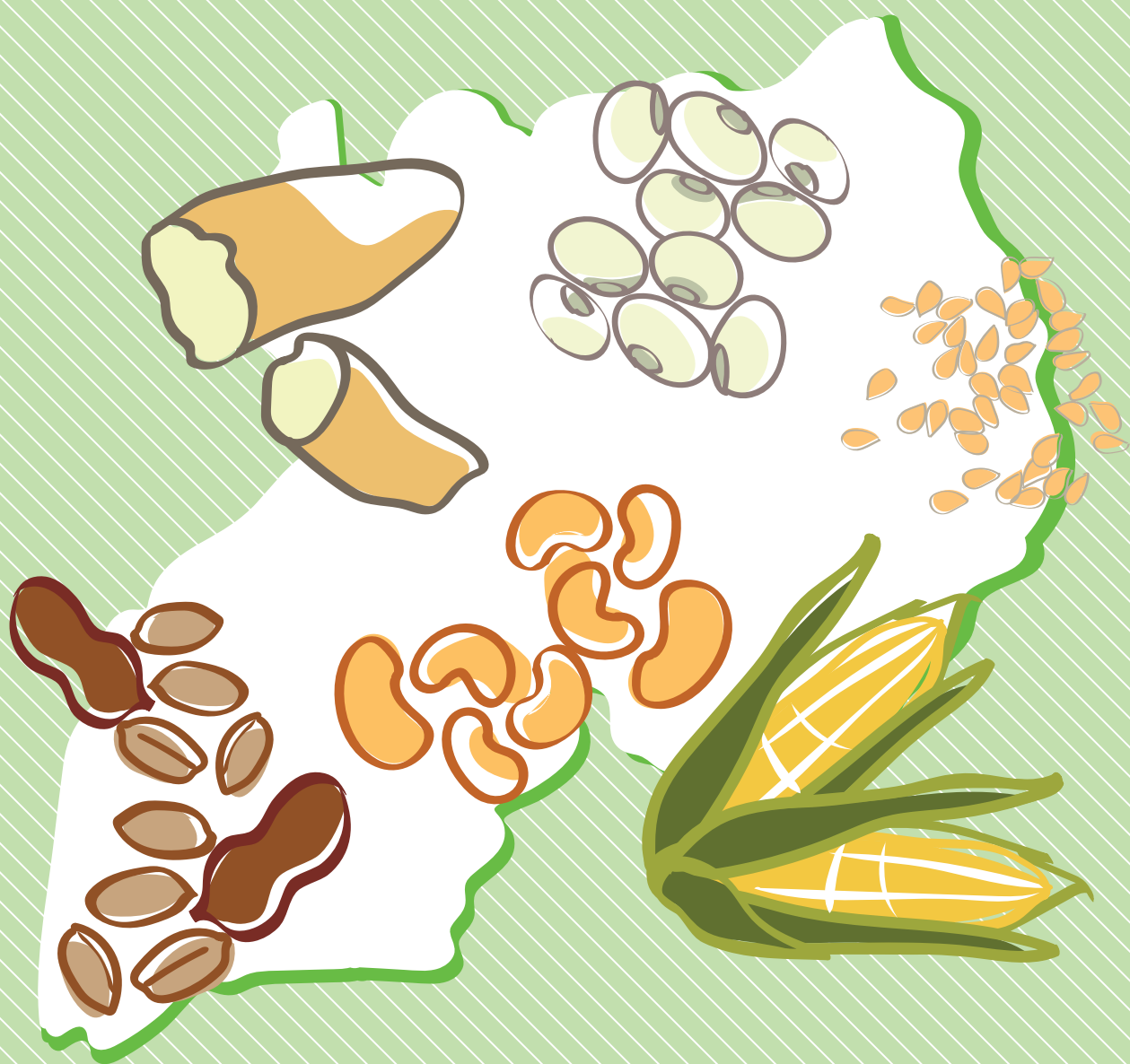


# CLIMATE CHANGE AND FUTURE CROP SUITABILITY IN UGANDA



## Research Highlights – Climate Change and Future Crop Suitability in Uganda

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**RESEARCH HIGHLIGHTS**

# **CLIMATE CHANGE AND FUTURE CROP SUITABILITY IN UGANDA**



# 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 Uganda.

The full Climate Risk Analysis report (accessible via the IFAD Country page <sup>1</sup>) provides an analysis of *inter alia* i) the current and future climate characteristics of Uganda; ii) the

potential change in the suitability of various 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 Uganda, 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 four regions.

## AGRICULTURE IN UGANDA

Uganda is characterised by a highly productive agriculture sector which benefits from a bimodal rainfall system (i.e. two rainy seasons

per year) in most districts and considerable geographic variability that allows a diverse range of cash and subsistence crops to be produced. The Karamoja area in the northeast of the country is characterised by a unimodal (i.e. one rainy season per year) climate while the rest of the northern region is characterised by bimodal rainfall similar to the other regions of the country. Rainfed agriculture, practiced by smallholder farmers, accounts for the vast majority of the planted area. Important subsistence crops include maize and other cereals, plantains, legumes such as beans and groundnuts, cassava, sweet potatoes and a variety of vegetables and horticultural crops. Important cash crops include coffee (*Arabica* and *Robusta* varieties), sesame, soyabean and other oilseed crops.

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<sup>1</sup> <https://www.ifad.org/en/web/operations/country/id/uganda>

# SUMMARY RESULTS

The likely effects of climate change are not fully consistent between each of Uganda's four regions or the crops assessed, however, several general observations can be made. The entire country is predicted to experience increased temperatures throughout the year. Furthermore, all regions are predicted to experience an overall decrease in annual and seasonal precipitation between the present day and the 'Mid-Century' future (defined by the period 2040–2069). In addition to the predicted trend of reduced rainfall during the two traditional growing seasons (commencing in March and August/September, respectively), it is also projected that there will be an increase in rainfall during the months of November, December, January and February (outside of the traditional rainy seasons). These findings may indicate that climate change will result in a delay in the onset of the traditional rainy seasons, or alternatively may indicate that the second rainy season may effectively be extended for one to two months. Overall, the predicted trend is one of decreased annual rainfall, where average annual rainfall across Uganda is predicted to decrease from 1,160 mm to 1,090 mm (i.e. a decrease of 72 mm or 6%).

The full study includes analyses of the predicted effect of climate change on various crops including *inter alia* cereals (maize and sorghum), legumes (common bean and groundnuts), root crops (cassava and sweet potato) and oilseed crops (sesame, soyabean and sunflower). The combined effects of reduced precipitation during the traditional

growing seasons and increased temperatures are likely to result in a complex matrix of positive and negative effects on the crops assessed. The annual production of certain climate-sensitive crops such as beans, maize and cassava 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 sorghum and oilseed crops such as sunflower, soyabean and sesame are comparatively less affected by the predicted climate changes and may be appropriate alternatives to be promoted in areas where the production of other crops is expected to become marginal.

However, despite these common trends, there are also several region-specific effects on climate variables and resultant crop suitability that will necessitate the development of tailored local-level adaptation plans and strategies for agricultural development. The Central and Western regions are predicted to be the most vulnerable to climate change impacts on the production of three out of the four oil crops assessed in this report, including groundnuts, sesame and soyabean. However, the production impacts on these crops are relatively small and oil crops generally appear to be relatively climate-resilient. The analysis revealed that some of the largest crop production impacts (predicted for beans and cassava), at both the household- and regional-levels, are consistently expected

to occur in the Northern region. These crop production impacts are of particular concern given that the Northern region was also identified as the region with the lowest adaptive capacity score, based on a number of socio-economic and agronomic characteristics, and is therefore anticipated to be the least able to respond to climate change-related impacts. As a result, the Northern region is particularly vulnerable and should be prioritised for adaptation interventions.

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. In addition, the study cannot consider or predict the effect of different cultivation methods and technologies that may be practiced within the study area. Finally, in terms of predicting the likely effects of climate change and resultant risks to crop production, 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, particularly in the Northern region, through disruption of familiar seasonal trends, increased water and heat stress and reduced growing season.

# 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 Uganda's four regions. For each of the crops considered in this study (beans, cassava, groundnuts, maize, sesame and soyabean) the relative **Climate Change Vulnerability (V)** of crop production is considered at the regional level and aims to identify those regions which are likely to be most or least vulnerable to climate change impacts on the given crop.

The relative vulnerabilities of each region can be expressed as a **Vulnerability Index (VI)** score, derived by comparison of the relative scale of:

- **Impacts (I)** of climate change on crop production (estimated through analysis of climate models and resulting changes to crop suitability); and
- the **Adaptive Capacity (AC)** of agricultural households to respond and adapt to the impacts of climate change (derived through statistical indicators of socio-economic, developmental and agronomic context);

in each of Uganda's four regions. **Vulnerability** is considered to be proportional to the relative size of

**Impacts**, and inversely proportional to **Adaptive Capacity**. The product of the scores for **AC** and **I** are used to calculate a standardised score for **V**, thereby allowing comparisons between each region and allowing the identification of those regions and households which are likely to be most vulnerable to climate change impacts on each crop.

