
Bié	-8	-4	-20	-6 287
Cabinda	-37	-3	-13	-2 181
Cuando Cubango	-50	-3	-12	-1 449
Cuanza Norte	-19	-4	-16	-1 694
Cuanza Sul	-6	-2	-7	-3 058
Cunene	-58	-1	-6	-1 177
Huambo	-2	-1	-2	-1 095
Huíla	-17	-3	-13	-6 680
Luanda	-61	0	0	-144
Lunda Norte	-16	0	-1	-177
Lunda Sul	-19	0	-2	-256
Malanje	-11	-3	-12	-2 527
Moxico	-24	-3	-13	-2 138
Namibe	-26	-10	-53	-509
Uige	-13	-2	-12	-3 555
Zaire	-24	-1	-6	-770
Total				**-42 351**

At the household level, the provinces which will experience the most severe negative impacts on per capita production are Luanda (1), Cunene (2) and Cuanda Cubango (3). At the province level, the regions that will experience the most severe negative impacts on total production are Benguela (1), Huíla (2) and Bié (3).

KEY FINDINGS AND RECOMMENDATIONS

- All provinces are expected to experience negative impacts on bean production.
- The total annual shortfall in bean production is estimated to be up to 42,000 tonnes per year.
- Despite the negative impacts on production, the country is expected to maintain large areas which will continue to be suitable for beans.
- Future efforts to promote the increased production of beans in Angola will require additional investments in research and development to identify the most locally appropriate cultivars to be promoted as an alternative/complementary crop to other highly vulnerable staples such as maize.

[11] Note that projections for suitable production area does not indicate the actual planted area for each crop – rather, these figures indicate the size of area which is considered to be climatically suitable for production of that crop, but do not include consideration of agronomic factors such as soil type or land use factors such as accessibility of land, tenure etc.

CLIMATE CHANGE AND ITS EFFECT ON CASSAVA

BROAD CONTEXT

Cassava is grown as a staple subsistence crop across all of Angola's central and norther provinces, with relatively widespread areas of moderate to excellent suitability, particularly in the northern and northeast. The suitable extent for cassava production is limited by the arid southern provinces.

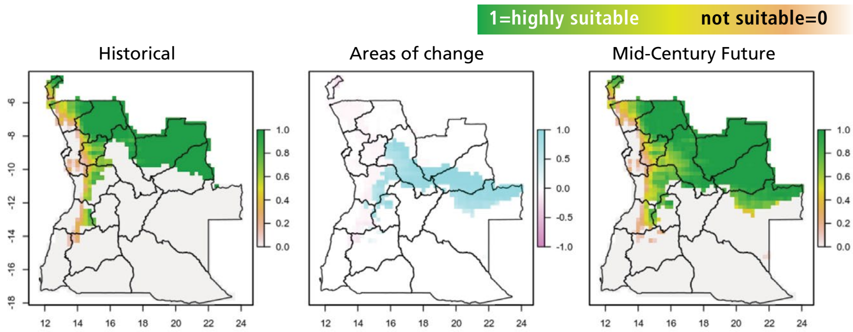
Climate change is likely to result in mixed impacts on cassava in different provinces. All provinces that are current production areas for cassava are expected to experience negative changes to average suitability index score, ranging from -0.3% to -30% (with the exception of Cuanza Sul, which is expected to experience a small increase in average suitability). Simultaneously, despite the decrease in average suitability index score, almost all the provinces are likely to benefit from increased suitable production areas.

Consequently, the results indicate that several provinces may only experience small reductions in productivity or may benefit from an increase in suitable production areas. Bengo, Cabinda, Huíla, Uige and Zaire are predicted to experience negative impacts on crop production, in addition to which, there are several provinces for which results cannot be calculated as a result of a low existing (baseline) suitability.

PRODUCTION OF CASSAVA IN ANGOLA[12].

PROVINCE	PRODUCTION AREA		ANNUAL PRODUCTION	
	TOTAL (HA)	% NATIONAL TOTAL	TOTAL (TONNES)	% NATIONAL TOTAL
Bengo	40,906	1.7	265,245	1.7
Benguela	64,747	2.7	419,836	2.7
Bié	79,055	3.4	512,613	3.4
Cabinda	65,355	2.8	423,779	2.8
Cuando Cubango	20,480	0.9	132,798	0.9
Cuanza Norte	76,528	3.2	496,227	3.2
Cuanza Sul	107,770	4.6	698,809	4.6
Cunene	4,109	0.2	26,644	0.2
Huambo	14,241	0.6	92,342	0.6
Huíla	38,843	1.6	251,868	1.6
Luanda	2,968	0.1	19,245	0.1
Lunda Norte	83,124	3.5	538,998	3.5
Lunda Sul	92,317	3.9	598,607	3.9
Malanje	153,081	6.5	992,617	6.5
Moxico	93,498	4.0	606,265	4.0
Namibe	5,208	0.2	33,770	0.2
Uige	198,791	8.4	1,289,013	8.4
Zaire	37,044	1.6	240,203	1.6
Total	**1,178,065**		**7,638,879**	

PROJECTED EFFECT OF CLIMATE CHANGE ON DISTRIBUTION OF SUITABILITY FOR CASSAVA IN ANGOLA



HOUSEHOLD- AND PROVINCE-LEVEL IMPACTS

In terms of negative impacts on production of cassava per person, it is predicted that households in Bengo, Cabinda, Huíla, Uige and Zaire will experience a decrease in annual production ranging from -4% in Zaire up to -15% in Bengo. The annual deficit of cassava production in these provinces is equivalent to a reduction ranging from 4-15 kg per household in Huíla, Uige and Zaire, up to 113 kg per household in Bengo.

