THE EFFECT OF CLIMATE CHANGE ON COTTON PRODUCTION IN UGANDA

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DECLARATION

I, Kubyanukula Eria declare that this research thesis is my original work, except where due acknowledgement has been made. I declare that this work has never been submitted to this University or any other institution for funding/ for partial fulfilment for any award.

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I dedicate this work to Mrs. Naikoba Rachel, Mr. Babalanda David, my Mother Mrs. Kubyanukula Monic and my late father Mr. Kubyanukula Samuel.

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ABBREVIATIONS

CCSM Community Climate System Model

C.D.O Cotton Development organization

CMIP Coupled model inter comparison project

CSA Climate Smart Agriculture

CSDP Cotton Subsector Development Project

FAO Food and Agriculture organization

GCM General Circulation model

GDP Gross Domestic Product

GESI Gender Equality and social Inclusion

GHG Green House Gas

GIS Geographic Information Systems.

ICT Information Communication Technology

IFAD International Fund for Agriculture Development

IPCC Intergovernmental Panel on climate change

LMB Lint Marketing Board

MAAIF Ministry of Agriculture Animal Industry and Fisheries

MCA Multi Criteria Analysis

NARO National Agricultural Research Organization

RCP Representative Concentration path way

°C Degrees centigrade

Operational Definitions

Cotton seed	Seed produced from seed cotton after ginning.
Ginning	Separating seed from lint.
Seed cotton	Un ginned cotton that contains both cotton lint and cottonseed.

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ABSTRACT

Agriculture is the backbone of Ugandan economy and as the population explosion is a concern, there is high demand of food from the increasing population. Hence, there is need of high agricultural production for both cash crops and food crops to from available land by using modern agricultural practices. Cotton is the most important fiber plant in Uganda and the world. The effect of climate change on cotton production is being felt in Uganda in various forms including very high temperature, erratic nature of rains, floods, and droughts. Climate has been changing in the last three decades and will continue to change regardless of any mitigation strategy. Cotton growing is climate dependent and hence it's highly sensitive to climatic changes and nevertheless there is a knowledge gap when researchers intend to assess the production of same crops for which data or models are not available. The aim of this study was to assess the potential effect of climate change on cotton production in Uganda. The EcoCrop module in DIVA-GIS was used to predict the adjustment of cotton suitability in Uganda. The model uses climate datasets and expert-derived temperature and rainfall ranges as inputs to determine the main niche of a given crop and then produces a suitability score as output. For the current climate, data from WorldClim for temperature and precipitation was downloaded and was used, a dataset of global climate surfaces representative of the years 1950 to 2000.Cotton suitable areas for future climate scenarios were also predicted where the future climate datasets projected by the Community Climate System Model (CCSM) 4 for the year 2050 under a Representative Concentration Pathway (RCP) 2.6 emission scenario were used. The cotton site suitability index was analyzed in which marginal, suitable, very suitable and excellent suitability sites were obtained in Uganda.. The findings revealed that Uganda will witness a decrease in suitable cotton growing by 2050.The study also assessed the most suitable adaptation options for cotton production under the changing climate in Uganda using the multi criteria analysis and recommendations were made.

CHAPTER ONE

1.1 Background

Agriculture is one of Uganda's leading sector employing over 70% of the total population and contributing around 23.7% of the country's gross domestic product with coffee, tea, cocoa, vanilla, tobacco including cotton for which efforts are underway to revamp it to its original position of a major cash crop (UBOS, 2016).

Cotton was introduced in Uganda by the British Colonial Government in 1903 as the first cash crop (Mukiibi, 2001). It was the major export until the 1950's when it was surpassed by coffee (Serunjogi et al, 2001).While production was carried out in Uganda by small scale farmers, ginning was done in Kenya and the lint was then exported to Liverpool to service the British Textile Mills (Serunjogi et al, 2001). The crop was initially grown only in the Central Region but eventually it spread to the rest of the Country. Between 1903 and 1930, it was grown purely as a Government crop whereby each family had to mandatorily have at least 0.5 Ha as a way of generating household incomes (Baffes, 2007). Production rose steadily to 44,000 bales in 1920 (Mukiibi, 2001).

References

Agricultural and Forest Meteorology, 170, pp. 67-78.

Agricultural Policy Secretariat (APSEC),. (2001). *An Assessment of the Impact of Cotton Sub-sector Development Project (CSDP).*

Apuuli B., Wright J., Elias C. and Burton I. *Assessing vulnerability of food crop systems in Africa to Climate Change. Reconciling National and Global properties in Adaptation to Climate Change with Illustration from Uganda.* Meteorology Department Ministry of Water and Environment, Kampala, Uganda.

Baffes, John. 2009a. *Comparative analysis of organanization and performance of African Cotoon sectors: the cotton sector of Uganda.*

Baffes, J . (2001). *Cotton Marketing Setting, Trade Policies, and Issues in Beghin, j,c and Aksoy, A,M: Global Agricultural Trade and Developing countries* . World Bank.

Bates BC, Kundzewicz Zw. (2008). *Climate change and water, Technical Paper of the Intergovernmental Panal on Climate Change.* Geneva: IPCC Secretariat.

Chaudhry, R. and A. Guitchounts. (2003). *Cotton Facts. International Cotton Advisory Commitee (ICAC).* Washington, D.C., United States of America.

Cotton Development Organisation (CDO). (2007). *Annual report 2006/07.* Kampala: CDO.

Cotton Development Organisation (CDO). (2008). *Annual Report 2007/2008.* Kampala: CDO.

Cotton Development Organisation. (2009). *Annual Report 2008/2009:* CDO.

Cotton Development Organisation (CDO). 2012. *Production trends and earnings.* www.cdo.org

Cotton Development Organisation. (2007). *Annual Report 2006/07.* Kampala: CDO.