## IMPACTS

The **Impacts (I)** of climate change on crops were estimated by projecting the likely future changes to Uganda's climate, and then analysing the effects of those projected climate changes on economically important crops. Firstly, the potential future changes to Uganda'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)<sup>3</sup>. 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 Uganda, comparing the historical baseline (the average climate for the period 1980–2010) to the Mid-Century future (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*.

Analyses of current and future crop suitability were generated using the Food and Agriculture Organisation's EcoCrop Suitability model<sup>4</sup> 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, and a score of 1 is considered excellent, with a continuous spectrum of

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

<sup>3</sup> 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

<sup>4</sup> <https://ecocrop.fao.org/ecocrop/srv/en/home>

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 Uganda's four regions. 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, below.

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:

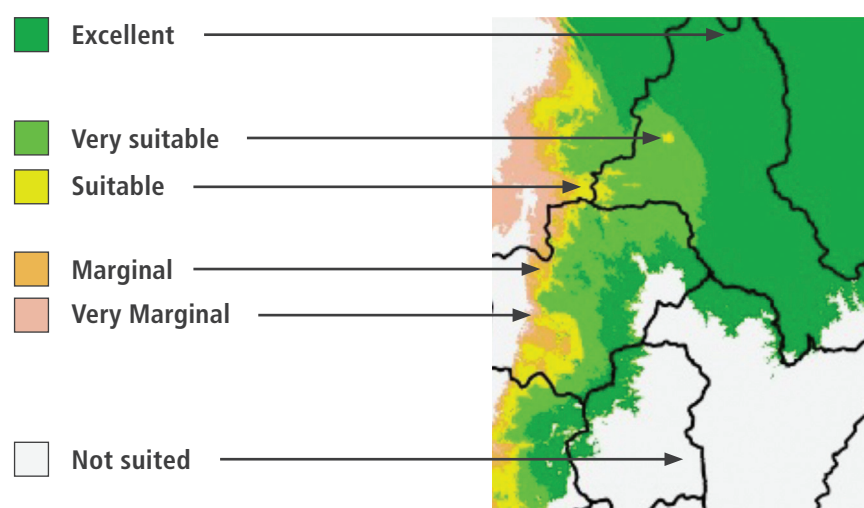
- the changes to total suitable area (km<sup>2</sup>) and average suitability index score between the historical baseline and 'mid-century' future<sup>5</sup>;

- and estimated historical crop production in each region, derived from national agricultural production statistics<sup>6</sup>.

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 region".

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**



<sup>5</sup> 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

<sup>6</sup> Derived from the most recent national statistics available: 2008/9 figures reported by Uganda's Bureau of Statistics (UBOS. 2010). Uganda Census of Agriculture: Crop Area and Production Volume Report. [https://www.ubos.org/wp-content/uploads/publications/03\\_2018UCACrop.pdf](https://www.ubos.org/wp-content/uploads/publications/03_2018UCACrop.pdf)



# ADAPTIVE CAPACITY

Indicators for **Adaptive Capacity (AC)** – the relative ability of agricultural households to respond and adapt to predicted climate change impacts – were derived from the most recent statistics available at the sub-national level <sup>7</sup>. In the case of Uganda, the indicators used to estimate AC in each region included

- **‘Access to Education’** (% literacy rate, primary school enrolment rate);
- **‘Access to agricultural information’** (registered mobile money users, availability of extension services);

- and **‘Adoption of improved agricultural practices’** (% inorganic and organic fertiliser use, manure use, herbicide use, and pesticide use).

The national statistics collected to assess AC – which are summarised in the Appendix (Table A.1) – were used to calculate an average AC score for each region. The indicator category **‘Adoption of improved agricultural practices’** was assigned a weighting of 50% towards the final AC score, and the remaining 50% was contributed equally by the remaining indicator categories. These are presented in Table 1.

The AC scores generated indicate that smallholder farmers in the

Eastern and Western regions have the highest overall capacities to respond to climate change’s impacts (ranking 1<sup>st</sup>, 2<sup>nd</sup>, respectively). The Central and Northern regions have the lowest overall AC scores (ranking 3<sup>rd</sup> and 4<sup>th</sup>, respectively) and therefore are anticipated to be least able to respond or adapt to climate change-related impacts. These results are consistent with expectations of the Northern region as it is largely rural and characterised by subsistence or smallscale agriculture. However, the results are surprising for the Central region which is relatively more developed and with comparatively high scores on indicators relating to access to education and technology.

**TABLE 1. RANKED ADAPTIVE CAPACITY (AC) INDICATOR SCORES FOR ALL REGIONS OF UGANDA**

	<i>Adaptive capacity Indicator category</i>				<i>Adaptive capacity rank</i>
	<i>Adoption of improved agricultural practices</i>	<i>Access to agricultural information</i>	<i>Education</i>	<i>Adaptive capacity score</i>	
<i>Contribution to index</i>	50%	25%	25%		
Central	12.5	43.3	90.6	39.7	3
Eastern	68.7	23.9	76.5	59.4	1
Northern	4.6	26.0	31.2	16.6	4
Western	47.6	29.3	74.8	49.8	2

<sup>7</sup> Derived from the most recent national statistics available: 2008/9 figures reported by Uganda’s Bureau of Statistics (UBOS. 2010). Uganda Census of Agriculture: Crop Area and Production Volume Report. [https://www.ubos.org/wp-content/uploads/publications/03\\_2018UCACrop.pdf](https://www.ubos.org/wp-content/uploads/publications/03_2018UCACrop.pdf)

# CLIMATE PROJECTIONS

## PROJECTED CHANGES TO TEMPERATURE IN UGANDA BY 2050

The predicted changes in Mean Monthly Temperature (TMean) from the historical baseline to the mid-century (2050) future indicate that climate change will result in consistent increases in TMean across regions and months. The hottest months of January, February and March are predicted to increase by 1.7 °C, relative to a Historical average of 24.4–25.2 °C. Similar increases of 1.6–2.1 °C are predicted for all other months of the year (see Table 2, below. Region-level summaries of TMean can be found in the supplementary Appendix). The predicted changes in Minimum Monthly Temperature (Tmin) are similar, indicating consistent increases in temperature minimums of at least 1.6°C, and up to 1.9–2.1°C

during the rainy season months of March-May and August-October.

The overall effect of these increases in TMean and Tmin is likely to result in complex impacts on the agricultural sector, particularly when considered in combination with the predicted decreases in precipitation (see next section).

The large increases in temperature (1.7–2.0°C) in the rainy season months of March-May and August-October 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 may increase the risk 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.

Taken cumulatively over the entire growing season, the combination of reduced rainfall and increased TMean is 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. However, the magnitude of this effect is likely to vary between and within each region.

**TABLE 2. PROJECTED INFLUENCE OF CLIMATE CHANGE ON MEAN MONTHLY TEMPERATURE (°C) IN UGANDA AT HISTORICAL AND MID-CENTURY PERIODS, AND MONTHLY ANOMALIES BETWEEN THE TWO TIME PERIODS <sup>8</sup>**

Tmean (°C)	MONTH											
	J	F	M	A	M	J	J	A	S	O	N	D
Historical	24.4	25.2	24.9	24.0	23.3	22.8	22.5	22.8	23.2	23.3	23.5	23.7
Future	26.1	26.9	26.6	25.8	25.1	24.7	24.5	24.8	25.1	25.1	25.1	25.4
Anomaly	+1.7	+1.7	+1.7	+1.8	+1.8	+1.9	+2.1	+2.0	+1.9	+1.8	+1.6	+1.6

<sup>8</sup> 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 UGANDA BY 2050

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

All regions are predicted to experience decreases in total annual precipitation, as well as reduced rainfall during the months which correspond with the two rainy seasons (in March–May and August–October, respectively).

Total rainfall at the onset of the first rainy season in the months of March, April and May is predicted to be reduced from 368 to 338 mm (total reduction of rainfall of 31 mm). Similarly, at the onset of the second rainy season in the months of August, September and October, total rainfall is predicted to be reduced from 375 to 344 mm (total reduction of rainfall of 31 mm).

In contrast to the decreased precipitation predicted during the rainy seasons, it is projected that the dry season months of November to February will experience a minor increase of 11 mm over the 4-month period.

These results may indicate a delay in the onset of the traditional rainy seasons, in turn resulting in changes to the timing of various agricultural activities such as field preparation and sowing of seed. Alternatively, these results may indicate that rainy seasons (particularly the second season, August – October) may effectively be extended for one to two months, thereby providing farmers with the option to extend or stagger the timing of crop establishment.

