



**FARMERS' PERCEPTION OF THE EFFECTS OF CLIMATE VARIABILITY ON
RICE PRODUCTION AND ADAPTATION STRATEGIES
THE STUDY OF LIMOTO WETLANDS,
KIBUKU DISTRICT UGANDA**

BY

**JOSEPH KAUGULE
REG NO BU/GS21/MCC/04**

**A DISSERTATION SUBMITTED TO THE DIRECTORATE OF GRADUATE
STUDIES, RESEARCH AND INNOVATIONS IN PARTIAL FULFILLMENT
OF THE REQUIREMENTS FOR THE AWARD OF MASTER OF SCIENCE IN
CLIMATE CHANGE AND DISASTER MANAGEMENT DEGREE OF
BUSITEMA UNIVERSITY**

NOVEMBER, 2025

DECLARATION

I, **Kaugule Joseph**, hereby declare that this dissertation, submitted to the Faculty of Natural Resources and Environmental Science, is my original work. To the best of my knowledge, it has not been submitted to any other institution for the award of a degree or any other purpose. All sources used have been properly acknowledged.

NAME: **KAUGULE JOSEPH**

REG. NO: **BU/GS21/MCC/04**

DATE: **30/1/2025**

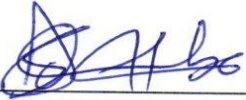
SIGNATURE: 

APPROVAL

This dissertation has been submitted for examination with approval from the following supervisors:

1. Dr. Saul Daniel Ddumba

Faculty of Natural Resources and Environmental Sciences.

Signature: _____

Date: 04/11/2025

2. Dr. Vianny Natugonza

Busitema University Maritime Institute

Signature: _____

Date: 4/11/2025

DEDICATION

I dedicate this dissertation to my family, especially my children (Kaugule Jethro Elvis, Nangobi Annah Patience, Kirabo Josephine, and Kaugule Jennifer), my mother, my father, my brothers and my sisters, whose unwavering support and encouragement have been my greatest source of strength. To my beloved wives, whose patience and understanding have been invaluable throughout this journey of education.

ACKNOWLEDGEMENTS

First and foremost, I extend my deepest gratitude to the Almighty God for His guidance, wisdom, and strength throughout this academic journey. Without His wisdom, grace and blessings, none of this would have been possible.

I would also like to express my sincere thanks to my family for their unwavering support and encouragement both socially and financially. To my parents, your constant belief in me has been a cornerstone of my success. To my beloved wives and children, your momentous love and insights have been a source of immense strength and motivation to my academic performance.

I am profoundly grateful to my research supervisors Dr. Saul Daniel Ddumba, and Dr. Vianny Natugonza, for their invaluable guidance, insightful feedback, and unwavering support throughout the development and undertaking of this research dissertation. Your expertise and encouragement and guidance have been instrumental in shaping this academic work.

To my workmates at Kibuku District Local Government and my Chief Administrative Officer (Mr. Samuel Ruhweza Kaija), whose undisputed advice let me go back to school for further studies. I further extend my gratitude to my course mates at the Master's degree level, especially Musenero Nandi Nasif and Mugumya Phillipson, who tirelessly contributed to my academic journey through discussions during the course. Your companionship and moral support have been indispensable throughout this academic endeavor. May the almighty God bless them abundantly.

Table of Contents

DECLARATION.....	i
APPROVAL.....	ii
DEDICATION.....	iii
ACKNOWLEDGEMENTS	iv
Table of Contents	v
List of Tables.....	viii
List of Figures.....	ix
Abstract.....	x
CHAPTER ONE: INTRODUCTION	1
1.1 Background to the Study	1
1.2 Statement of the Problem	6
1.3 Objectives of the study.....	6
1.3.1 Main Objective	6
1.3.2 Specific Objectives	7
1.4 Research questions.....	7
1.7 Justification of the Study	8
1.8 Scope of the Study	8
1.8.1 Time scope	8
1.8.2 Content scope	8
1.8.3 Geographical scope	8
1.8.3.1 The physical environment of Kibuku district	10
1.8.3.1.1 Soils in Kibuku district.....	10
1.8.3.1.3 Average Temperature in Kibuku district.....	10
1.8.3.1.4 Precipitation in Kibuku district.....	10
1.8.3.1.5 Flora and fauna in Kibuku district	11
1.8.3.1.6 Settlement patterns in Kibuku district.....	11
1.9 Conceptual framework.....	11
CHAPTER TWO: LITERATURE REVIEW	13
2.1 Introduction	13
2.2 Theoretical framework	13

2.2.1	The Climate Change Adaptation Theory	13
2.2.2	The Theory of Planned Behavior (TPB)	13
2.3	The trends and challenges of climate variability (Global, Regional, and Local)	14
2.3.1	Global Trends and Impacts of observed and projected climate variability.	14
2.3.4	Climate patterns and variability in Uganda and the eastern region.	16
2.3.5	Key climate drivers (ENSO, ITCZ shifts, temperature, rainfall anomalies).	18
2.3.6	Relevance of Climate Patterns in Eastern Uganda	19
3.3.7	Rice Production in Wetland Agro ecosystems	20
3.3.7.1	Importance of Rice in Uganda's Agriculture	20
2.3.8	Government initiatives to promote rice farming (Upland Rice Project, NAADS). ..	21
2.3.9	Wetlands and Rice Farming Systems	22
2.3.9.1	Agro-ecological benefits of wetlands for rice production.....	22
2.3.10	Ecological constraints and environmental degradation.	24
2.3.11	Climate variability and Rice Yields.....	26
2.3.11.1	Effects of temperature rise, erratic rainfall, wet, and dry events on rice farming. ..	26
2.3.12	Studies on rice production losses and seasonal disruptions.	27
2.3.13	Study findings from East Africa and Uganda.....	28
2.4	Farmers' perceived impacts of climate variability on rice production and its factors	30
2.4.1	Understanding Farmer Perception	30
2.4.2	Farmers' Perceived Climate Risks in Rice Farming	31
2.5	Factors influencing effectiveness of adaptation to climate variability on rice farming	33
2.5.1	Climate change agricultural adaptation definition and relevance	33
2.5.2	Influencing effectiveness factors (education, gender, extension, farm experience).....	35
2.5.3	Coping adaptation factors of Small Rice Farmers in Uganda	35
2.5.3	Drivers of adaptation factors among rice farmers	36
CHAPTER THREE: METHODOLOGY.....		38
3.1	Introduction	38
3.2	Research Design	38
3.3	Sampling strategies and sample size.....	39
3.4	Data collection for specific objectives	40
3.4.2	The trends and challenges of climate variability (temperature and rainfall).....	40
3.4.3	Farmers' perceived impacts of climate variability on rice production and the factors that shape these perceptions.....	40