ANNUAL PRODUCTION

ZAIRE — 4% annual production
BENGO — 15% annual production
least affected — most affected

HUÍLA, UIGE, ZAIRE — 4-15KG annual production
BENGO — 113KG annual production
least affected — most affected

Total loss of annual production: 117 000 tonnes

Total annual cost: USD 45.7 million

[12] Relatório 1ªEpoca Campanha Agrícola 2018-2019, for the season 2017-2018

[13] Assuming a wholesale replacement cost of USD 390/tonne for wet cassava

At the provincial level, Bengo, Huíla and Cabinda are the worst affected provinces and may experience an annual deficit in cassava production ranging from 20,000 up to 40,000 tonnes in each province. In total, it is estimated that the annual national production of cassava will be reduced by 117,000 tonnes, only in those four provinces for which results can be calculated. The total replacement cost for lost production of cassava is estimated to be USD 45.7 million[13].

CLIMATE VULNERABLE PROVINCES AND HOUSEHOLDS

Table. Impact of predicted climate changes on the future production area (ha) and total annual production (tonnes/ annum) of Cassava (*Manihot esculenta*) in each province of Angola at Baseline (Historical) and future Mid-Century periods, and resultant changes to annual production per capita, per household and per province[14]

PROVINCE	PREDICTED IMPACTS			
	% CHANGE PRODUCTION PER CAPITA	TOTAL CHANGE PER PERSON (KG)	TOTAL CHANGE PRODUCTION PER HOUSEHOLD (KG)	TOTAL CHANGE PRODUCTION PER PROVINCE(TONNES)
Bengo	-15	-113	-463	-40 285
Benguela	positive impacts			
Bié	Unsuitable			
Cabinda	-7	-40	-168	-28 628
Cuando Cubango				
Cuanza Norte	positive impacts			
Cuanza Sul				
Cunene	Unsuitable			
Huambo	positive impacts			
Huíla	-13	-13	-63	-32 710
Luanda	Unsuitable			
Lunda Norte	positive impacts			
Lunda Sul				
Malanje				
Moxico				
Namibe	Unsuitable			
Uige	0	-4	-21	-6 346
Zaire	-4	-15	-68	-9 188
Total				**-117 156**

At the household AND provincial levels, the provinces which will experience the most severe negative impacts on production are Bengo (1), and Huíla (2) and Cabinda (3).

KEY FINDINGS AND RECOMMENDATIONS

Angola's potential production for cassava is likely to be reduced across multiples provinces as a result of climate change, while others may benefit from increased productivity.

Most of the northern and central provinces are expected to remain suitable for production, while the southern and western regions become increasingly marginal.

The total replacement cost for the predicted loss in production of cassava is estimated to be 117,000 tonnes, or a total replacement cost of USD 45.7 million.

Despite the negative changes to the production potential of cassava, the flexible growth habit of the crop suggests that it is still likely to be a useful option for climate-resilient farming systems.

Recommended actions: increased access to quality, virus-free planting material of improved varieties; increased access to facilities and equipment for processing fresh cassava; improved capacity of farmers to monitor and respond to common pests and diseases.

[14] Note that projections for suitable production area does not indicate the actual planted area for each crop – rather, these figures indicate the size of area which is considered to be climatically suitable for production of that crop, but do not include consideration of agronomic factors such as soil type or land use factors such as accessibility of land, tenure etc.

CLIMATE CHANGE AND ITS EFFECT ON GROUNDNUT

BROAD CONTEXT

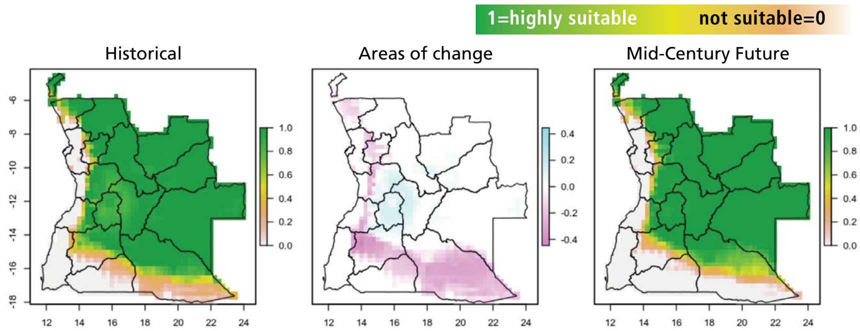
Groundnuts are grown as a subsistence crop across all of Angola's provinces, with widespread areas of excellent suitability – the suitable range is only limited by the aridity of the southern provinces and western coastal regions.

Most provinces are expected to undergo only very minor changes to suitability for cultivation of groundnuts as a result of climate change, with the exception of Bengo, Cunene and Namibe which may experience larger reductions in suitability ranging from 13% (Bengo) up to 116% (Namibe). These three provinces are currently characterised by marginal suitability for groundnut production. The provinces of Lunda Norte and Lunda Sul are expected to remain unchanged, while Benguela, Bié and Huambo may benefit from slight increases in productivity.

PRODUCTION OF GROUNDNUTS IN ANGOLA[15].