**TABLE 3. PROJECTED INFLUENCE OF CLIMATE CHANGE ON MEAN MONTHLY PRECIPITATION (MM/MONTH) IN UGANDA AT HISTORICAL AND MID-CENTURY PERIODS, AND MONTHLY ANOMALIES BETWEEN THE TWO TIME PERIODS <sup>9</sup>.**

MM/MONTH	MONTH												TOTAL
	J	F	M	A	M	J	J	A	S	O	N	D	
Historical	36.9	41.2	93.8	145.9	128.6	81.5	91.9	118.6	119.7	136.6	113.5	55.9	1164.1
Future	39.9	42.3	93.3	135.6	109.1	66.6	84.1	106.6	107.5	130.0	116.0	60.4	1091.4
Anomaly	<b>+3.0</b>	<b>+1.1</b>	<b>-0.5</b>	<b>-10.4</b>	<b>-19.6</b>	<b>-14.9</b>	<b>-7.8</b>	<b>-12.1</b>	<b>-12.2</b>	<b>-6.6</b>	<b>+2.5</b>	<b>+4.5</b>	<b>-72.7</b>

<sup>9</sup> Historical precipitation based on the average of the period 1980-2010, and projected Mid-Century precipitation for the period 2040-2070. Anomalies are defined as the total change between Historical and Mid-Century projections. Region-level summaries of predicted monthly changes in precipitation can be found in the supplementary Appendix).

# CLIMATE CHANGE AND ITS EFFECT ON BEANS



## BROAD CONTEXT

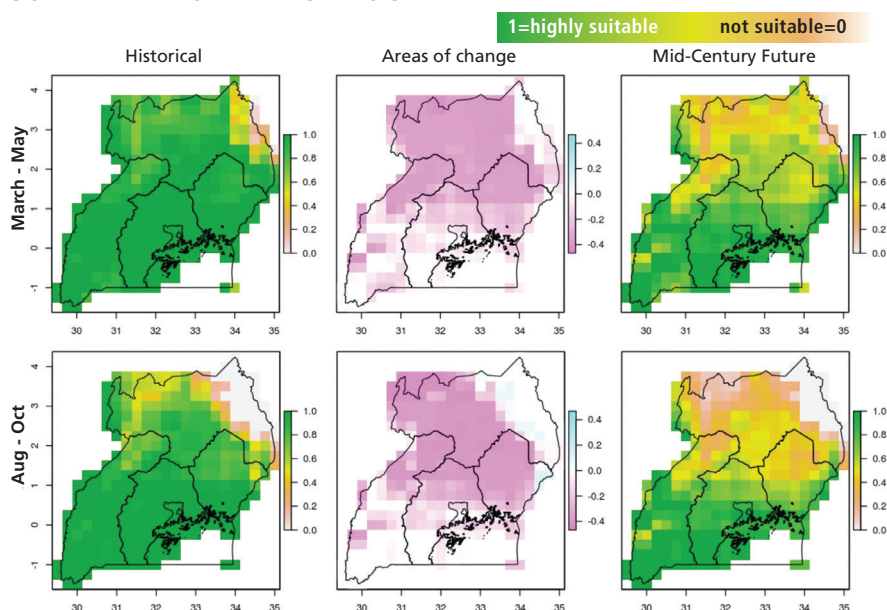
Beans are widely grown as a staple subsistence crop across Uganda's four regions, where the crop is grown in both rainy seasons.

The total spatial extent of suitable area is predicted to remain largely unchanged between historical (1990-2010) and mid-century (2040-2060) time periods for both rainy seasons (except for minor reductions in the Northern region). However, all regions are expected to experience negative changes in average suitability in both rainy seasons as a result of climate change. Examination of the anomalies (centre, Figure 1) for the months of April and August indicates that the north-western and central parts of the country will experience decreases in average suitability. The Northern region is likely to be the worst affected, where productivity is projected to decrease by 20% and 29% in the first and second rainy seasons respectively.

## PRODUCTION OF BEANS IN UGANDA<sup>1</sup>

REGION	PRODUCTION AREA		ANNUAL PRODUCTION	
	TOTAL (HA)	% NATIONAL TOTAL	TOTAL (TONNES)	% NATIONAL TOTAL
Central	120,798	19.6	167,276	18.0
Eastern	108,107	17.5	98,835	10.6
Northern	146,702	23.8	251,222	27.0
Western	241,915	39.2	411,946	44.3
<b>Total</b>	<b>617,522</b>		<b>929,279</b>	

## PROJECTED EFFECT OF CLIMATE CHANGE ON DISTRIBUTION OF SUITABILITY FOR BEANS IN UGANDA

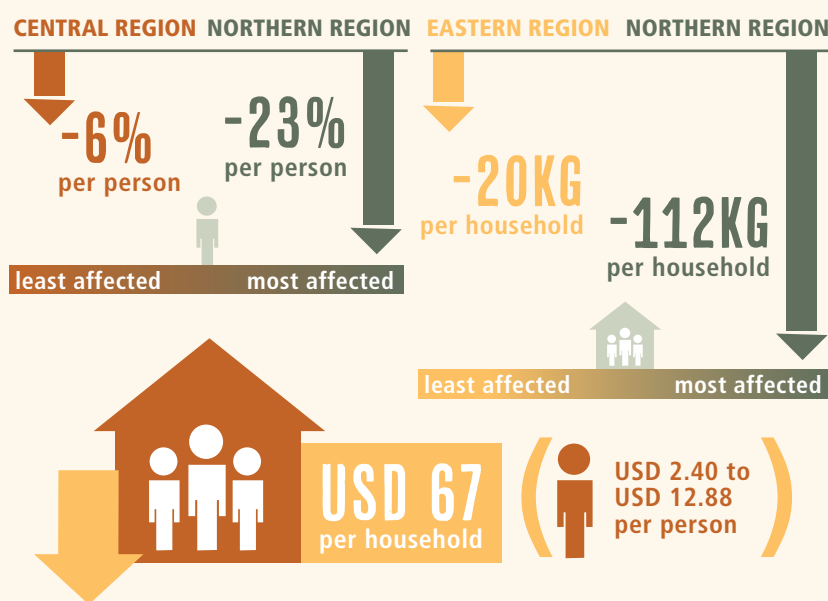


## HOUSEHOLD LEVEL IMPACTS

In terms of the potential change in production per capita (%), it is predicted that households will experience a decrease in annual production ranging from 6% in the Central region, up to 23% in the Northern region.

In terms of the potential change in household annual production, the predicted decrease is from 20 kg per household in the Eastern region, up to 112 kg per household in the Northern region. This may relate to a per person cost of USD 2.40 to USD 12.88 per person, or a household cost of roughly USD 67 per household if farmers replace their predicted lost production<sup>2</sup>.

### ANNUAL PRODUCTION



<sup>1</sup> Derived from the most recent national statistics available: 2008/9 figures reported by Uganda's Bureau of Statistics (UBOS, 2010), Uganda Census of Agriculture: Crop Area and Production Volume Report, [https://www.ubos.org/wp-content/uploads/publications/03\\_2018UCACrop.pdf](https://www.ubos.org/wp-content/uploads/publications/03_2018UCACrop.pdf)

<sup>2</sup> Based on current market prices and annual crop production statistics



## REGIONAL AND NATIONAL-LEVEL IMPACTS

At the regional level, the reduction in total annual production ranges from 10 745 tonnes in the Central region to 57 118 tonnes in the Northern region (resulting in costs to replace lost production of up to USD 34 million in the latter region).

In total, it is estimated that the annual production of beans across all regions will be reduced by roughly 116 400 tonnes. At a national scale, the total annual costs of climate-related impacts on beans is estimated to be roughly USD 69.8 million.

Total loss  
of annual  
production

116 400  
tonnes



Total replacement cost

USD 69.8 million



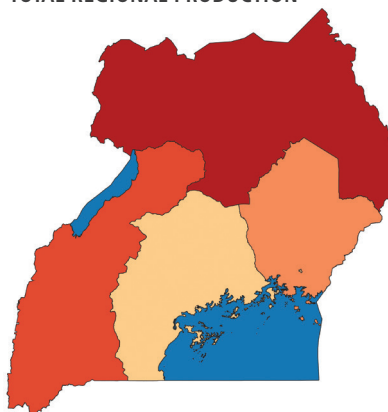
## CLIMATE VULNERABLE REGIONS AND HOUSEHOLDS

At the household level, the two regions which will experience the most severe negative impacts on per capita production are the Northern and Eastern regions.

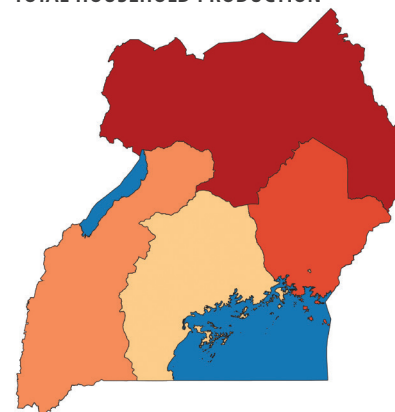
The two regions which will experience the most severe negative impacts on total regional production are the Northern and Western regions.

### MOST VULNERABLE REGIONS, BASED ON CHANGES TO:

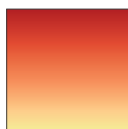
TOTAL REGIONAL PRODUCTION



TOTAL HOUSEHOLD PRODUCTION



Most vulnerable



Least vulnerable



## KEY FINDINGS AND RECOMMENDATIONS



All of Uganda's regions are predicted to experience decreased production of beans as a result of climate change



The total replacement costs incurred by households to replace lost food production is estimated to be up to USD 70 million per year<sup>2</sup>



The Northern region is likely to be the worst affected and households may be exposed to a decrease in annual production of up to 23%.