3.5	Data Analysis and presentations	42
3.5.2	Farmers’ perceived impacts of climate variability on rice production and the factors that shape these perceptions	43
3.6	Ethical considerations	45
3.7	Environmental and gender equality integration.....	46
3.8	Limitation to the Study	46
CHAPTER FOUR: RESULTS AND DISCUSSIONS		47
4.1	Introduction	47
4.2	The trends and challenges of climate variability in Limoto wetlands from 1995-2024....	47
4.1	Farmers’ perceived impacts of climate variability on rice production and the factors that shape these perceptions.....	55
4.3	Factors influencing effectiveness of adaptation to climate variability on rice production	58
CHAPTER FIVE: CONCLUSIONS AND RECOMMENDATIONS.....		67
5.1	Conclusions	67
5.2	Recommendation	68
REFERENCES.....		69
APPENDIX 1: QUESTIONNAIRE FOR RICE FARMER HOUSEHOLD HEADS		87
APPENDIX 11: INTERVIEW FOR KEY INFORMANTS.....		94
APPENDIX III: Map of Kibuku District and its neighboring districts at Limoto wetland.....		96
APPENDIX IV: Map of sampled sub counties of Buseta and Kituti on Limoto wetlands		97

List of Tables

Table 1: Relative proportions (%) on the impacts of wet and dry seasons on rice farming....	55
Table 2: Relative proportions (%) adaptation measures by farmers	59
Table 3: Summary of demographic characteristics of rice farmers in Kibuku district	61
Table 4: Summary of results of the logistic regression model.	64

List of Figures

Figure 1: Conceptual Framework shows the relationship between these variables.....	12
Figure 2: Decadal analysis of minimum monthly temperature for the period 1994-2024.	48
Figure 3: Maximum monthly temperature around Limoto wetlands from 1995-2024	49
Figure 4: Annual rainfall around Limoto wetlands for the period of 1995-2024	50
Figure 5: Annual rainfall anomalies around Limoto wetlands for the period 1995–2024.	51
Figure 6: Trend analysis of rainfall seasons onset of long-wet (March), short-wet (Sept).	52
Figure 7: Rainfall seasons received long-wet (March-May) and short-wet (Sept-Nov).....	53
Figure 8:Trend analysis of total rainfall for long-wet (March-May), short-wet (Sept-Nov).	54
Figure 9:Comparison of rice production (yield per tons per acre).....	57
Figure 10: Decadal changes in rice production (Kilogram/ tons per acre per season).	58
Figure 11: Ranking of demographic features of farmers as by their influence on adaptation.	63

Abstract

The main objective of the study was to assess the farmers' perception of the effects of climate variability on rice production in Limoto wetlands in Kibuku district. The research was cross-sectional in nature where both quantitative and qualitative approaches to produce data on historical trends and challenges of climate variability, farmers' perceptions of the impacts of climate variability on rice production and factors influencing adaptation strategies that would allow rice farmers to shape sustainability and resilience to their livelihoods. Both purposive sampling and Simple random sampling were employed to select respondents from both rice farmers and key informants in the two sub-counties of Buseta and Kituti within Kibuku district comprised a population of 900 active farmers and were only 268 were sampled during the study, 160 were from Buseta Sub-County, while 108 were from Kituti Sub-County. Data on monthly temperature and rainfall for the period 1995–2024 were obtained from the department of Meteorological services, under the Ministry of Water and Environment. This period matches a minimum of 30 years. Rice farmers' perceived impacts of climate variability on rice production relied on cross-sectional data from 268 rice farmers interviewed using a combination of semi structured questionnaires. The medians within each boxplot indicated a slight temperature upward shift over time, particularly from the 1990s to the 2010s. Contrastingly, the annual rainfall does not show any monotonic trend, despite substantial inter-annual variability. Statistical tests revealed that inter-annual variability in rainfall, with extreme anomalies observed in 2000 and 2016 had SPI values below -2, signifying severe drought years. Conversely, 1996, 2007, and 2019 had SPI values above +1.5 significantly wetter conditions. These findings were consistent with findings from responses obtained from FGDs and KIIs. The results from the analysis of minimum temperature were consistent with those of maximum temperature, where the decadal increase in maximum temperature was significant between the 1990s and 2010s. The medians within each boxplot indicate a slight upward shift over time, particularly from the 1990s to the 2010s. However, the 2020s appear to show a stabilization or slight reduction in median maximum temperatures. Contrastingly, the annual rainfall does not show any monotonic trend, despite substantial inter-annual variability. The demographic and socio- characteristics revealed education, social, and technological involvement to enhance adaptation. The study concluded that significant climatic shifts have occurred in both rainfall and temperature patterns, including the frequency of dry spells and elevated mean temperatures. It was also concluded by the results there is evident decline in rice kilograms over the last three decades.

It was recommended that enhancement of adaptation through improved means of support, and make sure food is enough in people's homes amidst an increasingly uncertain climatic future, scaling up to equip farmers with knowledge on adaptation practices, sustainable land use, and policies that encourage livelihood options in income-generating activities

REFERENCES

- Abraha, M. G. (2015). Local Climate Trends and Farmers' Perceptions in Southern Tigray, Northern Ethiopia. *International Journal of Environment and Sustainability*, 4, 262-277.
- Adger et al., (2003) W.N. Adger, S. Huq, K. Brown, D. Conway, M. Hulme Adaptation to climate change in the developing world *Prog. Dev. Stud.*, 3, pp. 179-195
- Adger, W. N., et al. (2009). "Social-Ecological Resilience to Coastal Disasters." *Science*, 309 (5737), 1036-1039.
- Adger, W.N., Barnett, J., Brown, K., Marshall, N. and O'Brien, K. (2013), "Cultural dimensions of climate change impacts and adaptation", *Nature Climate Change*, Vol. 3 No. 2, pp. 112-117
- Ajzen, I. (1991). The theory of planned behavior. *Organizational Behavior and Human Decision Processes*, 50(2), 179-211.
- Akhtar, I., and N. Nazir. (2013). Effect of waterlogging and drought stress in plants. *Int. J. Water Resour. Environ. sci.* 2:34:20.
- Akhtar, M., Ahmad, N., & Booij, M. J. (2008). The impact of climate change on the water resources of Hindukush–Karakorum–Himalaya region under different glacier coverage scenarios. *Journal of hydrology*, 355(1-4), 148-163.
- Akman, Z. (2009). Comparison of high temperature tolerance in maize, rice and sorghum seeds, ny plant growth regulator. *Journal of animal and veterinary advances* 8:358-361.
- An, S., & Verhoeven, J. (2019). Wetland functions and ecosystem services: Implications for wetland restoration and wise use. In *Wetlands: Ecosystem services, restoration and wise use. Ecological studies (analysis and synthesis)* (Vol. 238, pp. 1 –10). Cham: Springer.
- Apata, T.G. (2010). Effects of global climate change on Nigerian agriculture: An empirical analysis. *CBN J. Appl. Statistics*, 2(1): 45-60.
- Apuuli, B., Wright, J., Elias, C. and Burton, I. (2000), "Reconciling national and global priorities in adaptation to climate change: with an illustration from Uganda", *Environmental Monitoring and Assessment*, Vol. 61 No.1, pp. 145-159.
- Asadullah A, McIntyre NE, Kigobe MA. (2008). Evaluation of five satellite products for estimation of rainfall over Uganda/Evaluation de cinq produits satel litaires pour l'estimation des précipitations en Ouganda. *Hydrol Sci J.* 2008; 53(6):1137–50.