PROVINCE	PRODUCTION AREA		ANNUAL PRODUCTION	
	TOTAL (HA)	% NATIONAL TOTAL	TOTAL (TONNES)	% NATIONAL TOTAL
Bengo	15,323	4.4	11,187	4.4
Benguela	6,225	1.8	4,545	1.8
Bié	37,675	10.9	27,507	10.9
Cabinda	26,152	7.6	19,094	7.6
Cuando Cubango	20,904	6.0	15,262	6.0
Cuanza Norte	25,088	7.3	18,317	7.3
Cuanza Sul	52,383	15.1	38,245	15.1
Cunene	1,659	0.5	1,211	0.5
Huambo	24,988	7.2	18,244	7.2
Huíla	5,656	1.6	4,130	1.6
Luanda		0.0	0	0.0
Lunda Norte	6,851	2.0	5,002	2.0
Lunda Sul	2,634	0.8	1,923	0.8
Malanje	27,151	7.9	19,823	7.9
Moxico	24,548	7.1	17,923	7.1
Namibe	1,554	0.4	1,135	0.4
Uige	60,068	17.4	43,856	17.4
Zaire	6,952	2.0	5,076	2.0
Total	**345,811**		**252,480**	

PROJECTED EFFECT OF CLIMATE CHANGE ON DISTRIBUTION OF SUITABILITY FOR GROUNDNUTS IN ANGOLA



HOUSEHOLD- AND PROVINCE-LEVEL IMPACTS

Namibe, Bengo, Cuando Cubango and Cuanza Norte are expected to experience the largest negative impacts on groundnut production, where households are projected to experience a decrease of 9% (Cuanza Norte) up to 26% (Cuando Cubango) per person, and up to 80% in Namibe province, relative to average annual production. This is equivalent to a deficit of between 7-8 kg (Bengo, Cuando Cubango) or up to 18kg in Namibe, per household. In terms of impacts on total annual production of groundnuts within each province, the greatest losses are predicted in the provinces of Cuando Cubango (4,000 tonnes), Bengo (2,600 tonnes) and Cuanza Norte (1,600 tonnnes). In total, it is estimated that the annual production of groundnuts across the negatively affected provinces will be reduced by 12,800 tonnes. The estimated total replacement cost for lost production of groundnuts is USD 12.8 million[16].

ANNUAL PRODUCTION

BENGO, CUANDO CUBANGO — 7-8KG per household

NAMIBE — 18KG per household

least affected — most affected

Total replacement cost

$ USD 12.8 million

[15] Relatório 1ªEpoca Campanha Agrícola 2018-2019, for the season 2017-2018

[16] Assuming a wholesale replacement cost of USD 1000/tonne

In the case of Bié and Huambo, which may benefit from increased suitable area, these results must not be interpreted as a strong prediction that annual production of groundnuts will increase as a result of climate change. Rather, these results may be interpreted as a prediction that those provinces which benefit from increased suitable area are unlikely to be impacted severely by climate change.

CLIMATE VULNERABLE PROVINCES AND HOUSEHOLDS

Table. Impact of predicted climate changes on the future production area (ha) and total annual production (tonnes/annum) of Groundnuts (*Arachis hypogea*) in each province of Angola at Baseline (Historical) and future Mid-Century periods, and resultant changes to annual production per capita, per household and per province[17]

PROVINCE	PREDICTED IMPACTS			
	% CHANGE PRODUCTION PER CAPITA	TOTAL CHANGE PER PERSON (KG)	TOTAL CHANGE PRODUCTION PER HOUSEHOLD (KG)	TOTAL CHANGE PRODUCTION PER PROVINCE(TONNES)
Bengo	-24	-7	-30	-2 637
Benguela	-8	0	-1	-349
Bié	Positive Impacts			
Cabinda	-1	0	-1	-198
Cuando Cubango	-26	-8	-35	-4 006
Cuanza Norte	-9	-4	-16	-1 636
Cuanza Sul	-2	0	-2	-683
Cunene	-53	-1	-3	-646
Huambo	Positive Impacts			
Huíla	-22	0	-2	-903
Luanda	No baseline production			
Lunda Norte	No change			
Lunda Sul				
Malanje	0	0	0	-26
Moxico	-1	0	-1	-97
Namibe	-78	-18	-91	-882
Uige	-1	0	-1	-453
Zaire	-5	0	-2	-258
Total				**-12 775**

At the household level, the provinces which will experience the most severe negative impacts on per capita production are Namibe (1), Cunene (2) and Cuanda Cubango (3). At the province level, the most severe negative impacts on total production are projected for Cuanda Cubango (1), Bengo (2) and Cuanza Norte (3).

KEY FINDINGS AND RECOMMENDATIONS

Angola will likely experience minor to moderate decreases in production of groundnut as a result of climate change-related declines in total production area and productivity.

The loss of household production of groundnuts is likely to be relatively minor in comparison to other staple crops, but will result in increased costs for households to replace lost production of food.

The total annual losses in production of groundnut are equivalent to 12,800 tonnes per year, resulting in replacement costs of USD 12.8 million per year.

Despite the predicted negative impacts, the continued extensive distribution of suitable areas for groundnut production (particularly in the Central and Northern provinces) suggests that this crop is likely to be a useful option for climate-resilient farming systems.

Recommended actions: promote within diversified, multi-crop and intercrop combinations; research, develop and promote locally-adapted and drought resilient varieties; invest in post-harvest processing facilities.

[17] Note that projections for suitable production area does not indicate the actual planted area for each crop – rather, these figures indicate the size of area which is considered to be climatically suitable for production of that crop, but do not include consideration of agronomic factors such as soil type or land use factors such as accessibility of land, tenure etc.