The Western, Central and Eastern regions may experience moderate decreases in production, however, these regions will still benefit from widespread distribution of highly suitable areas for beans despite climate change.



Despite the negative results outlined above, beans, and other leguminous crops, will remain a useful option for climate-resilient farming systems.

# CLIMATE CHANGE AND ITS EFFECT ON CASSAVA



## BROAD CONTEXT

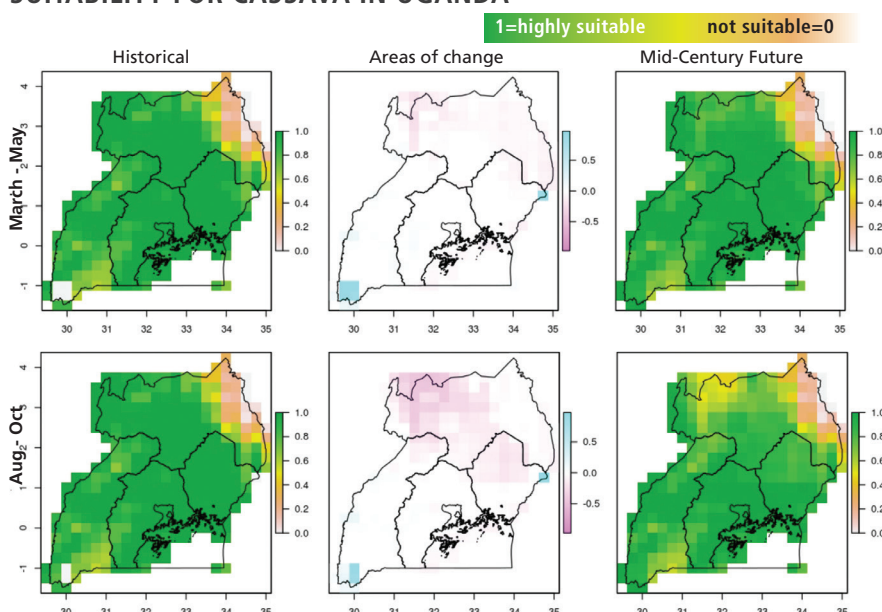
Cassava is widely grown as a staple crop across Uganda's four regions, where the crop is grown in both rainy seasons.

Overall, climate change is predicted to result in relatively minor impacts on future suitability for cassava in most regions, including both positive and negative effects. Virtually the entire spatial extent of Uganda, except for the arid Karamoja area, is predicted to remain suitable for production of cassava during both rainy seasons. Small negative changes to the suitability index score are predicted for the Northern, Eastern and Western regions. However, the latter two regions may benefit from small increases in suitable area, whereas the Northern region is the only region which is predicted to undergo decreases in productivity by the mid-Century future (2040-2060).

## PRODUCTION OF CASSAVA IN UGANDA<sup>10</sup>.

REGION	PRODUCTION AREA		ANNUAL PRODUCTION	
	TOTAL (HA)	% NATIONAL TOTAL	TOTAL (TONNES)	% NATIONAL TOTAL
Central	127,788	14.7	409,812	14.2
Eastern	342,387	39.3	1,061,186	36.7
Northern	269,886	31.0	983,124	34.0
Western	131,328	15.1	440,189	15.2
<b>Total</b>	<b>871,389</b>		<b>2,894,311</b>	

## PROJECTED EFFECT OF CLIMATE CHANGE ON DISTRIBUTION OF SUITABILITY FOR CASSAVA IN UGANDA

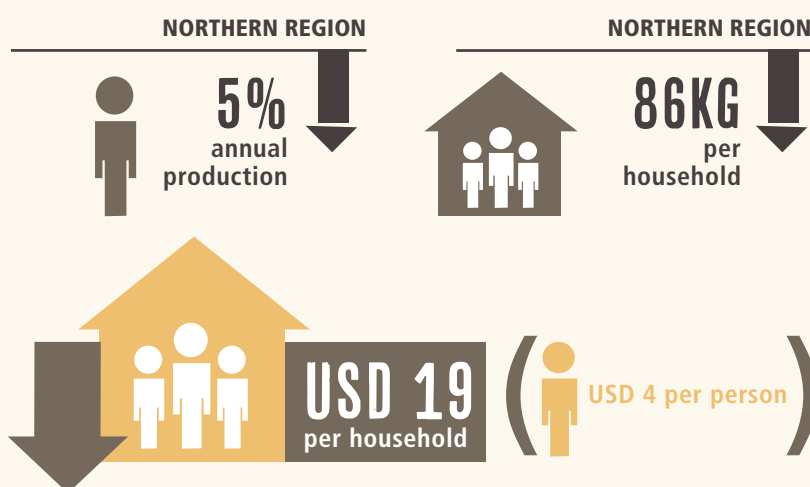


## HOUSEHOLD LEVEL IMPACTS

The Northern region is the only region predicted to experience negative impacts on cassava production, where households are projected to experience a decrease of 5% in per capita annual production, equivalent to a loss of up to 86 kg per household.

This may relate to a cost of up to USD 4 per person, or a household cost of USD 19 per household if farmers replace their predicted lost production.<sup>11</sup> It is unclear to what extent the remaining regions will benefit from increased production potential, but they are considered to be less likely to experience major negative climate change impacts on cassava.

### ANNUAL PRODUCTION



<sup>10</sup> Derived from the most recent national statistics available: 2008/9 figures reported by Uganda's Bureau of Statistics (UBOS, 2010), Uganda Census of Agriculture: Crop Area and Production Volume Report, [https://www.ubos.org/wp-content/uploads/publications/03\\_2018UCACrop.pdf](https://www.ubos.org/wp-content/uploads/publications/03_2018UCACrop.pdf)

<sup>11</sup> Based on current market prices and annual crop production statistics





## REGIONAL AND NATIONAL-LEVEL IMPACTS

At the regional level, the total reduction in annual production of cassava from the Northern region is estimated to be 44,200 tonnes, equivalent to a total replacement cost of USD 9.5 million.

Total loss  
of annual  
production

44 200  
tonnes

\$

Total replacement cost

USD 9.5 million



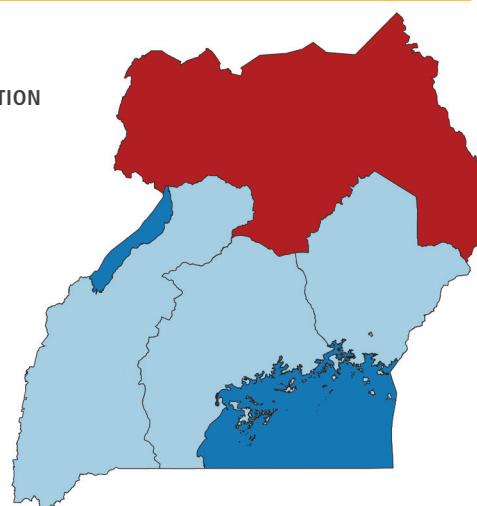
## CLIMATE VULNERABLE REGIONS AND HOUSEHOLDS

The Northern region is the only region which is predicted to be vulnerable to negative impacts on cassava production as a result of climate change. Results suggest that cassava production in the remaining regions is relatively less vulnerable to climate change in Uganda, and in some cases may experience minor benefits as a result of increased suitable area.

### MOST VULNERABLE REGIONS, BASED ON CHANGES TO:

TOTAL REGIONAL/HOUSEHOLD PRODUCTION

- Most vulnerable
- Suitability increase



## KEY FINDINGS AND RECOMMENDATIONS



Most of Uganda is likely to remain widely suitable for production of cassava.



Cassava is a flexible crop, allowing stems and roots to be harvested throughout the year according to household needs.



The only region that is likely to experience negative climate change impacts on cassava is the Northern region, where annual production may decrease by up to 5%.



The total replacement costs incurred by households to replace lost food production is estimated to be up to USD 9.5 million per year<sup>12</sup>.



Cassava is likely to be a useful option for climate-resilient and diversified farming systems, to maintain food security or contribute to household income.