Cotton Development Organisation (CDO). (2001). *The Cotton Industry in Uganda.*

COMPETE Project, . (2002). *The Path Foward for Uganda's Cotton and Textile Sector.*

Cotton Development Organisation (CDO), . (2001). *Strategy for Increasing Annual Cotton Production to Over One Million Bales In the Years 2002-2006 and adding value to Raw Cotton into Yarn Textiles, Textiles and Garments.*

COMPLETE Project,. (2001). *Strengthening the Export Competitiveness of Uganda's Cotton Sector.*

DIVA-GIS Plant Genetic Resources Newsletter, 122. 15-19.

Edinburgh. Retrieved from http:www.itsi.co.uk

FAO,EcocropdatasetforMetroxylonsagu.RetrievedAugust1,2015,2007,fromhttp:www:ecocrop.fao.org/ecocrop/srv/en/dataSheet?id=1466

FAO.2013a. (2013). *The state of food security in the World: The multiple dimensions of food security.* Rome, Italy: Food and Agricuture Organisation (FAO) of the United Nations.

FAO.2013b. (2013). *The state of food security in the World 2013: The multiple dimensions of food security.* Rome, Italy: Food and Agricuture Organisation (FAO) of the United Nations.

FAO(2010).Climate Smart Agriculture: Policies, Practices and Financing for Food Security, Adaptation and Mitigation. Food and Agriculture Organisation (FAO) of United Nations, Rome, Italy.

FAOSTAT, various statistics. (2012). Retrieved from http://faostat.fao.org/?lang=en

Jornal of Environment and Earth Science, (3 (7)). pp. 129-140.

FAO, . (2003). Retrieved from http://www.fao.org

G.M. Ochieng.(1998). *Factors Limiting Cotton Productivity in Uganda.*

Hijmans, R.J., Guarino, L.Mathur, p.,. (2012). *DAVA GIS Version 7.5.* .http://www.diva-gis.org/

Hijmans, R.J., Guarino, L., Cruz, M., Rojas,E.,. (2001). *Empirical approaches for assessing impacts of climate change on agricture: The EcoCrop model and a case study with grain sorghum.*

Hijmans, R, J., Guarino, L., Mathur, P. (2012). *DAVA-GIS manual , ver. 7.5.0.*

Hijmans, R,J., Cruz, M., Rojas, E . (2001): *Computer tools for spatial analysis of plant genetic resources data:*

IPCC.2014: Climate change 2014 Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to Fifth Assessment Report of Intergovernmental Panel on Climate change.

IPCC. (2007). *Climate Change 2007 the physical science basis. Contribution of Working Group 1 to the Fourth Assessment Report of IPPC. Cambridge University Press.*

John Baffes. (2009). *The cotton sector of Uganda.*

Kalungu, JW and Filho, WL and Harris, D,. (2013). *Smallholder Farmers "perception of the Impacts of Climate Change and Variability on Rain-fed Agricultural Practices in Semi-arid and Sub-humid Regions of Kenya.*

Lundbaek, J . (2001). *Privatization of the cotton sub sector in Uganda: Market Failures and Insitutional Mechanisms to Overcome these.*

Makinano-Santillian, M.,& Santillan, J.R. (2015). *GIS BASED MODELLING TO ASSESS POTENTIAL CLIMATE CHANGE EFFECTS ON SAGO PALM SUITABILITY DISTRIBUTION.*

MCGraw-Hill companies, 2004 Hepworth, N and Goulden. M.,. (2008). *Climate Change in Uganda: Understanding the Implications and Appraising the Response, LTS International.*

Multicriteriaanalysis.(2009).Retrievedfromhttps//www.gov.uk/government/uploads/system/uploads/attachment_data/file/7612/1132618.pdf

MWLE. (2007). *Report on state of Environment.* Ministry of Water Lands and Environment 2007. Republic of Uganda.

Nyabako, T., & Manzungu, E. (2012). *An assessment of the adaptability to Climate change of commercially available maize varieties in Zimbabwe. Environment and Natural Resources Research, 2(1), 32.*

Production trends and earnings. Retrieved from www.cdo.org

Ramirez, V.J, Fransisco Cuesta, Devenish. (2014). Using species distribution models for designing conservation strategies of Tropical Andean diversity under climate change. *Jornal for Nature Conservation, G- Model JNC-25349.*

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 andd forestry meteorology, 170, 67-78.*

R.J.Hijmans, S.E. Cameron.J.L. Parra.p.g Jones. A.Jarvis. *Very high resolutioon interpolated climate surfaces for global areas, Int.J. Climatol.25 (15).* 1965-1978.

Sement, G. (1988). *Cotton Tropical Agriculturalist.* CTA/MacMillan, 88p.

Serunjogi, L.K. Elobu, P., Epieru, G., Okoth, V.A.O, Sekamatte, M.B., Taken, J.P. and Orokot, J.O.E. (2001). *Cotton "(Gossypium Sp.)" In Agriculture in Uganda Volume II: Crops ed. Mukiibi J.K.* Fountain Publishers Ltd./CTA/NARO.

Ton, P. (2004). *Cotton and climate change in West Africa.*

Utpala, P., Jayarajan, K., Johny, A. k., A.Parthasarathy. (2008). Identification of suitable areas and effect of Climate climate on ginger- a GIS study. *Jornal of species and Aromatic crops, Vol. 17 (12)* , 61-68.

Pawar-Patil, V.S., & Mali, S.P. (2015). Ecocrop Model Approach for Agro-Climatic Sugarcane Crop Suibility in Bhogawati River Basin of Kolhapur District, Maharashtra. *India Universal of Environmental Research and Technology,* , 5(5), 259-264.