CLIMATE CHANGE AND ITS EFFECT ON MAIZE

BROAD CONTEXT

Maize is grown as a subsistence crop across all of Angola's provinces. Long-maturing varieties have moderate suitability, while short-maturing varieties have widespread areas of excellent suitability, particularly in the central and northern regions.

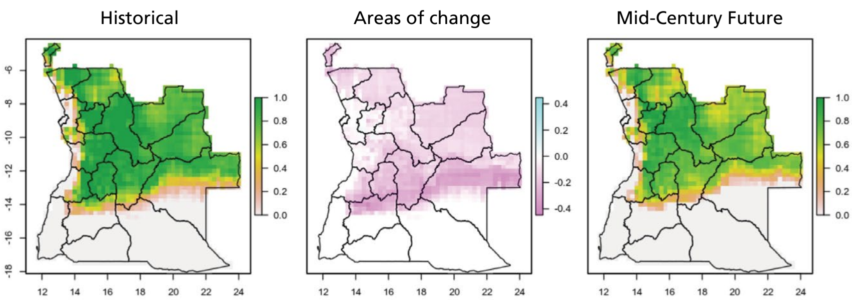
Most provinces are projected to experience decreases to average suitability index scores as well as total suitable area, except for Cuanza Sul, Huambo, Lunda Norte, Lunda Sul and Malanje, which are expected to remain unchanged with regard to area suitable for maize production. Namibe is projected to undergo a considerable reduction in total suitable area (86%), and is likely to remain marginal in the future. Cunene and Luanda are considered totally unsuitable for production of maize, both in the baseline and future scenarios. Consequently, no changes to the suitable areas could be calculated for these provinces, which are likely to remain marginal or totally unsuitable in the future. Cuando Cubango is likely to be particularly negatively impacted, with considerable reductions predicted for total suitable area and productivity..

PRODUCTION OF MAIZE IN ANGOLA[18].

PROVINCE	PRODUCTION AREA		ANNUAL PRODUCTION	
	TOTAL (HA)	% NATIONAL TOTAL	TOTAL (TONNES)	% NATIONAL TOTAL
Bengo	20,923	0.5	18,260	0.5
Benguela	207,955	5.4	181,488	5.4
Bié	256,638	6.6	223,975	6.6
Cabinda	8,794	0.2	7,675	0.2
Cuando Cu-bango	65,447	1.7	57,117	1.7
Cuanza Norte	15,542	0.4	13,564	0.4
Cuanza Sul	431,186	11.2	376,308	11.2
Cunene	14,628	0.4	12,766	0.4
Huambo	424,054	11.0	370,084	11.0
Huíla	226,876	5.9	198,001	5.9
Luanda	-	0.0	1,153	0.0
Lunda Norte	24,924	0.6	21,752	0.6
Lunda Sul	31,626	0.8	27,601	0.8
Malanje	70,045	1.8	61,130	1.8
Moxico	47,662	1.2	41,596	1.2
Namibe	32,245	0.8	28,141	0.8
Uige	43,243	1.1	37,739	1.1
Zaire	9,760	0.3	8,518	0.3
Total	**1,931,548**		**1,686,868**	

PROJECTED EFFECT OF CLIMATE CHANGE ON DISTRIBUTION OF SUITABILITY FOR MAIZE IN ANGOLA

1=highly suitable not suitable=0



HOUSEHOLD- AND PROVINCE-LEVEL IMPACTS

Cunene and Luanda are projected to be completely unsuitable in the historical baseline as well as in the future scenario, while Cuanda Cubango was projected to become completely unsuitable in the future. As a result, the impacts on the latter provinces could not be assessed further. However, It is likely that these provinces will undergo severe decreases in productivity similar to the rest of Angola.

ANNUAL PRODUCTION

NAMIBE
77% per household
most affected

HUAMBO AND MOXICO
80-90KG per household
least affected

HUÍLA AND BIE
110-190KG per household
most affected

Total loss of annual production: 264 000 tonnes

Total annual cost: USD 103 million

[18] Relatório 1ªEpoca Campanha Agrícola 2018-2019, for the season 2017-2018

[19] Assuming a wholesale replacement cost of USD 390/tonne

In addition to the latter provinces, some of the most severe impacts at the household level are projected for Namibe, Huíla and Bié provinces. Namibe is most dramatically impacted, with annual household production decreased by 77%, equivalent to 2,200 tonnes per household. Huíla and Bié are also projected to undergo shortfalls of 110-190 kg per household, followed by Huambo and Moxico provinces with losses of 80-90 kg per household.

At the provincial level, the greatest total decreases in production of maize are projected for Huila, Huambo, Bié and Benguela provinces (losses of 98,000, 40,000, 36,000 and 24,000 tonnes, respectively). At the national level, the total decrease in maize production across all provinces is equivalent to 264,000 tonnes, resulting in total replacement costs of USD 103 million[19].

CLIMATE VULNERABLE PROVINCES AND HOUSEHOLDS

Table. Impact of predicted climate changes on the future production area (ha) and total annual production (tonnes/annum) of Maize (*Zea mays*) in each province of Angola at Baseline (Historical) and future Mid-Century periods, and resultant changes to annual production per capita, per household and per province[20]

At the household level, the provinces which will experience the most severe negative impacts on per capita production are Namibe (1), Huíla (2) and Moxico (3). At the province level, the most severe negative impacts on total production are Huíla (1), Bié(2) and Benguela (3).