<sup>12</sup> Based on current market prices and annual crop production statistics

# CLIMATE CHANGE AND ITS EFFECT ON GROUNDNUT



## BROAD CONTEXT

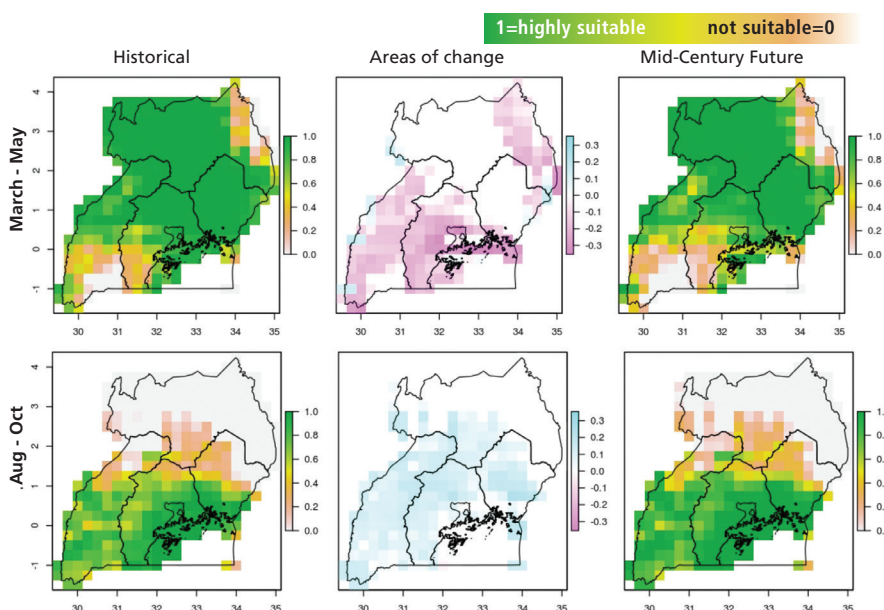
Groundnuts are widely grown as a staple crop across Uganda in both rainy seasons, both as a leguminous staple as well as an oil seed.

Results indicate climate change may result in minor decreases in productivity at the onset of the first rainy season (ranging from -1.4 to -8.3%) and increases in productivity at the onset of the second rainy season (ranging from 4.1 to 20.1). Similarly, changes to the suitable area of each region are negative (or zero for the Eastern region) for the onset of the first rainy season and positive (or zero for the Central region) for the second rainy season. Most of the regions are projected to remain suitable to highly suitable for groundnuts by the mid-century (2040-2060) future, except for the Northern region which remains relatively marginal during the second rainy season.

## PRODUCTION OF GROUNDNUTS IN UGANDA<sup>13</sup>

REGION	PRODUCTION AREA		ANNUAL PRODUCTION	
	TOTAL (HA)	% NATIONAL TOTAL	TOTAL (TONNES)	% NATIONAL TOTAL
Central	26,504	4.8	32,758	8.1
Eastern	122,404	22.1	77,248	19.0
Northern	345,232	62.4	244,684	60.2
Western	59,431	10.7	51,498	12.7
<b>Total</b>	<b>553,571</b>		<b>406,188</b>	

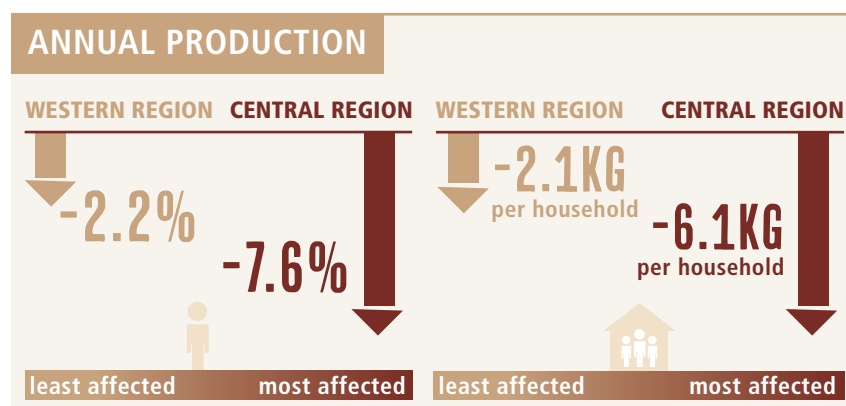
## PROJECTED EFFECT OF CLIMATE CHANGE ON DISTRIBUTION OF SUITABILITY FOR GROUNDNUTS IN UGANDA



## HOUSEHOLD LEVEL IMPACTS

Climate change may result in a mix of positive, negative and neutral impacts on groundnuts. The Central and Western regions are predicted to experience small negative impacts on groundnut production, where households are projected to experience a decrease of 2.2% (Western) to 7.6% (Central) in annual production per capita.

In terms of the potential change in household annual production, the predicted decrease is from 2.1kg per household in the Western region, and up to 6.1kg per household in the Central region. This may relate to a per person cost of USD 0.40 to USD 1.6 per person, or a household cost of roughly USD 6 per household if farmers replace their predicted lost production. Results



suggest that the Northern and Eastern regions may benefit from minor positive effects, however, it should be noted that these regions are still characterised by a lower overall suitability for groundnuts (particularly during the August-October rainy season) compared to Central and Western regions.



<sup>13</sup> Derived from the most recent national statistics available: 2008/9 figures reported by Uganda's Bureau of Statistics (UBOS, 2010), Uganda Census of Agriculture: Crop Area and Production Volume Report, [https://www.ubos.org/wp-content/uploads/publications/03\\_2018UCACrop.pdf](https://www.ubos.org/wp-content/uploads/publications/03_2018UCACrop.pdf)

<sup>14</sup> Based on current market prices and annual crop production statistics





## REGIONAL AND NATIONAL-LEVEL IMPACTS

At the regional level, it is estimated that the Central and Western regions will experience a decrease in annual production of 2,480 and 1,130 tonnes respectively (resulting in costs to replace lost production of up to USD 2.4 million in the former region).

In total, it is estimated that the annual production of groundnuts across all regions will be reduced by 3,611 tonnes. At a national scale, the total annual costs of climate-related impacts on groundnut production is estimated to be roughly USD 3.5 million.

Total loss  
of annual  
production

**3 611**  
tonnes



Total replacement cost

**USD 3.5** million

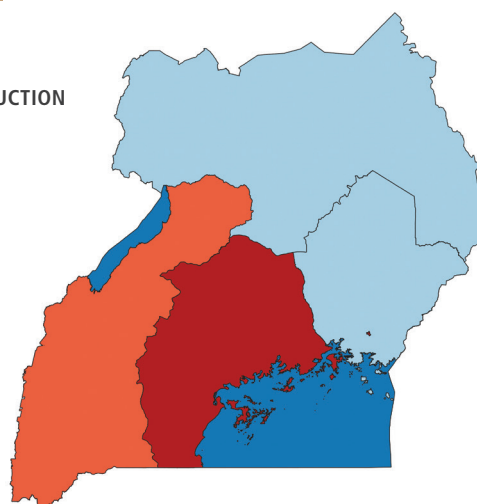


## CLIMATE VULNERABLE REGIONS AND HOUSEHOLDS

Of the two regions that are anticipated to experience negative impacts, the Central region is likely to be the most vulnerable to climate change impacts on groundnut production, both at the household-level and at the regional-level. The Eastern and Northern regions may benefit from minor increased suitability and suitable area for production of groundnuts, although it cannot be concluded that these areas will definitely benefit from increased annual production.

### MOST VULNERABLE REGIONS, BASED ON CHANGES TO:

TOTAL REGIONAL/HOUSEHOLD PRODUCTION



## KEY FINDINGS AND RECOMMENDATIONS



Eastern and Northern regions are unlikely to experience severe negative impacts to production of groundnuts as a result of climate change.



Central and Western regions are predicted to undergo small decreases in annual production, equivalent to a total loss of up to 3,600 tonnes.



The replacement costs incurred by households to replace lost production of groundnuts is estimated to be up to USD 5.90 per household, or a total of USD 3.5 million per year<sup>15</sup>.



Despite these negative impacts, Uganda will continue to be characterised by widespread areas of suitability for groundnuts.



Groundnuts are likely to be a useful option for climate-resilient farming systems, either to be promoted as an alternative or a complement to other crops.

# CLIMATE CHANGE AND ITS EFFECT ON MAIZE

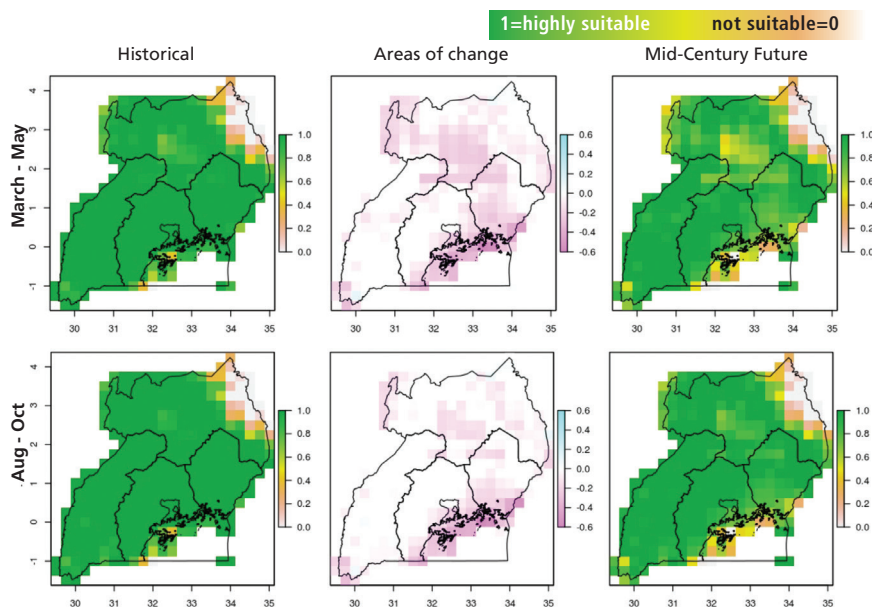


## BROAD CONTEXT

Maize is the main cereal crop of Uganda. It is characterised by widespread areas of suitability and is planted in both rainy seasons.