- Asadullah, A., McIntyre, N. and Kigobe, M. (2008), "Evaluation of five satellite products for estimation of rainfall over Uganda", *Hydrological Sciences Journal*, Vol. 53 No. 6, pp. 1137-1150.
- Asaduzzaman. M., (2010). "Investing in Crop Agriculture in Bangladesh for Higher Growth and Productivity, and Adaptation to Climate Change". Bangladesh Food Security Investment Forum. Dhaka.
- Auffhammer, M., (2012). "Climate Change, Agriculture, and Food Supply." *Annual Review of Resource Economics*, 4, 235-260.
- Ayanlade, A., & Drake, N. (2016) Forest loss in different ecological zones of the Niger Delta, Nigeria: evidence from remote sensing *GeoJournal*, 81(5), 717-735. DOI: 10.1007/s10708-015-9658-y. Springer,
- Baffour-Ata, F., Antwi-Agyei, P., Nkiaka, E. (2021) Effect of climate variability on yields of selected staple food crops in northern Ghana. *Journal of Agriculture and Food Research*, 6. 100205. ISSN 2666-1543
- Bagamba F, Bashaasha B, Claessens I, Antle J (2012). Assessing climate change impacts and adaptation strategies for smallholder agricultural systems in Uganda. *Afr Crop Sci J.*; 20:303–16
- Barakagira, A., & de Wit, A.H. (2017). Community livelihood activities as key determinants for community based conservation of wetlands in Uganda. *Environmental & Socio-Economic Studies*, 5(1), 11-24
- Barros, V. R. et al. (2014): Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (Cambridge Univ. Press, 2014).
- Basalirwa CPK (1995). Delineation of Uganda into climatological zones using the method of principal component analysis. *Int J Climatol* 15:1161-1177.
- Below, Tran, D. V., (2012). "Farmers' adaptation to climate change in the Mekong Delta." *Climate and Development*, 10(2), 127-141.
- Benjamini, Y., & Hochberg, Y. (1995). Controlling the false discovery rate: a practical and powerful approach to multiple testing. *Journal of the Royal Statistical Society: Series B (Methodological)*, 57(1), 289-300.
- Bentley, A.P.K., Petcovic, H.L. and Cassidy, D.P. (2019), "Development and validation of the anthropogenic climate change dissenter inventory", *Environmental Education Research*, Vol.

- Berkes, F., and Ross, H. (2013). "Community resilience: Toward an integrated approach." *Society & Natural Resources*, 26(1), 5-20.
- Berman, R., Quinn, C., & Paavola, J. (2012). "The role of institutions in the transformation of coping capacity to sustainable adaptive capacity." *Environmental Development*, 2, 86-100.
- Bernstein, L., Bosch, P., Canziani, O., Chen, Z., Christ, R., & Riahi, K. (2008). IPCC, (2007): *Climate Change: Synthesis Report: IPCC*.
- Bomuhangi, A., Nabanoga, G., Namaalwa, J. J., Jacobson, M. G., & Abwoli, B. (2016). Local Communities' Perceptions of Climate Variability in the Mt. Elgon Region, Eastern Uganda. *Cogent Environmental Science*, 2, Article ID: 1168276
- Bryan E, Deressa TT, Gbetibouo GA, Ringler C (2009) Adaptation to climate change in Ethiopia and South Africa: options and constraints. *Environ Sci Policy* 12:413–426
- Bryan, E., Ringler, C., Okoba, B., Roncoli, C., Silvestri, S., and Herrero, M.: (2013) Adapting agriculture to climate change in Kenya: Household strategies and determinants, *J. Environ. Manage*, 114, 26–35.
- Bryman, A. (2012). Given as in text. "Social Research Methods." Oxford University Press. Can farmers' adaptation to climate change be explained by socio-economic household-level variables?
- Carmin, J., Tierney, K., Chu, E., Hunter, L., Roberts, T., & Shi, L. (2015). Adaptation to climate change. In R. Dunlap & R. Brulle (Eds.), *Climate change and society: Sociological perspectives*. Oxford, England: Oxford University Press.
- Chombo, O., Lwasa, S., & Makooma, T. M. (2018). Spatial Differentiation of Small Holder Farmers' Vulnerability to Climate Change in the Kyoga Plains of Uganda. *American Journal of Climate Change*, 7, 624
- Christensen, N. S. and Lettenmaier, D. P. (2007): A multi-model ensemble approach to assessment of climate change impacts on the hydrology and water resources of the Colorado River Basin, *Hydrol. Earth Syst. Sci.*, 11, 1417–1434, <https://doi.org/10.5194/hess>.
- Clark AJ, Clark AJ, Nottage RAC, Hansford D. (2012). Impacts of climate change on land-based sectors and adaptation options. In: Stakeholder report to the sustainable land management and climate change adaptation technical working group. Ministry for Primary Industries. 76 p
- Cline, W.R. (2008). *Global Warming and Agriculture*. Finance and Development. p. 23-27.

- Conway, D. (2005), "From headwater tributaries to international river: observing and adapting to climate variability and change in the Nile basin", *Global Environmental Change*, Vol. 15 No. 2, pp. 99-114.
- Cook KH, Vizy EK *J Clim.* (2013). Projected changes in East African rainy seasons. 26 (16):5931–48.
- Dekens, J., & Bagamba, F. (2014). Promoting an integrated approach to climate adaptation: Lessons from the coffee value chain in Uganda (Briefing note). Retrieved from http://www.iisd.org/sites/default/files/publications/value_chains_coffee_uganda_briefing_note.pdf
- Denzin, N. K. Y. S. Lincoln, Eds., (2018). *Handbook of qualitative research*, 5th ed .Thousand Oaks, CA: Sage.
- Department for International Development. (1999). *Sustainable Livelihoods Guidance Sheets*. DFID.
- Deressa, T. T., et al. (2009). "Determinants of farmers' choice of adaptation methods to climate change in the Nile Basin of Ethiopia." *Global Environmental Change*, 19(2), 248-255.
- E. Bryan, T.T. Deressa, G.A. Gbetibouo, C Ringler (2009). Adaptation to climate change in Ethiopia and South Africa: options and constraints *Environ. Sci. Policy*, 12 pp. 413-426
- Eakin, H., et al. (2014). "Adaptive capacity and its assessment." *Global Environmental Change*, 21(2), 647-656.
- Egeru, A., Osaliya, R., MacOpiyo, L., Mburu, J., Wasonga, O., Barasa, B., Majaliwa Mwanjalolo . (2014). Assessing the Spatio-Temporal Climate Variability in Semi-Arid Karamoja Sub-Region in North-Eastern Uganda. *International Journal of Environmental Studies*, 71, 490-509
- Ehrhardt-Martinez, K., Rudel, T., Norgaard, K., & Broadbent, J. (2015). Mitigating climate change. In R. Dunlap & R. Brulle (Eds.), *Climate change and society: Socio logical perspectives*. Oxford, England: Oxford University Press.
- Eike, L., Roeland, K., Swen, B., Sang, J., & Musau, J. (2014). *Climate Change Impacts on Ecosystems of Mt. Elgon*. Adapt EA Project Technical Report, World Agroforestry Centre/CIFOR/Rockefeller Foundation.
- Elbehri, A., Genest, A., & Burfisher, M. E. (2011). *Global Action on Climate Change in Agriculture: Linkages to Food Security, Markets and Trade Policies in Developing*