PROVINCE	PREDICTED IMPACTS			
	% CHANGE PRODUCTION PER CAPITA	TOTAL CHANGE PER PERSON (KG/CAPITA)	TOTAL CHANGE PRODUCTION PER HOUSEHOLD (KG)	TOTAL CHANGE PRODUCTION PER PROVINCE(TONNES)
Bengo	-7	-3	-14	-1 192
Benguela	-13	-11	-50	-24 386
Bié	-16	-25	-113	-35 770
Cabinda	-15	-2	-7	-1 149
Cuando Cubango	too low to calculate			
Cuanza Norte	-3	-1	-3	-348
Cuanza Sul	-5	-9	-40	-17 110
Cunene	too low to calculate			
Huambo	-11	-20	-91	-40 015
Huíla	-50	-39	-189	-98 118
Luanda	too low to calculate			
Lunda Norte	-8	-2	-9	-1 817
Lunda Sul	-8	-4	-21	-2 304
Malanje	-4	-3	-12	-2 589
Moxico	-33	-18	-84	-13 782
Namibe	-77	-442	-2 253	-21 789
Uige	-8	-2	-9	-2 897
Zaire	-11	-2	-7	-929
Total				**-264 195**

KEY FINDINGS AND RECOMMENDATIONS

- Angola will experience a moderate decrease in the production potential for short-maturing maize varieties as a result of climate change.
- Despite the predicted negative changes, wide expanses of the country are likely to be characterised by moderate/good suitability (especially for short-maturing, improved maize varieties).
- The total annual loss of maize production resulting from climate change is estimated to be 264,000 tonnes per year, equivalent to replacement costs of USD 103 million.
- The production and economic impacts are predicted to be more severe for long-maturing maize varieties.

Recommended actions: identify and increase access to locally-adapted cultivars; support farmers to adopt climate-resilient practices; promote the adoption of alternative, climate-resilient crops such as sorghum, beans, cowpeas, groundnuts and pigeonpeas.

[20] Note that projections for suitable production area does not indicate the actual planted area for each crop – rather, these figures indicate the size of area which is considered to be climatically suitable for production of that crop, but do not include consideration of agronomic factors such as soil type or land use factors such as accessibility of land, tenure etc.

CLIMATE CHANGE AND ITS EFFECT ON SORGHUM

BROAD CONTEXT

Sorghum is grown as a subsistence crop across most of Angola's provinces. Virtually the entire extent of the country is characterised by good or excellent suitability, with the exception of the arid extents of the southern provinces.

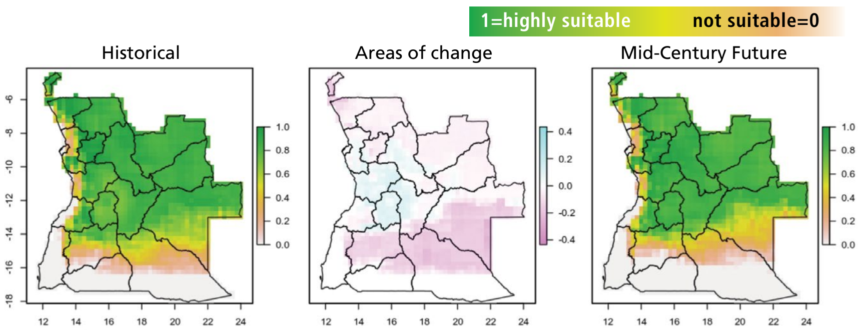
All provinces are predicted to undergo negative changes to the average suitability index score, ranging from -2.2 in Moxico to -35% in Namibe.

Many of the provinces are expected to remain unchanged with regard to total suitable area and virtually the entire spatial extent of Angola is expected to be characterised by moderate, good or excellent suitability for production of sorghum, particularly in September. Bengo (-10%), Cunene (-18.5%) and Namibe (-15%) are the only provinces that are expected to undergo a decline of more than 5% in suitable area.

PRODUCTION OF SORGHUM IN ANGOLA[21].

PROVINCE	PRODUCTION AREA		ANNUAL PRODUCTION	
	TOTAL (HA)	% NATIONAL TOTAL	TOTAL (TONNES)	% NATIONAL TOTAL
Bengo	No baseline data			
Benguela	16481	3.6	3509	3.6
Bié	4393	0.97	935	0.97
Cabinda	No baseline data			
Cuando Cubango	55831	12.3	11889	12.3
Cuanza Norte	No baseline data			
Cuanza Sul				
Cunene	56231	12.4	11974	12.4
Huambo	4125	0.91	878	0.91
Huíla	75782	16.7	16137	16.7
Luanda	No baseline data			
Lunda Norte				
Lunda Sul				
Malanje				
Moxico	2285	0.5	487	0.5
Namibe	10915	2.4	2324	2.4
Uige	No baseline data			
Zaire				
Total	**226,043**		**48,133**	

PROJECTED EFFECT OF CLIMATE CHANGE ON DISTRIBUTION OF SUITABILITY FOR SORGHUM IN ANGOLA



HOUSEHOLD- AND PROVINCE-LEVEL IMPACTS

The total % change of annual production of sorghum per capita is predicted to range from a loss of 2% in Moxico up to 45% in Namibe (equivalent to 20kg).