Climate change is expected to result in minor negative impacts on the future suitability of maize. All regions are predicted to undergo minor decreases to productivity in both rainy seasons. The Eastern region is predicted to experience the greatest decrease in productivity in both rainy seasons (with only very minor reductions predicted for the Northern and Central regions). Despite these negative changes, the total suitable area is expected to remain unchanged and all regions are expected to be characterised by good suitability on average.

### PROJECTED EFFECT OF CLIMATE CHANGE ON DISTRIBUTION OF SUITABILITY FOR MAIZE IN UGANDA

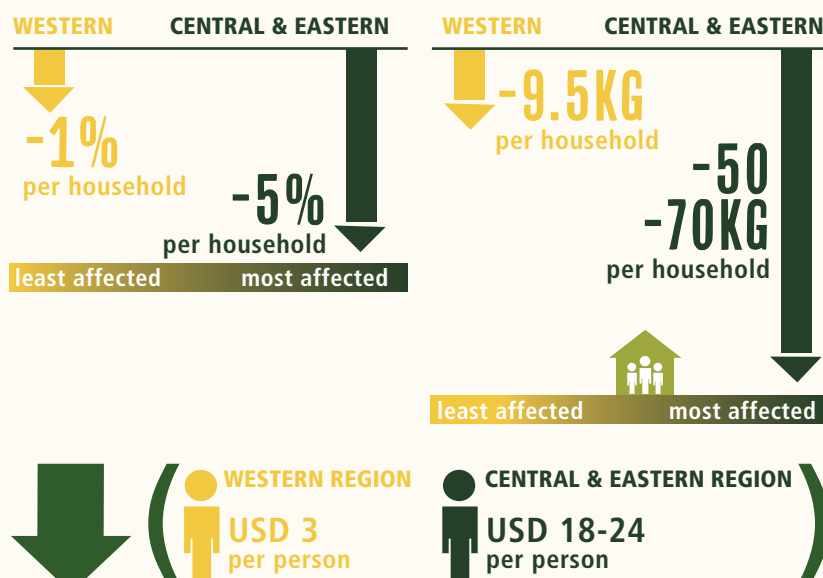


## HOUSEHOLD LEVEL IMPACTS

In terms of the potential change in production per capita (%), it is predicted that households will experience a decrease in annual production ranging from 1% in the Western region up to 5% in the Central and Eastern regions

In terms of the potential change in household annual production, the predicted decrease is from 9.5 kg in the Western region, up to 50 - 70 kg in the Central and Eastern regions, respectively. This may relate to a per person cost of USD 3 in the Western region, or up to USD 18-24 in the Central and Eastern regions, respectively.<sup>16</sup>

### ANNUAL PRODUCTION



<sup>16</sup> Based on current market prices and annual crop production statistics



## REGIONAL AND NATIONAL-LEVEL IMPACTS

At the regional level, the reduction in total annual production ranges from 5,200 tonnes in the Western region up to 50,600 tonnes in the Eastern region (resulting in costs to replace lost production of up to USD 17 million in the latter region).

In total, it is estimated that the annual production of maize across all regions will be reduced by 89,000 tonnes. At a national scale, the total annual costs of climate-related impacts on maize is estimated to be roughly USD 31 million.

Total loss  
of annual  
production

**89 000**  
tonnes

\$

Total replacement cost

**USD 31** million



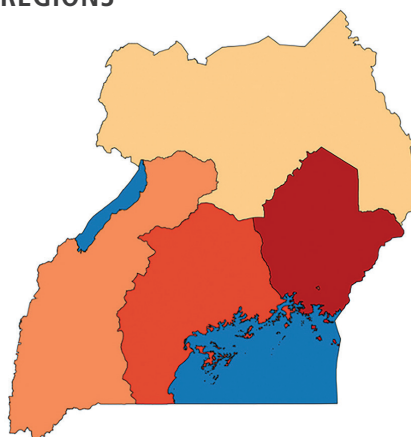
## CLIMATE VULNERABLE REGIONS AND HOUSEHOLDS

At the household level, the two regions which will experience the most severe negative impacts on per capita production are the Central and Northern regions.

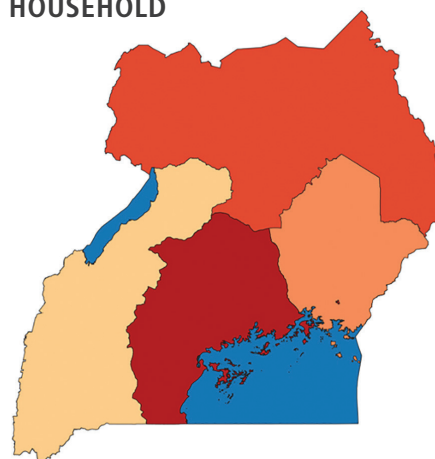
The two regions which will experience the most severe negative impacts on total regional production are the Eastern and Central regions.

### MOST VULNERABLE REGIONS, BASED ON CHANGES TO:

#### REGIONS

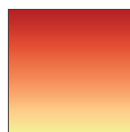


#### HOUSEHOLD



Most vulnerable

Least vulnerable



## KEY FINDINGS AND RECOMMENDATIONS



The negative effects of climate change on maize are expected to be minor or moderate across most of Uganda's regions.



Most of Uganda is likely to remain widely suitable for maize production.



The Central and Eastern regions are predicted to experience the greatest decreases in maize production, up to 89,000 tonnes or a replacement cost to households of USD 31 million.

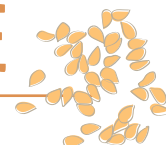


Maize is likely to remain well-suited for Uganda's climate by the mid-century future.



Results for sorghum (not included in this report) indicate minor increases in suitability - all regions are expected to be characterised by excellent suitability (this crop is likely to be a useful climate-resilient alternative to maize).

# CLIMATE CHANGE AND ITS EFFECT ON SESAME



## BROAD CONTEXT

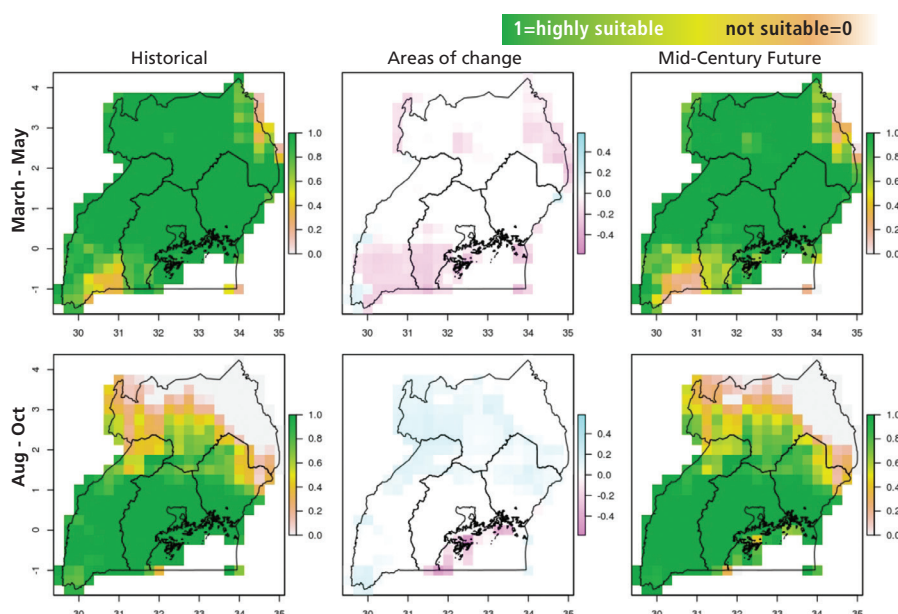
Sesame is a moderately valuable oilseed crop, which is grown in all of Uganda's regions but primarily in the North. The entire extent of the country is highly suitable for sesame in the March-May rainy season, while the northern and eastern extents of the country are only moderately suitable in the August-October season.

The effects of climate change on suitability for sesame may be a mix of positive and negative. All regions are expected to experience minor or moderate increases in productivity at the start of the first rainy season (ranging from 1.7 to 8.4 %), and minor decreases in productivity at the onset of the second rainy season (ranging from -0.4 to -1.8). The Central region is the only region projected to undergo decreases in productivity in both rainy seasons. Total suitable area for sesame production is likely to remain unchanged for all of the regions, except at the onset of the first rainy season in the Eastern and Northern regions, where suitable area may increase by 1.6 and 10%, respectively.