- Countries. Trade and Markets Division, Food and Agriculture Organization of the United Nations.
- Ellis F (2000). The determinants of Rural Livelihood diversification in developing countries, *Journal of Agricultural Economics* 51(2): 289-302.
- Epule, T. E., Ford, J. D., Lwasa, S., & Lepage, L. (2017). Vulnerability of Maize Yields to Droughts in Uganda. *Water*, 9, 181. <https://doi.org/10.3390/w9030181>
- F. Karanja, L. Emerton, J. Mafumbo, and W.Kakuru (2001) Assessment of the Economic Value of Pallisa District Wetlands, Biodiversity Economics Programme for Eastern Africa, IUCN-The World Conservation Union and Uganda National Wetlands Programme, Kampala, Uganda.
- FAO, (2009). State of the world fisheries report for 2008. Viale delle Terme di Caracalla, 00153 Rome, Italy.
- FAO, (2010). Guidance, Intentions and Commitment to Climate Change in Uganda (2010-2014), Food and Agriculture Organization of the United Nations (FAO), Kampala
- FAO, (2010). Guidance, Intentions and Commitment to Climate Change in Uganda (2010-2014), Food and Agriculture Organization of the United Nations (FAO), Kampala.
- FAO, (2011) Guidance, Intentions and Commitment to Climate Change in Uganda (2011-2014), Food and Agriculture Organization of the United Nations (FAO), Kampala.
- FAO. (2010). The state of food insecurity in the world. Addressing food insecurity in protracted areas. Rome: FAO.
- Fathauer, T. (2011). A glimpse into a changing climate: New climate normal take effect. *Weatherwise*, 64(6), 34–36.
- Field, C.B.; Barros, V.; Stocker, T.F.; Dahe, Q (2012). Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation: Special Report of the Intergovernmental Panel on Climate Change; Cambridge University Press: Cambridge, UK; New York, NY, USA.
- Folke, C., (2010). "Resilience thinking: Integrating resilience, adaptability and transformability." *Ecology and Society*, 15(4): 20.
- Food and Agricultural Organization (FAO). (2017). FAO Rice Market Monitor 2017. Global Rice Science Partnership. Rice almanac. Los Baños (Philippines): International Rice Research Institute (IRRI).
- Food and Agriculture Organization (FAO). (2017). The State of Food Security and Nutrition in the World. Food and Agriculture Organization.

- Government of Uganda, (2007). Climate Change: Uganda National Adaptation Programmes of Action. Department of Meteorology, Ministry of Water, Lands and Environment
- Government of Uganda, (2007). Climate Change: Uganda National Adaptation Programmes of Action. Kampala, Uganda.
- Government of Uganda, (2009). Uganda climate change case studies. Department of Meteorology, MWE. Kampala, Uganda.
- Government of Uganda, (2010). The State of Uganda's Population Report 2010. Kampala Uganda.
- Government of Uganda, (2002). Initial national communication to the UNFCCC. MWE. Uganda. Kampala
- Government of Uganda (GOU) (2015), Economic Assessment of the Impacts of Climate Change in Uganda, Final Study Report. Ministry of Water and Environment, Climate Change Department, Kampala.
- Government of Uganda (GoU). (2009). The Uganda National Rice Development Strategy (NRDS) lays out Uganda's strategy for promotion of rice production between 2009/10 - 2017/18.
- Government of Uganda (GoU). (2009). The Uganda National Rice Development Strategy (NRDS) lays out Uganda's strategy for promotion of rice production between 2009/10 - 2017/18.
- Government of Uganda (GoU). (2010). National development plan (NDP): 2010/2011-2014/2015. Ministry of finance and economic development. Kampala, Uganda.
- Grothmann, T., and Patt, A. (2005). "Adaptive capacity and human cognition: The process of individual adaptation to climate change." *Global Environmental Change*, 15(3), 199-213.
- Hertel, T. W. & Lobell, D. B (2014). Agricultural adaptation to climate change in rich and poor countries: current modeling practice and potential for empirical contributions. *Energy Econ.* 46, 562 –575
- Igodan CO, Gwary MM, Ekpere JA. (1990). Critical skills and competency needs of extension agents: evidence from Nigeria. *J Ext Syst.* 6(1):100–7
- a) Inter government Panel on Climate Change (IPCC), (2001). Impact, adaptation and vulnerability. Contribution of working Group II to the Third Assessment Report of the Inter government Panel on Climate Change: no of pages 1032
- b) Intergovernmental Panel on Climate Change (IPCC). (2014). Climate Change 2014: Impacts, Adaptation, and Vulnerability. Cambridge University Press.

- c) International Fund for Agricultural Development (IFAD). (2020). Enhancing Rural Resilience through Climate Adaptation in Uganda. International Fund for Agricultural Development.
 - d) IPCC (2021). Report of the IPCC Sixth Assessment Report (AR6), Katy, R., Calow, R., Pichon, F., New, S. & Osborne, R. (2022). Climate risk report for the East Africa region. Met office Hadley Centre Region
 - e) IPCC (2021): Intergovernmental Panel on Climate Change. (2021). Climate Change 2021: The Physical Science Basis. Cambridge University Press.
 - f) IPCC (Intergovernmental Panel on Climate Change) (2014). Summary for the Policymakers.
- IPCC (2007). Climate Change 2007: Synthesis Report, an Assessment of the Intergovernmental Panel on Climate Change. Geneva: IPCC.Google Scholar
- IPCC. (2007). Climate change 2007: Synthesis report. In Core Writing Team, R. K. Pachauri, & A. Reisinger (Eds.), Contribution of working groups I, II and III to the fourth assessment report of the Intergovernmental Panel on Climate Change. Geneva, Switzerland: Intergovernmental Panel on Climate Change.
- IPCC. (2014). Climate Change (2014): Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.
- UBOS (2004) Uganda National Population and Housing Census 2002. Main Report
- IPCC. (2014a). Climate change (2014): Synthesis report. In Core Writing Team, R. K. Pachauri, & L. A. Meyer (Eds.), Contribution of working groups I, II and III to the fifth assessment report of the Intergovernmental Panel on Climate Change. Geneva, Switzerland: Intergovernmental Panel on Climate Change.
- IPCC. (2014b). Climate change (2014): Mitigation of climate change. Contribution of working group III to the fifth assessment report of the Intergovernmental Panel on Climate Change. Cambridge, England: Cambridge University Press. 17577799, 2019.
- IPCC. Climate Change (2021): The Physical Science Basis Working Group I Contribution to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change, 6th ed.; Cambridge University Press: Cambridge, UK; New York, NY, USA.
- James, P., (2010). Using Farmers' Preferences to Assess Development Policy: A Case Study of Uganda. Development Policy Review, 28 (3): 359-378. Overseas Development Institute