At the household level, the projected decrease in production is almost negligible in most households, equivalent to less than 1 kg per household in Moxico, Bié and Huambo. Cunene and Cuanda

ANNUAL PRODUCTION

MOXICO — 2% per capita
NAMIBE — 45% per capita
least affected — most affected

MOXICO, BIE, HUAMBO — <1KG per household
NAMIBE — 107KG per household
least affected — most affected

Total loss of annual production: 7 400 tonnes

Total annual cost: $ USD 2.9 million

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21 Relatório 1ªEpoca Campanha Agrícola 2018-2019, for the season 2017-2018

22 Assuming a wholesale replacement cost of USD 390/tonne

Cubango may experience modest decreases, equivalent to a loss of 7-18 kg per household. At the household level, the worst-affected province is Namibe, where losses of sorghum production are equivalent to a decrease of 107 kg per household.

At the provincial level, the largest losses to production are projected for the provinces of Cunene (3,300 tonnes), Huíla (1,800 tonnes), Namibe (1,000 tonnes) and Cuanda Cubango (800 tonnes). At the national level, the total decrease in sorghum production across all provinces is equivalent to 7400 tonnes (not including consideration of those provinces for which no baseline production data could be identified), resulting in annual replacement costs of approximately USD 2.9 million[22].

CLIMATE VULNERABLE DISTRICTS AND HOUSEHOLDS

Table. Impact of predicted climate changes on the future production area (ha) and total annual production (tonnes/annum) of sorghum (*Sorghum bicolor*) in each province of Angola at Baseline (Historical) and future Mid-Century periods, and resultant changes to annual production per capita, per household and per province[23]

PROVINCE	PREDICTED IMPACTS			
	% CHANGE PRODUCTION PER CAPITA	TOTAL CHANGE PER PERSON (KG/CAPITA)	TOTAL CHANGE PRODUCTION PER HOUSEHOLD (KG)	TOTAL CHANGE PRODUCTION PER PROVINCE(TONNES)
Bengo	No baseline data			
Benguela	-9	0	-1	-315
Bié	-8	0	0	-78
Cabinda	No baseline data			
Cuando Cubango	-7	-2	-7	-804
Cuanza Norte	No baseline data			
Cuanza Sul	No baseline data			
Cunene	-28	-3	-18	-3 322
Huambo	-9	0	0	-80
Huíla	-11	-1	-3	-1 757
Luanda	No baseline data			
Lunda Norte	No baseline data			
Lunda Sul	No baseline data			
Malanje	No baseline data			
Moxico	-2	0	0	-11
Namibe	-45	-21	-107	-1 037
Uige	No baseline data			
Zaire	No baseline data			
Total				**-7 405**

At the household level, the two provinces which will experience the most severe negative impacts on per capita production are Namibe (1), Cunene (2) and Huíla (3). At the province level, the regions that will experience the most severe negative impacts on total production are Cunene (1), Huíla (2) and Namibe (3).

KEY FINDINGS AND RECOMMENDATIONS

Angola will likely experience minor decreases in production of sorghum as a result of climate change-related declines in total production area and productivity.

Total annual losses of sorghum production are equivalent to 7,400 tonnes per year.

Despite these negative trends, this cereal crop is predicted to be considerably more resilient to the impacts of climate change than other staples such as maize and beans.

Recommended actions: research and development required to identify the most locally appropriate cultivars to be promoted as a climate-resilient cereal alternative to maize; and promote a change in dietary preferences, and farmers' perceptions of the crop.

23 Note that projections for suitable production area does not indicate the actual planted area for each crop – rather, these figures indicate the size of area which is considered to be climatically suitable for production of that crop, but do not include consideration of agronomic factors such as soil type or land use factors such as accessibility of land, tenure etc.

SUMMARY OF FINDINGS, RECOMMENDATIONS, ADAPTATION STRATEGIES AND CLIMATE-RESILIENT ALTERNATIVES FOR SMALLHOLDER FARMERS

The summarised findings above indicate that several important staple crops – notably beans, cassava and maize – are predicted to experience significant decreases in production. Consequently, it is strongly recommended that initiatives related to climate change adaptation, food security and enhanced agricultural production include careful consideration of strategies to increase the resilience of households that rely on these three crops. This may include specific strategies to safeguard the production of traditional staples and other crops, as well as broader measures to diversify agricultural income and food production in general (including development of water resources and irrigation infrastructure, strengthening of value chains and facilities for agro-processing, and increasing the resilience of the livestock production sector).

IRRIGATION AND WATER

One of the primary constraints to Angola's future food security in all provinces is likely to be the reliability and volume of seasonal rainfall, particularly in the semi-arid coastal and southern provinces. The erratic rainfall and droughts experienced in these provinces mean that access to irrigation is considered one of the few strategies to maintain the food security of crop-farming households, with considerable investment needed to update and upgrade the limited irrigation infrastructure and water points available. In addition to supporting basic food security, Angola's potential for production of various high-value horticultural crops can be unlocked through improved access to reliable irrigation. Irrespective of priorities related to promotion of irrigation, many districts are characterised by an urgent need to invest in infrastructure for water management – in part to supply fresh water for irrigation, livestock and human use, but also to prevent or mitigate the impacts of floods after heavy rainfall events.

However, the urgent need for establishment of waterpoints and boreholes will also require investments in research and monitoring of surface- and ground-water sources to safeguard against unsustainable use. Finally, the devolution of irrigation schemes to community-based management structures requires sustained support and capacity-building to ensure that correct operation and maintenance of infrastructure will be sustained.