## PRODUCTION OF SESAME IN UGANDA<sup>17</sup>.

REGION	PRODUCTION AREA		ANNUAL PRODUCTION	
	TOTAL (HA)	% NATIONAL TOTAL	TOTAL (TONNES)	% NATIONAL TOTAL
Central	590	0.3	126	0.1
Eastern	15,316	8.0	6,774	6.2
Northern	175,596	91.3	101,028	93.1
Western	928	0.5	565	0.5
<b>Total</b>	<b>192,430</b>		<b>108,493</b>	

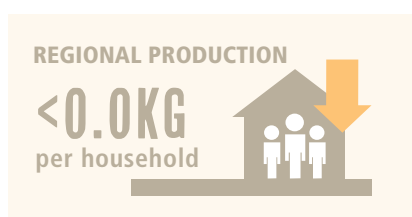
## PROJECTED EFFECT OF CLIMATE CHANGE ON DISTRIBUTION OF SUITABILITY FOR SESAME IN UGANDA



## HOUSEHOLD LEVEL IMPACTS

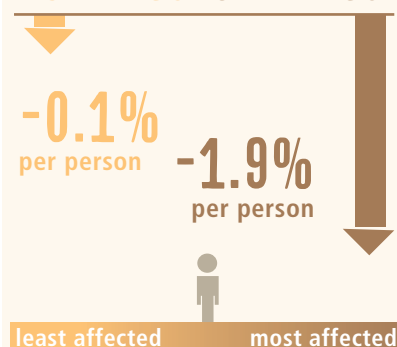
The Central and Western regions are predicted to experience very minor negative impacts on sesame production, where the potential change in annual production per capita (%) is projected to decrease by 0.1% (Western) and 1.9% (Central). However, in consideration of the relatively small historical production of sesame in these regions, the potential changes in annual household production are negligible (<0.0kg).

The Northern and Eastern regions may experience minor positive effects, which may be attributed to increases in total suitable area at the onset of the March-May rainy season.



## ANNUAL PRODUCTION

### WESTERN REGION CENTRAL REGION



<sup>17</sup> Derived from the most recent national statistics available: 2008/9 figures reported by Uganda's Bureau of Statistics (UBOS, 2010), Uganda Census of Agriculture: Crop Area and Production Volume Report, [https://www.ubos.org/wp-content/uploads/publications/03\\_2018UCACrop.pdf](https://www.ubos.org/wp-content/uploads/publications/03_2018UCACrop.pdf)



## REGIONAL AND NATIONAL-LEVEL IMPACTS

In terms of total annual production of sesame within each region, it is predicted that the Central and Western regions will experience a negligible decrease in annual production of 2 and 1 tonnes respectively. It is possible that these small deficits will be partly offset by the potential for increased production in those regions that are expected to benefit from increased suitability. However, these results cannot predict whether the worst-affected regions will be able to benefit from the increased production in other regions, and consequently these potential positive impacts are not included in the final estimation of changes to annual production.

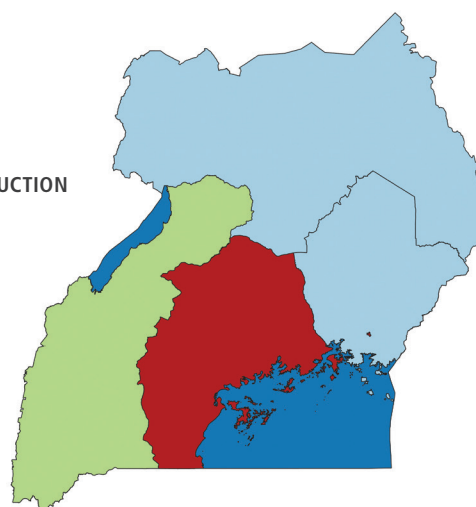
Total loss of  
annual production



**MOST VULNERABLE REGIONS, BASED ON CHANGES TO:**

TOTAL REGIONAL/HOUSEHOLD PRODUCTION

- Most vulnerable
- Suitability increase
- No suitability change



## KEY FINDINGS AND RECOMMENDATIONS



Most of Uganda is unlikely to experience major negative effects of climate change on sesame production.



Central and Western regions may experience minor impacts on production potential, equivalent to a decrease of <2 tonnes per region.



Sesame is an oilseed crop which is likely to be a useful option for climate-resilient farming systems in Uganda, particularly as a means of improving household income by processing oils or marketing seeds to commercial oilseed processors.



# CLIMATE CHANGE AND ITS EFFECT ON SOYABEAN



## BROAD CONTEXT

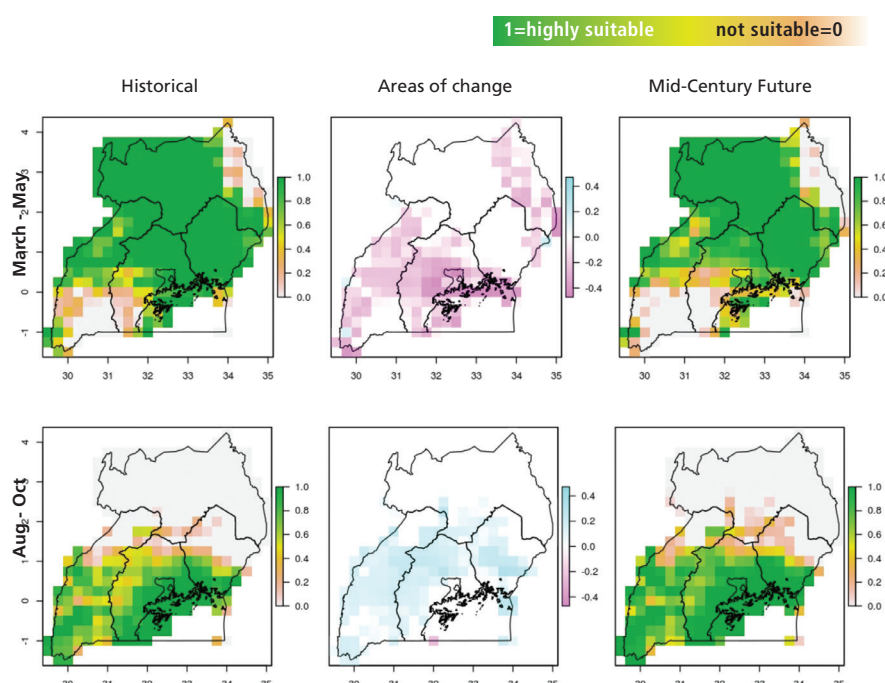
Soyabean is a moderately important oil seed crop grown in all regions of Uganda, of which the Northern region accounts for 75% of total production. Widespread areas of very good or excellent suitability occur across the country in the March-May rainy season, with the exception of isolated areas in lower Central and Western regions. In the second (August-October) rainy season, widespread areas of good suitability occur across the Central, Western, and parts of Eastern regions, with only limited suitability in the Northern region.

Overall, climate change is predicted to result in relatively minor impacts on future suitability for cassava in most regions, including both positive and negative effects. Virtually the entire spatial extent of Uganda, except for the arid Karamoja area, is predicted to remain suitable for production of cassava during both rainy seasons. Small negative changes to the suitability index score are predicted for the Northern, Eastern and Western regions. However, the latter two regions may benefit from small increases in suitable area, whereas the Northern region is the only region which is predicted to undergo overall decreases in productivity by the mid-Century future (2050).

## PRODUCTION OF SOYABEAN IN UGANDA<sup>18</sup>.

REGION	PRODUCTION AREA		ANNUAL PRODUCTION	
	TOTAL (HA)	% NATIONAL TOTAL	TOTAL (TONNES)	% NATIONAL TOTAL
Central	750	1.6	207	0.7
Eastern	7,279	15.6	5,801	18.4
Northern	36,444	78.1	23,623	75.0
Western	2,220	4.8	1,887	6.0
<b>Total</b>	<b>46,693</b>		<b>31,518</b>	

## PROJECTED EFFECT OF CLIMATE CHANGE ON DISTRIBUTION OF SUITABILITY FOR SOYABEAN IN UGANDA



<sup>18</sup> Derived from the most recent national statistics available: 2008/9 figures reported by Uganda's Bureau of Statistics (UBOS, 2010), Uganda Census of Agriculture: Crop Area and Production Volume Report, [https://www.ubos.org/wp-content/uploads/publications/03\\_2018UCACrop.pdf](https://www.ubos.org/wp-content/uploads/publications/03_2018UCACrop.pdf)



## HOUSEHOLD- AND NATIONAL-LEVEL IMPACTS

The Western region is the only region predicted to experience negative impacts on soyabean production, where households are projected to experience a decrease of 8% in annual production per capita. This change in annual production is equivalent to a small deficit of 0.3 kg per household.