- Kabeer, N. (2005). Gender equality and women's empowerment: A critical analysis of the third Millennium Development Goal. *Gender & Development*, 13(1), 13-24.
- Kampala Capital City Authority (KCCA). (2018). Climate Change Strategy and Action Plan 2014-2025. Kampala Capital City Authority.
- Kansiime, K. M., Wambugu, K. S., & Shisanya, A. C. (2013). Perceived and Actual Rainfall Trends and Variability in Eastern Uganda: Implications for Community Preparedness and Response. *Journal of Natural Sciences Research*, 3(8), 179–194.
- Karanja F, Emerton L, Mafumbo J, Kakuru W (2001): Assessment of the Economic Value of Pallisa District Wetlands. Kampala, Uganda: Biodiversity Economics Programme for Eastern Africa, IUCN-The World Conservation Union and Uganda National Wetlands Programme.
- Kassaye, A. Y., Shao, G., Wang, X., Shifaw, E., & Wu, S. (2021). Impact of climate change on the staple food crops yield in Ethiopia: Implications for food security. *Theoretical and Applied Climatology*, 145(1–2), 327–343
- Kijima, Y. (2012). An empirical analysis of expanding rice production in sub-Sahara Africa expansion of lowland rice production and constraints on a rice green revolution: Evidence from Uganda. JICA Research Institute.
- Kijima, Y., Ito, Y., & Otsuka, K. (2012). A perspective on agricultural development and rice production in Sub-Saharan Africa: The case of Uganda. *The Developing Economies*, 50(1), 1-39.
- Kisakye, M., Van der Bruggen, B., & Buytaert, W. (2018). The potential of rice husks and bamboo leaves to remove nutrients from synthetically prepared wastewater. *Water Practice and Technology*, 13(2), 374-381.
- Kizza, M., Rhode, A., Xu, Y.C., Ntale, H.K. and Halldin, S. (2009), “Temporal rainfall variability in the Lake Victoria Basin in East Africa during the twentieth century”, *Theoretical and Applied Climatology*, Vol. 98 Nos 1/2, pp. 119-135.
- Komutunga, E.T. and Musiitwa, F. (2001). *Agriculture in Uganda, Volume 1: General Information*, Fountain Publishers, Kampala, 21-32.
- Krejcie RV, Morgan DW (1970). Determining sample size for research activities. *Educ Psychol Meas*; 30(3):607–10.
- Kruskal, W. H., & Wallis, W. A. (1952). Use of ranks in one-criterion variance analysis. *Journal of the American Statistical Association*, 47(260), 583–621.

- Kummu M, Sarkkula J. (2008). Impact of the Mekong river flow alteration on the Tonle Sap flood pulse. *Ambio* 37: 185–192.
- Kummu, M. and Sarkkula, J. (2008). Impact of the Mekong River Flow Alteration on the Tonle Sap Flood Pulse, *Ambio*, and Vol. 37 (3), pp: 185-192.
- Kyazze, F. B., & Kristjanson, P. (2011). Coping with climate variability and change in Uganda: A case study of communities around Lake Victoria. *Environment and Natural Resources Research*, 1(1), 10-18.
- Li, R.; Cheng, L.; Ding, Y.; Chen, Y.; Khorasani, K (2012). Spatial and temporal variability analysis in rainfall using standardized precipitation index for the Fuhe Basin, China. In *International Conference on Intelligent Computing for Sustainable Energy and Environment*; Springer: Berlin/Heidelberg, Germany, pp. 451–459.
- Lobell, D. B., et al. (2011). "Climate Trends and Global Crop Production since 1980." *Science*, 333(6042), 616-620.
- Lwasa, S., Mugagga, F., Wahab, B., Simon, D., Connors, J., & Griffith, C. (2014). Urban and Peri-Urban Agriculture and Forestry: Transcending Poverty Alleviation to Climate Change Mitigation and Adaptation. *Urban Climate*, 7, 92-106.
- Maddison, D. (2007). *The Perception of and Adaptation to Climate Change in Africa*. Washington DC: The World Bank.
- Mann, H. B. (1945). Nonparametric tests against trend. *Econometrica*, 13, 245–259.
- Mann, H. B., & Whitney, D. R. (1947). On a test of whether one of two random variables is stochastically larger than the other. *The Annals of Mathematical Statistics*, 18(1), 50-60.
- Mase, A. S., Gramig, B. M., & Prokopy, L. S. (2017). Climate change beliefs, risk perceptions, and adaptation behavior among Midwestern U.S. crop farmers. *Climate Risk Management*, 15, 8-17.
- Mauboussin, M.J. (2007). *More Than You Know – Finding Financial Wisdom in Unconventional Places*. New York: Columbia University Press.
- Mendelsohn R (2006). The role of markets and governments in helping society adapt to a changing climate. *Clim Change*; 78 (1):203–15.
- Mendelsohn, R. (2007). Past climate change impacts on agriculture. Chapter 60, *Handbook of Agricultural Economics*. In: Evenson R. and P Pingali (eds.) North Holland: Elsevier. 3: 3009-3031.
- Mertz, O., et al. (2009). "Farmers' perceptions of climate change and agricultural adaptation strategies in rural Sahel." *Environmental Management*, 43(5), 804-816.