LIVESTOCK PRODUCTION

Production of various species of livestock for meat, milk and eggs is widely practiced across the country as a supplementary or main source of income, particularly in those areas where rainfall is inadequate to support reliable crop cultivation. Management of small numbers of livestock, including cattle for meat and dairy production, various goat species and poultry chickens, were noted as important contributors to income and food security within the mixed farming systems practiced in various regions. Farmers and extension workers are increasingly interested in the promotion of small livestock species as an alternative to cattle herding, as a result of the adaptable diets, small space requirements, and rapid return of income of small livestock. In semi-arid zones where rainfall is too low or erratic to reliably support productive subsistence farming, grazing of locally-adapted cattle or small livestock is a comparatively resilient source of food and income.

However, a factor which challenges the climate-resilience of livestock production is the widespread degradation of grazing resources, as a result of persistent overgrazing and the impact of droughts. An additional challenge is the likelihood of increased bush encroachment and a decline of preferred grazing species in favour of less palatable species, driven both by climate change as well as overgrazing and degradation of grazing lands. The limited availability of forage will reduce the overall health of the national herd, thereby increasing susceptibility to diseases and climate-related stresses. Indigenous pastures have a relatively low holding capacity, and most farmers are unfamiliar with, or unwilling to invest in, approaches to supplement free grazing with additional fodder (e.g. through purchase of supplementary feed or through establishment of fodder banks).

The results of this study indicate that production of most cereal and pulses/legumes is likely to undergo minor or moderate decreases. This includes maize, beans and to a lesser degree other staples such as cassava, cowpeas and pigeonpeas. The shortfall in national production of these crops will most likely be met by increased imports and rising prices, and consequently a shortage of affordable supplementary feed for livestock. Therefore, there is a need for supporting measures to increase the sustainability and climate-resilience of Angola's livestock sector, particularly to safeguard against loss of animals during periods of drought or erratic rainfall.

MAIZE

In the case of maize, the results strongly support the case for development, promotion and dissemination of fast-growing, early-maturing varieties and promotion of alternative cereal and grain crops. Analyses indicate that potential losses to annual production, assuming long-maturing varieties are grown, may be in excess of 200,000 tonnes. In addition to strategies based on selection of locally-adapted and climate-resilient cultivars, the risk of reduced production of all maize varieties can be partly offset by continued promotion of crop diversification, including intercropping and multi-crop approaches that include diverse legumes and alternative cereals such as sorghum and millet. Finally, farmers will benefit from capacity-building and training on techniques to manage the challenge of delayed or unreliable rainfall at the onset of the rainy season – for example, strategies to stagger planting times over an extended period, techniques such as conservation agriculture to improve the water-holding capacity of soils, and increased access and ability to use seasonal weather forecasts.

BEANS

In the case of beans, the results indicate a moderate or severe reduction of production between the current baseline period and the mid-century future. Despite this predicted negative trend, beans and other leguminous crops are still expected to be a useful component of future strategies to adapt smallholder agriculture to climate change in Angola. The crop is already widely grown and eaten, can be incorporated into diverse inter-cropping and crop rotation strategies with other staple crops, and contributes positively to soil fertility. The potential risk of negative impacts of climate change on beans can partly be offset by promoting the adoption of a diversity of bean cultivars as well as additional legume species, notably including cowpea and groundnuts which are predicted to remain relatively resilient to the changing climate.

CASSAVA

In the case of cassava, climate change is predicted to result in negative climate change effects on production in the Southern region (mainly in areas which are considered marginal or poorly suitable in the baseline scenario) but with possible positive effects in some of the Central and Northern regions. It is recommended that future initiatives aiming to increase the climate change resilience and food security of Angola's cassava farmers should include a focus on development of facilities and a supporting value chain for post-harvest processing and value addition of cassava. The ability to process fresh cassava roots into chips, flour, starch or other shelf-stable products will reduce the loss of fresh cassava to waste and spoilage, thereby contributing to food security and providing farmers with potential sources of income. Furthermore, the production of cassava in Angola can be further strengthened by initiatives that promote access to good-quality plant materials, focusing on virus-free clones of high-yielding and locally-adapted varieties. In addition, it is recommended that farmers are provided with capacity building and training to control pests and diseases, particularly to control the insect vectors of cassava mosaic virus as well as to identify and remove infected plants.

APPENDIX TABLES

APPENDIX TABLE A.1.

PROJECTED INFLUENCE OF CLIMATE CHANGE ON MEAN MONTHLY PRECIPITATION (MM/MONTH) IN THE PROVINCES OF ANGOLA AT HISTORICAL AND MID-CENTURY PERIODS, AND MONTHLY ANOMALIES BETWEEN THE TWO TIME PERIODS.