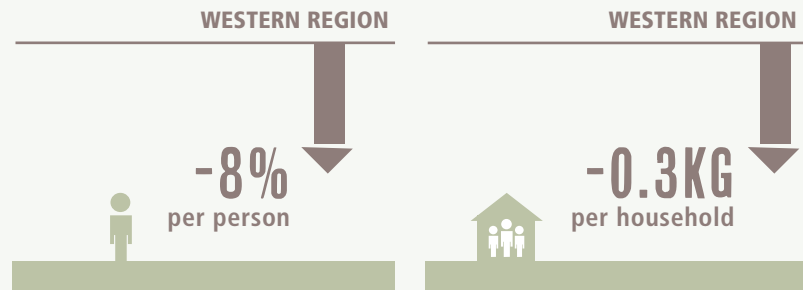
At the regional level, this decrease in production is equivalent to 151 tonnes and can be considered almost negligible.

Total loss of annual production



The remaining regions may experience minor positive effects, which may be attributed to an increase in total suitable area. **These results should not be interpreted as a strong prediction that annual production of soyabean will increase as a result of climate change in the latter**

### ANNUAL PRODUCTION

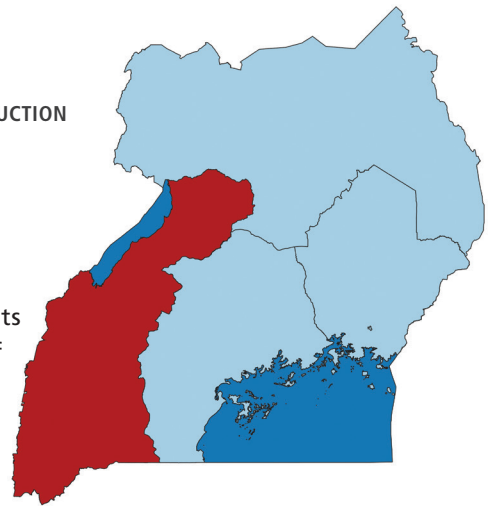


### MOST VULNERABLE REGIONS, BASED ON CHANGES TO:

TOTAL REGIONAL/HOUSEHOLD PRODUCTION

- Most vulnerable
- Suitability increase

**regions.** However, these results suggest that the impacts of climate change on soyabean production in Uganda are likely to be mild or negligible in most regions.



## KEY FINDINGS AND RECOMMENDATIONS



Most of Uganda is unlikely to experience negative effects of climate change on soyabean production.



Western region is predicted to experience decreased production potential, however these decreases are likely to be relatively small.



Extensive distribution of highly suitable areas for soyabean production at the future Mid-Century period suggests that this oilseed crop is likely to be a useful option for climate-resilient farming systems.



Promotion of soyabean production to support sale to commercial oilseed producers and exporters may be a climate-resilient option to improve the income of agricultural households.

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

Several important staple crops – notably beans, cassava and maize – are predicted to experience moderate to severe decreases in production. It is strongly recommended that initiatives related to climate change adaptation, food security and enhanced agricultural production consider strategies to increase the resilience of these three crops. Simultaneously, analysis of the future suitability of various oilcrop species – including groundnuts, sesame, soyabean and sunflowers – indicate that Uganda may benefit from widespread areas of good or excellent suitability by the Mid-Century future.

In the case of maize, the results strongly support the case for development and promotion of fast-growing, early-maturing varieties. 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.

In the case of beans, the results indicate a moderate to 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 Uganda. 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.

In the case of cassava, climate change is predicted to result in negative climate change effects on production in the Northern region but with possible positive effects in

the Central, Eastern and Western districts. It is recommended that future initiatives focused on increasing the climate change resilience of Uganda's cassava farmers and food security 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 a potential source of income. Furthermore, the production of cassava in Uganda 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.

## SUMMARISED ADAPTIVE CAPACITY (AC) INDICATORS COLLECTED FOR ALL REGIONS OF UGANDA <sup>19</sup>

Indicator category	Adaptive capacity indicators	Central	Eastern	Northern	Western
Adoption of improved agricultural practices	% of farms using organic fertilisers	10.7	62.9	12.6	35.5
	% of farms using inorganic fertilisers	13.8	64.0	0.0	44.5
	% of farms using pesticides	13.3	81.2	5.8	60.4
	% of farms using herbicides	12.3	66.6	0.0	49.8
Access to agricultural information	Registered mobile money user	84.9	46.6	40.5	54.6
	Availability of extension services	1.6	1.1	11.4	4.0
Education	% Literacy rate (18+)	87.8	83.0	35.5	81.2
	Primary school enrolment rate	93.3	69.9	26.8	68.3

APPENDIX TABLE A.2.

## PROJECTED INFLUENCE OF CLIMATE CHANGE ON MEAN MONTHLY TEMPERATURE (°C) IN THE REGIONS OF UGANDA AT HISTORICAL AND MID-CENTURY PERIODS, AND MONTHLY ANOMALIES BETWEEN THE TWO TIME PERIODS

		MONTH											
		J	F	M	A	M	J	J	A	S	O	N	D
CENTRAL	Historical (°C)	23.3	24.0	23.7	22.9	22.5	22.2	22.0	22.4	22.5	22.6	22.6	22.8
	Future (°C)	25.0	25.6	25.4	24.6	24.2	24.2	24.1	24.4	24.5	24.4	24.2	24.4
	Anomaly (°C)	1.7	1.6	1.7	1.7	1.7	1.9	2.1	2.0	1.9	1.8	1.6	1.6
EASTERN	Historical (°C)	24.9	25.6	25.4	24.3	23.4	22.9	22.5	22.8	23.3	23.7	24.0	24.3
	Future (°C)	26.5	27.2	27.0	26.1	25.1	24.8	24.5	24.7	25.3	25.5	25.5	25.7
	Anomaly (°C)	1.5	1.6	1.6	1.8	1.7	1.9	2.0	1.9	2.0	1.7	1.5	1.5
NORTHERN	Historical (°C)	25.9	26.8	26.5	25.3	24.3	23.6	23.1	23.4	24.0	24.3	24.7	25.1
	Future (°C)	27.7	28.6	28.2	27.1	26.1	25.5	25.1	25.3	25.8	26.0	26.3	26.7
	Anomaly (°C)	1.8	1.8	1.7	1.8	1.7	1.9	2.0	2.0	1.9	1.7	1.6	1.6
WESTERN	Historical (°C)	22.8	23.5	23.3	22.8	22.4	22.1	22.0	22.5	22.5	22.3	22.2	22.4
	Future (°C)	24.7	25.3	25.1	24.6	24.2	24.1	24.2	24.5	24.4	24.2	23.9	24.2
	Anomaly (°C)	1.9	1.8	1.8	1.8	1.8	2.0	2.1	2.1	1.9	1.9	1.7	1.8

<sup>19</sup> Uganda's Bureau of Statistics (UBOS, 2017). National Population and Housing Census, 2014 [https://www.ubos.org/onlinefiles/uploads/ubos/2014CensusProfiles/National\\_Analytical\\_Report\\_nphc%202014.pdf](https://www.ubos.org/onlinefiles/uploads/ubos/2014CensusProfiles/National_Analytical_Report_nphc%202014.pdf) and UBOS 2010 Uganda Census of Agriculture: Agricultural Household and Holding Characteristics Report. [https://www.ubos.org/wp-content/uploads/publications/03\\_2018UCAholding.pdf](https://www.ubos.org/wp-content/uploads/publications/03_2018UCAholding.pdf)

APPENDIX TABLE A.3.

PROJECTED INFLUENCE OF CLIMATE CHANGE ON MEAN MONTHLY PRECIPITATION (MM/MONTH) IN THE REGIONS OF UGANDA 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	
CENTRAL	Historical	55.9	55.4	125.7	167.5	139.9	57.0	57.7	92.4	117.7	146.8	83.3	1242.1
	Future	60.5	57.0	125.7	157.0	116.5	43.4	50.0	80.3	105.1	137.5	91.4	1170.5
	Anomaly	4.6	1.7	0.0	-10.6	-23.5	-13.6	-7.7	-12.1	-12.6	-9.3	8.1	-71.6
EASTERN	Historical	39.2	44.3	101.7	173.5	153.6	89.1	92.3	121.8	118.5	135.7	53.4	1236.7
	Future	43.3	46.6	102.4	160.2	129.4	72.6	86.3	106.1	107.1	127.6	57.9	1151.9
	Anomaly	4.1	2.3	0.7	-13.2	-24.1	-16.5	-6.0	-15.7	-11.4	-8.1	4.5	-84.8
NORTHERN	Historical	15.2	21.9	63.9	127.2	123.7	106.3	131.5	148.4	119.0	126.7	28.1	1094.3
	Future	17.2	22.6	63.9	117.5	107.2	89.3	121.3	135.6	106.2	123.5	29.9	1020.4
	Anomaly	2.0	0.7	0.0	-9.7	-16.5	-17.0	-10.2	-12.8	-12.8	-3.2	1.8	-73.9
WESTERN	Historical	46.0	53.1	103.8	134.1	103.7	56.0	59.7	99.5	131.0	151.2	70.9	1146.9
	Future	48.4	53.5	101.8	125.4	86.2	44.6	54.4	90.2	118.8	142.4	75.7	1081.5
	Anomaly	2.4	0.4	-2.1	-8.7	-17.5	-11.4	-5.3	-9.3	-12.2	-8.8	4.9	-65.4