- Michael J. Mauboussin (2007). *Explaining the Wisdom of Crowds: Applying the Logic of Diversity*. Mauboussin on Strategy.
- Miller Hesed, C. D., & Paolisso, M. (2015). Cultural knowledge and local vulnerability in African American communities. *Nature Climate Change*, 5, 683–687.
- Ministry of Agriculture, Animal Industry and Fisheries (MAAIF) (2010). *Agriculture Sector Development Strategy and Investment Plan (DSIP)*, (2010/11-2014/15)
- Ministry of Agriculture, Animal Industry, and Fisheries (MAF). (2016). *Uganda Wetlands Atlas*. Ministry of Agriculture, Animal Industry, and Fisheries.
- a) Ministry of Water and Environment (MWE) (2007) *Climate Change: Uganda National Adaptation Programmes of Action*, Uganda. Kampala: MWE. p69.
- b) Ministry of Water and the environment (MWE), (2007). *Climate Change. Uganda's National Adaptation Programmes of Action. Summary for Policy Makers*. Kampala, Uganda.
- Ministry of Water and the environment (MWE), (2007). *Climate Change. Uganda's National Adaptation Programmes of Action. Summary for Policy Makers*. Kampala, Uganda.
- Mombo, F. (2017). *Conservation and livelihoods: where do we strike a balance to sustain the Wetlands in the Kilombero Valley?*
- Morton, J. E. (2007). "The impact of climate change on smallholder and subsistence agriculture." *Proceedings of the National Academy of Sciences*, 104(50), 19680-19685.
- Moser SC, Ekstrom JA (2010) A framework to diagnose barriers to climate change adaptation. *Proceedings of the National Academy of Sciences of the United States of America* 107, 22026–22031.
- Moser, S. C., (2008): *Toward a deeper engagement of the U.S. public on climate change: An open letter to the 44th president of the United States of America*. *Int. J. Sustainability Commun.*, 3, 119–132.
- Mubangizi, N., Kyazze, F., & Mukwaya, P. (2017). *Smallholder Farmers' Perception and Adaptation to Rainfall Variability in Mt. Elgon Region, Eastern Uganda*. *International Journal of Agricultural Extension*, 5, 103-117.
- Mubiru, D.N., Komutunga, E., Agona, A., Apok, A. and Ngara, T. (2012), "Characterizing agro meteorological climate risks and uncertainties: crop production in Uganda", *South African Journal of Science*, Vol. 108 Nos 3/4, pp. 108-118.

- Mugagga, F. (2017). Perceptions and Response Actions of Smallholder Coffee Farmers to Climate Variability in Montane Ecosystems. *Environment and Ecology Research*, 5, 357-366
- Mugagga, F., Kakembo, V., & Buyinza, M. (2019). A longitudinal analysis of rainfall variability in the Mount Elgon region, eastern Uganda. *Theoretical and Applied Climatology*, 136(3-4), 851-867.
- Mugume, I (2016). Micro-climatic variations within wetland ecosystems: Implications for agricultural productivity. *Journal of Environmental Management*, 180, 315-324.
- Musinguzi (2015) Fishers' perceptions of climate change, impacts on their livelihoods and adaptation strategies in environmental change hotspots: a case of Lake Wamala, Uganda
- Mutai CC, Ward MN, Colman AW (1998). Towards the prediction of the East Africa short rains based on sea-surface temperature–atmosphere coupling; 18(9):975–97.
- Mwakubo SM, Obare GA (2009): Vulnerability, livelihood assets and institutional dynamics in the management of wetlands in Lake Victoria watershed basin, 17:613–626.
- MWE (Ministry of Water and Environment). (2010). National statement at the 4th National Climate Change Forum, Uganda. 4 - 5 November 2010. Republic of Uganda.
- Mwebaze, S. (2002). Grassland and pasture crops. Country pasture/forage resource profiles. Food agriculture Organisation (FAO) of the United Nations.
- Nabikolo, D., et al. (2019). "The socio-economic dynamics of farmers' responses to climate variability: Evidence from Uganda." *Environmental Development*, 28, 3-14.
- a) Nabikolo, D., et al. (2019). Climate change adaptation among smallholder farmers in Uganda: Evidence from micro-level data. *Global Environmental Change*, 56, 73-83.
- b) Nabikolo, D., et al. (2019). Climate Variability and Its Effects on Agriculture in Uganda: A Case Study of Masindi District. *International Journal of Environmental Sciences & Natural Resources*, 23(1), 1-10.
- Namaalwa s, Vandam AA, Funk A and Kagwa RC (2013) A characterisation of drivers, pressures, ecosystem functions and services of Namatala wetland. *Environmental Science and Policy* 34: 44-57.
- National Agricultural Research Organization (NARO) (2010). Rice Production in Uganda, Annual Report, Ministry of Agriculture, Animal Industry and Fisheries, Entebbe,.
- National Environment Management Authority (NEMA) (2008), State of Environment Report for Uganda, 2008, National Environment Management Authority, Kampala, p.282.

- National Planning Authority. National Development Plan III (NDPIII) 2020/21–2024/25 (2020); Kampala, Uganda,. Available online: www.npa.go.ug (accessed on 27 May 2021).
- Ngoma, H.; Wen, W.; Ojara, M.; Ayugi, B (2021). Assessing current and future spatiotemporal precipitation variability and trends over Uganda, East Africa, based on CHIRPS and regional climate model datasets. *Meteorol. Atmos. Phys*, 133, 823–843.
- Ngoma, H.; Wen, W.; Ojara, M.; Ayugi, B (2021). Assessing current and future spatiotemporal precipitation variability and trends over Uganda, East Africa, based on CHIRPS and regional climate model datasets. *Meteorol. Atmos. Phys*, 133, 823–843.
- Nhemachena, C., & Hassan, R. (2007). Micro-level Analysis of Farmers' Adaptations to Climate Change in Southern Africa. IFPRI, Environment and Production Technology Division. Washington, DC: International Food Policy Research Institute.
- Niang., (2014). Africa. In: Climate Change: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.
- Nicholson, S.E. (1996), “A review of climate dynamics and climate variability in Eastern Africa”, in Johnson, T.C. and Odada, E. (Eds), *The Limnology, Climatology and Paleo-Climatology of the East African Lakes*, pp. 25-56.
- Nsubuga, F. W., Botai, O., Olwoch, J. M., Rautenbach, C. D., Bevis, Y., & Adetunji, A. O. (2014). The Nature of Rainfall in the Main Drainage Sub-Basins of Uganda. *Hydrological Sciences Journal*, 59, 278-299. <https://doi.org/10.1080/02626667.2013.804188>
- Nsubuga, F. W., Namutebi, E. N., & Nsubuga-Ssenfuma, M. (2014). Water resources of Uganda: An assessment and review. *Journal of Water Resource and Protection*, 6(14), 1297-1315.
- Nsubuga, F.W.; Olwoch, J.M.; Rautenbach, H (2014). Variability properties of daily and monthly observed near-surface temperatures in Uganda: 1960–2008. *Int. J. Climatol.* , 34, 303–314.
- Nsubuga, F.W.N., Botai, O.J., Olwoch, J.M., Rautenbach, C.J.deW., Bevis, Y. and Adetunji, A.O. (2014c), “The nature of rainfall in the main drainage sub-basins of Uganda”, *Hydrological Sciences Journal*, Vol. 59 No. 2, pp. 278-299.
- Nsubuga, F.W.N., et al (2014c), “The nature of rainfall in the main drainage sub-basins of Uganda”, *Hydrological Sciences Journal*, Vol. 59 No. 2, pp. 278-299
- Nsubuga, F.W.N., Olwoch, J.M. and Rautenbach, C.J.deW. (2011), “Climatic trends at Namulonge in Uganda: 1947-2009”, *Journal of Geography and Geology*, Vol. 3 No.1, pp. 119-131.