mm/month		MONTH												TOTAL
		J	F	M	A	M	J	J	A	S	O	N	D	
BENGO	Historical	58	73	159	158	25	1	1	2	6	38	106	72	**699**
	Future	56	70	156	158	20	1	1	2	4	22	93	69	**650**
	Anomaly	*-2*	*-4*	*-3*	*0*	*-5*	*0*	*0*	*0*	*-2*	*-17*	*-13*	*-3*	***-48***
BENGUELA	Historical	90	94	182	100	8	0	0	1	8	66	106	99	**754**
	Future	83	93	177	94	5	0	0	1	5	38	95	94	**685**
	Anomaly	*-7*	*-1*	*-5*	*-7*	*-3*	*0*	*0*	*0*	*-3*	*-27*	*-11*	*-5*	***-68***
BIÉ	Historical	201	172	202	100	11	1	0	3	22	92	171	198	**1173**
	Future	200	172	192	91	6	1	0	2	14	67	157	198	**1098**
	Anomaly	*1*	*0*	*-10*	*-9*	*-4*	*0*	*0*	*-1*	*-8*	*-25*	*-14*	*0*	***-70***
CABINDA	Historical	131	157	155	140	56	2	2	5	19	79	177	156	**1078**
	Future	126	136	146	128	53	2	1	4	13	55	176	154	**993**
	Anomaly	*-5*	*-21*	*-9*	*-12*	*-3*	*1*	*1*	*-2*	*-7*	*-24*	*0*	*-1*	***-83***
CUANDO CUBANGO	Historical	165	148	123	39	3	1	1	1	4	26	77	122	**707**
	Future	150	134	102	31	2	1	0	0	2	14	61	109	**605**
	Anomaly	*-16*	*-14*	*-21*	*-8*	*-2*	*0*	*0*	*0*	*-3*	*-12*	*-16*	*-13*	***-101***
CUANZA NORTE	Historical	92	99	191	196	33	2	1	6	20	80	168	117	**1004**
	Future	90	96	190	199	28	1	1	4	12	47	152	115	**935**
	Anomaly	*-2*	*-3*	*1*	*3*	*-5*	*1*	*0*	*-1*	*-8*	*-34*	*-16*	*-2*	***-65***
CUANZA SUL	Historical	100	100	187	129	18	1	0	4	24	102	156	123	**945**
	Future	100	103	188	126	14	1	0	3	17	64	141	122	**879**
	Anomaly	*1*	*3*	*1*	*-3*	*-4*	*0*	*0*	*1*	*-8*	*-38*	*-15*	*1*	***-62***
CUNENE	Historical	105	116	110	36	2	1	0	0	2	19	49	81	**520**
	Future	93	103	93	29	1	0	0	0	1	9	37	70	**435**
	Anomaly	*-12*	*-13*	*-17*	*-7*	*1*	*0*	*0*	*0*	*-1*	*-10*	*-12*	*-12*	***-83***
HUAMBO	Historical	173	152	209	119	14	0	1	2	19	107	175	188	**1159**
	Future	172	153	201	108	9	0	0	2	12	72	164	190	**1084**
	Anomaly	*-1*	*1*	*-7*	*-11*	*-5*	*0*	*0*	*1*	*-7*	*-35*	*-11*	*2*	***-73***

mm/month		MONTH												TOTAL
		J	F	M	A	M	J	J	A	S	O	N	D	
HUÍLA	Historical	134	136	170	75	5	0	1	1	5	46	92	118	**783**
	Future	124	127	153	62	3	0	0	1	3	25	75	108	**680**
	Anomaly	*-11*	*-9*	*-16*	*-12*	*-2*	*0*	*0*	*0*	*-3*	*-21*	*-18*	*-11*	***-102***
LUANDA	Historical	42	49	131	124	15	1	0	1	3	17	61	41	**485**
	Future	40	46	126	124	12	1	0	1	2	10	49	36	**445**
	Anomaly	*-2*	*-4*	*-5*	*0*	*-3*	*0*	*0*	*0*	*-1*	*-8*	*-12*	*-5*	***-40***
LUNDA NORTE	Historical	170	157	196	142	22	6	2	20	70	138	210	198	**1330**
	Future	176	157	190	140	17	4	1	13	56	110	198	202	**1263**
	Anomaly	*6*	*0*	*-6*	*-2*	*-6*	*-2*	*1*	*-7*	*-14*	*-28*	*-13*	*4*	***-67***
LUNDA SUL	Historical	201	186	212	119	14	4	1	11	44	111	192	208	**1303**
	Future	206	185	204	116	8	3	1	6	34	85	175	210	**1232**
	Anomaly	*6*	*-2*	*-9*	*-3*	*-5*	*-1*	*0*	*-5*	*-11*	*-26*	*-18*	*2*	***-71***
MALANJE	Historical	148	142	189	139	20	2	1	7	42	124	199	169	**1182**
	Future	151	143	186	138	16	1	1	4	29	87	186	169	**1110**
		3	*1*	*-3*	*-1*	*-5*	*1*	*0*	*-3*	*-13*	*-37*	*-13*	*0*	***-70***
MOXICO	Historical	216	189	185	67	6	1	0	3	14	59	150	192	**1082**
	Future	205	179	167	61	3	1	0	1	8	41	129	186	**981**
	Anomaly	*-10*	*-9*	*-18*	*-6*	*-3*	*0*	*0*	*-2*	*-6*	*-18*	*-21*	*-7*	***-100***
NAMIBE	Historical	49	55	79	34	2	0	0	0	2	15	29	36	**302**
	Future	42	48	70	30	2	0	0	0	1	7	20	30	**251**
	Anomaly	*-8*	*-7*	*-8*	*-5*	*1*	*0*	*0*	*0*	*1*	*-8*	*-9*	*-6*	***-48***
UIGE	Historical	128	131	183	208	67	4	2	9	40	131	214	182	**1299**
	Future	125	120	179	205	58	3	2	6	27	92	206	178	**1199**
	Anomaly	*-3*	*-11*	*-4*	*-3*	*-9*	*-1*	*1*	*-3*	*-14*	*-39*	*-9*	*-4*	***-98***
ZAIRE	Historical	97	110	157	167	60	2	1	3	9	62	146	131	**945**
	Future	93	97	150	156	53	1	1	2	6	38	139	128	**864**
	Anomaly	*-5*	*-13*	*-6*	*-11*	*-7*	*0*	*0*	*1*	*-3*	*-25*	*-7*	*-3*	***-78***