- Nyasimi M, Radeny M, Kinyangi J. (2013). Climate change adaptation and mitigation initiatives for agriculture in East Africa. CCAFS Working Paper No. 60. Copenhagen, Denmark: CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS).
- MWE. (2009). Mapping a better future: How spatial analysis can benefit wetlands and reduce poverty in Uganda. Wetlands Management Department, Ministry of Water and Environment- Uganda, Uganda Bureau of Statistics, International Livestock Research Institute and World Resources Institute. Washington, DC., USA and Kampala, Uganda: World Resources Institute. ISBN: 978-1-56973-716-3. http://pdf.wri.org/mapping_a_better_future.pdf
- National Planning Authority (NPA). (2010). The National Development Plan (2010/11 – 2014/ 15). Government of Uganda. Ministry of Finance Planning and Economic Development, [www. http://npa.ug/wp-content/themes/npatheme/documents/NDP2.pdf](http://npa.ug/wp-content/themes/npatheme/documents/NDP2.pdf)....
- UBOS. (2010). Uganda Bureau of Statistics. Uganda Census of Agriculture 2008/2009. Volume IV: Crop Area and Production Report.
- UBOS. (2011). Uganda Bureau of Statistics. The 2011 Statistical Abstract. pp. 45.
- Ochieng, J. (2016). Effects of climate variability and change on agricultural production: The case of small-scale farmers in Kenya. NJAS –Wageningen Journal of Life Sciences, 77: 71–78.
- Ogallo, L.J. (1988), “Relationships between seasonal rainfall in East Africa and the Southern oscillation”, *Journal of Climatology*, Vol. 8 No. 1, pp. 31-43.
- Okonya, J. S., Syndikus, K., & Kroschel, J. (2013). Farmers’ Perception of and Coping Strategies to Climate Change: Evidence from Six Agro-Ecological Zones of Uganda. *Journal of Agricultural Science*, 5, 252
- Omondi PA, Awange JL, Forootan E, Ogallo LA, Barakiza R, Girmaw GB, Fesseha I, Kululetera V, Kilembe C, Mbatia MM, Kilavi M (2010). Changes in temperature and precipitation extremes over the Greater Horn of Africa region from 1961 to. *Int J Climatol*. 2014; 34(4):
- Anon (2005) Uganda districts information handbook, expanded edition 2005-2006. Fountain Publishers, Uganda.
- a) Omondi, P. A., et al. (2020). Climate change and variability impact on rice production in East Africa: A review. *Agriculture & Food Security*, 9(1), 1-18.

- b) Omondi, P. A., et al. (2020). Climate change and variability impact on rice production in East Africa: A review. *Agriculture & Food Security*, 9(1), 1-18.
 - c) Omondi, P., et al. (2020). Changing rainfall patterns and implications for maize production in East Africa. *Climate Research*, 82(1), 1-12.
 - d) Omondi, P., et al. (2020). Impacts of Climate Change on Rice Production in East Africa: A Review. *Journal of Agriculture and Sustainability*, 14(2), 95-110.
 - e) Omondi, P., et al. (2020). Impacts of Climate Change on Rice Production in East Africa: A Review. *Journal of Agriculture and Sustainability*, 14(2), 95-110.
 - f) Omondi, P., et al. (2020). Impacts of Climate Change on Rice Production in East Africa: A Review. *Journal of Agriculture and Sustainability*, 14(2), 95-110.
- Ongoma V, Chen H, Omony GW (2018). Variability of extreme weather events over the equatorial East Africa, a case study of rainfall in Kenya and Uganda. *Theor Appl Climatol.*; 131 (1):295–308.
- Osbahr, H., Dorward, P., Stern, R. and Cooper, S. (2011), “Supporting agricultural innovation in Uganda to respond to climate risk: linking climate change and variability with farmer perceptions”, *Experimental Agriculture*, Vol. 47 No. 2, pp. 293-316.
- Osborne T, Rose G, Wheeler T. Year (2013). Variation in the global-scale impacts of climate change on crop productivity due to climate model uncertainty and adaptation. *Agricultural and Forest Meteorology*,; 170, 183 –194.
- Pandve, H.T., Chawla, P.S., Fernandez, K., Singru, S.A., Khismatrao, D. and Pawar, S.
- Perevedentsev, Y. P., & Vasil’ev, A. A. (2011). Climate Change and Its Impact on Agriculture. *Russian Meteorology and Hydrology*, 48(9), 739-744.
- Phillips J, McIntyre B. J *Climatol.* (2000); Sharma S, Srivastava P, Fang X, Kalin L ENSO and inter-annual rainfall variability in Uganda: implications for agricultural management. *Int. Hydrologic simulation approach for El Niño Southern Oscillation (ENSO). Affected watershed with limited rain-gauge stations*, 20(2):171–82.
- Retallack, S., T. Lawrence, and M. Lockwood, (2007): Positive energy: Harnessing people power to prevent climate change: A summary. Institute for Public Policy Research, 23 pp.
- Riahi, K., Roa, S., Krey, V., Cho, C., Chirkov, V., Fisher, G., Kindermann, G., Nakicenovic, N. and Rafaj, P. (2011), “RCP 8.5—a scenario of comparatively high greenhouse gas emissions”, *Climate Change*, Vol. 109, pp. 33-57.
- Rishi, P., Omprakash, M.D. and Mudaliar, R. (2011), “Behavioural mapping of Indian urban settlements towards changing climate: an empirical study”,

- Rosa, E., York, R., & Dietz, T. (2004). Tracking the anthropogenic drivers of ecological impacts. *Ambio*, 33(8), 509–512.
- Rosenzweig, C., Solecki, W., Romeo-Lankao, P., Mehrotra, S., Dhakal, S., & Ali-Ibrahim, S. (Eds.). (2018). *Second assessment of research on climate change in cities*. Cambridge, UK: Cambridge University Press.
- Rosenzweig, C. C., Solecki, W., Romeo-Lankao, P., Mehrotra, S., Dhakal, S., & Ali-Ibrahim, S. (2014). Assessing agricultural risks of climate change in the 21st century in a global gridded crop model intercomparison. *Proc. Natl Acad. Sci.* **111**, 3268–3273.
- Rosenzweig, C., & Tubiello, F. N. (2007). *Adaptation and Mitigation Strategies in Agriculture: An Analysis of Potential Synergies*. *Mitigation and Adaptation Strategies for Global Change*, 12, 855-873
- Rosenzweig, C., et al. (2001) Climate Change and Extreme Weather Events: Implications for Food Production, Plant Diseases and Pests. *Global Change and Human Health*, 2, 90-104.
- Rosenzweig, C., Solecki, W., Romeo-Lankao, P., Mehrotra, S., Dhakal, S., & Ali-Ibrahim, S. (Eds.). (2018). *Second assessment of research on climate change in cities*. Cambridge, UK: Cambridge University Press.
- Ruddiman, W. F. (2005). How did humans first alter
- Schlenker, W. & Roberts, M. J (2009). Nonlinear temperature effects indicate severe damages to US crop yields under climate change. *Proc. Natl Acad. Sci.* 106, 15594–15598.
- Scoones, I. (2009). Livelihoods perspectives and rural development. *Journal of Peasant Studies*, 36(1), 171-196.
- Serdeczny, O., Adams, S., Baarsch, F., Coumou, D., Robinson, A., Hare, W., & Reinhardt, J. (2017). Climate change impacts in Sub-Saharan Africa: From physical changes to their social repercussions. *Regional Environmental Change*, 17(6), 1585-1600.
- Shongwe, Mxolisi, Jan Van Oldenborgh, G, Van den Hurk, B. (2010). Projected Changes in Mean and Extreme Precipitation in Africa under Global Warming. Part II: East Africa. *Journal of Climate*, pp 3718 – 3733, Volume 24. American Meteorological Society. DOI: 10.1175/2010JCLI2883.1
- Silvestri, S., et al. (2012). "Households' strategies for coping with the impacts of climate variability and economic constraints: Evidence from East Africa." *Agricultural Systems*, 106(1), 1-9.
- Smit, B., and Wandel, J. (2006). "Adaptation, adaptive capacity and vulnerability." *Global Environmental Change*, 16(3), 282-292.
- Spencer R., (2008). *The Discovery of Global Warming*, Harvard University Press,

- Stampone, M. D., Hartter, J. N., Chapman, C. A., & Ryan, S. J. (2011). Trends and Variability in Localized Precipitation around Kibale National Park, Uganda, Africa. *Research Journal of Environmental and Earth Sciences*, 3, 14-23.
- Stocker, T., Qin, D., Plattner, G., Tignor, M., Allen, S., Boschung, J., Midgley, P. et al. (2013). IPCC, 2013: Climate Change (2013): The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (1535 p.). Cambridge and New York: Cambridge Univ. Press.
- Stuecker, M. F., Bitz, C. M., Armour, K. C., Proistosescu, C., Kang, S. M., Xie, S. P., & Jin, E. F. (2018). Polar amplification dominated by local forcing and feedbacks. *Nature Climate Change*, 8(12), 1076-1081.
- Tan X. Tan, T.Y. Gan, D.E. Horton (2018): Projected timing of perceivable changes in climate extremes for terrestrial and marine ecosystems
- Thornton, P. K., Jones, P. G., Ericksen, P. J., & Challinor, A. J. (2014). Agriculture and food systems in sub-Saharan Africa in a 4°C+ world. *Philosophical Transactions of the Royal Society A*, 369, 117-136.
- Tollens, E., Demont, M., Sié, M., Diagne, A., Saito, K., Wopereis, M. C., & Jalloh, A. (2013). From WARDA to AfricaRice: an overview of rice research for development activities conducted in partnership in Africa. *Realizing Africa's rice promise*,
- Treynor, Jack L., (1987) "Market Efficiency and the Bean Jar Experiment," *Financial Analysts Journal*, May/June, 50-53.
- TUMBO, M. (2007). Community vulnerability and adaptation to the impacts of climate variability and extremes on Simiyu Wetlands: The case of Simiyu Wetlands, Lake Victoria Basin. 1st International Conference on Adaptive and Integrative Water Management (CAIWA, 2007). Basel, Switzerland, 12 – 15 November 2007.
- Turner, B. L., et al. (2016). "Land system science and sustainable development of the earth system: A global land project perspective." *Anthropocene*, 12, 29-41.
- Turyahabwe N, Nanfumba D, Samuka M, Kaugule j., (2013). Contribution of wetland resources to household food security in Uganda. *Agriculture and food security journal*. Uganda Bureau of Statistics (UBOS). (2010). Uganda Census of Agriculture 2008/2009. Summary report. Uganda Bureau of Statistics and Ministry of Agriculture, Animal Industry and Fisheries, Kampala.
- UBOS (Uganda Bureau of Statistics). (2014). Statistical abstract. Ministry of Ministry of Finance Planning and Economic Development.

- Uganda Bureau of Statistics (UBOS). (2020). Uganda National Household Survey 2019/20. Uganda Bureau of Statistics.
- a) Uganda Bureau of Statistics (UBOS) (2004). Statistical abstracts. Kampala, Uganda.
 - b) Uganda Bureau of Statistics (UBOS) (2004).. Statistical abstracts. Kampala, Uganda.
 - c) Uganda Bureau of Statistics (UBOS) (2004).. Statistical abstracts. Kampala, Uganda.
 - d) Uganda: Reasons for the rapid spread. African Crop Science Conference Proceedings
- UNFCCC. (2007). Climate change impact, vulnerability and adaptation in developing countries.
- UNFCCC (2011). Fact Sheet: Climate Change Science. The Status of Climate Change Science Today. In United Nations Framework Convention on Climate Change; Bonn, Germany,;
- a) UNFCCC, (2011). National Adaptation Programmes of Action. http://unfccc.int/national_reports/napa/items/2719.ph
 - b) UNFCCC, (2011). National Adaptation Programmes of Action. http://unfccc.int/national_reports/napa/items/2719.php
- United Nations Development Programme (UNDP). (2019). Uganda Human Development Report 2019. United Nations Development Programme.
- UNMA. (2015). The State of Uganda's Climate 2015. Uganda National Meteorological Authority.
- Van Aalst, M.K. van Aalst, T. Cannon, I. Burton (2008). Community level adaptation to climate: the potential role of participatory community risk assessment
- VijayaVenkata Raman S, Iniyan S, Goic R. (2012). A review of climate change, mitigation and adaptation. Renewable and Sustainable Energy Reviews, 16, 878–897.
- Wang, N., Gao, Y., Wang, Y., & Li, X. (2016). Adoption of ecofriendly soil-management practices by smallholder farmers in Shandong province of China. Soil Science and Plant Nutrition, 62, 185–193. Retrieved from
- Kenmore P, (2003): Sustainable rice production, food security and enhanced livelihoods in “Rice Science: Innovations and Impact for Livelihood, pg. 27-34. Edited by Mew Wassmann., (2009) Climate change affecting rice production: The physiological and agronomic basis for possible adaptation strategies
- Waswa, A., & Satognon, F. (2020). Development and the Environment: Overview of the Development Planning Process in Agricultural Sector, in Uganda. Journal of Sustainable Development, 13(6), 1.

Welch,J.R., Vincent,J.R., Auffhammer,M.,Moya,P.F.,Dobermann,A.,Dawe,D (2010). Rice yields in tropical/subtropical Asia exhibit large but opposing sensitivities to minimum and maximum temperatures. Proc. Natl. Acad. Sci. U.S.A.

Yamane, Y (1967), Mathematical formulae for simple size determination