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LOCALIZED KNOWLEDGE FOR LOCAL CLIMATE CHANGE ADAPTATION: A FOCUS ON COASTAL SMALLHOLDER FARMERS IN KENYA

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ABSTRACT

This paper proposes a localization mechanism for climate knowledge for effective and sustainable climate change adaptation for Kenyan coastal farmers. The climate observation data is analysed to generate historical climate trends over the Kenyan coast. CORDEX RCA climate model output (driven by 8 GCMs) is used to generate projected climate outlook for the period 2016 to 2045. Socio-economic characteristics of coastal farmers in Kenya as well as historical coping strategies are obtained through semi-structured questionnaire interviews and focus group discussions (FGDs). This information is used to evaluate the effectiveness of traditional coping strategies and to propose appropriate and localized adaptation measures in the face of a changing climate. The proposed adaptation measures not only blend scientific and traditional knowledge but also strategically position and coordinate common but differentiated roles of various actors in the area of study. Hence, appropriate and sustainable adaptation to climate change and variability is achieved.

Keywords: CORDEX; GCM; RCA; Scientific knowledge; Indigenous knowledge; Climate Change Adaptation; Climate variability; Emerging Knowledge

Introduction

Warming of the global climate is unequivocal (IPCC, 2014). The Kenyan coast is already experiencing the impacts of climate change and variability (Anyah and Qiu, 2012). Given that farming in the region is predominantly rain-fed (WFP, 2015), there is urgent need for localized climate change adaptation strategies to build the adaptive capacity and resilience.

Progress has been made in evaluating climate change and variability using global climate models (GCM). However, current limitations in computer technology make it difficult for GCMs to seamlessly represent local surface heterogeneities at scales of less than 100km (Giorgi *et al*., 2009; Rummukainen, 2010). To address this limitation, Regional Climate Models (RCMs) help downscale GCM outputs to scales useful for simulating local climate (Jacob *et al*. 2007). Through the RCMs, climate information at local scales can be obtained.

The CORDEX program, run by the World Climate Research Program, makes it possible to generate high-resolution climate projections at regional and local scales (Giorgi *et al*., 2009). Endris *et al*. (2013) made an assessment of RCMs in simulating the climate over the eastern Africa region. This study builds on the findings of Endris *et al*. (2013) to project the climate over the Kenyan coast.

The Kenyan coast has a wealth of coastal and marine resources and biodiversity including mangroves, sea grass meadows, coastal forests, marine fish species, and coral reefs. These resources support coastal livelihoods and national socio-economic development. Climate change and variability however poses a major threat to the integrity of these ecosystems and the predominantly nature based economic activities.

Coasts are sensitive to changes in intensity and frequency of storms, sea level rise, warmer ocean temperatures, and increased precipitation (EPA, 2009). Some of the areas in the Kenyan coast that have been particularly affected by increases in precipitation in the recent past include Vanga, Mtwapa and Mombasa island in Kwale, Kilifi and Mombasa counties respectively. In all these areas, farms have flooded and crops lost. Houses and infrastructure have been damaged and families left homeless. For this reason, there's need for a transdisciplinary approach to managing the complexity of climate change and its impacts on ecosystems and their goods and services (Scott *et al*. 2005). This calls for a robust planning, design and administration of risk-based usage of water and other resources (Onyutha and Willems, 2014).

This study aimed at achieving the following objectives: 1) to assess historical and projected climate trends in the study area, 2) to evaluate historical coping strategies used by smallholder farmers in the study area, and 3) to propose a localized integrated climate change adaptation strategy for smallholder farmers in the study area.

Data and Methodology

Study Area

This study focused on the Kenyan coast, in general, and Kilifi, Mombasa and Kwale Counties (Figure 1), in particular. The average annual rainfall for Kilifi County is 300 mm, at the hinterland, and 1300 mm along the coastal belt. The county experiences temperatures ranging from 21^o C to 30^o C (at the coastal strip) and from 30^o C to 34^o C at the hinterland (Kilifi County, 2013).

Mombasa County has a mean rainfall of 640 mm and mean annual temperature of 27.9o C. The county experiences monsoon winds that shape its climate (Mombasa County Government, 2013). Kwale County has an average annual rainfall of 800 mm, and a monsoon type of climate. Temperature ranges from 26.3^o C to 26.6^o C at the coastal strip, and 24.6^o C to 27.5^o C (County Government of Kwale, 2013).

The relatively small spatial extent (in terms of climate) of Kwale, Mombasa and Kilifi counties informed the choice of conducting a social survey with smallholder farmers from Kilifi County. The findings of the social survey in Kilifi was assumed (and indeed verified using focus group discussions and existing literature) to represent the smallholder farmers from Mombasa and Kwale counties as well.

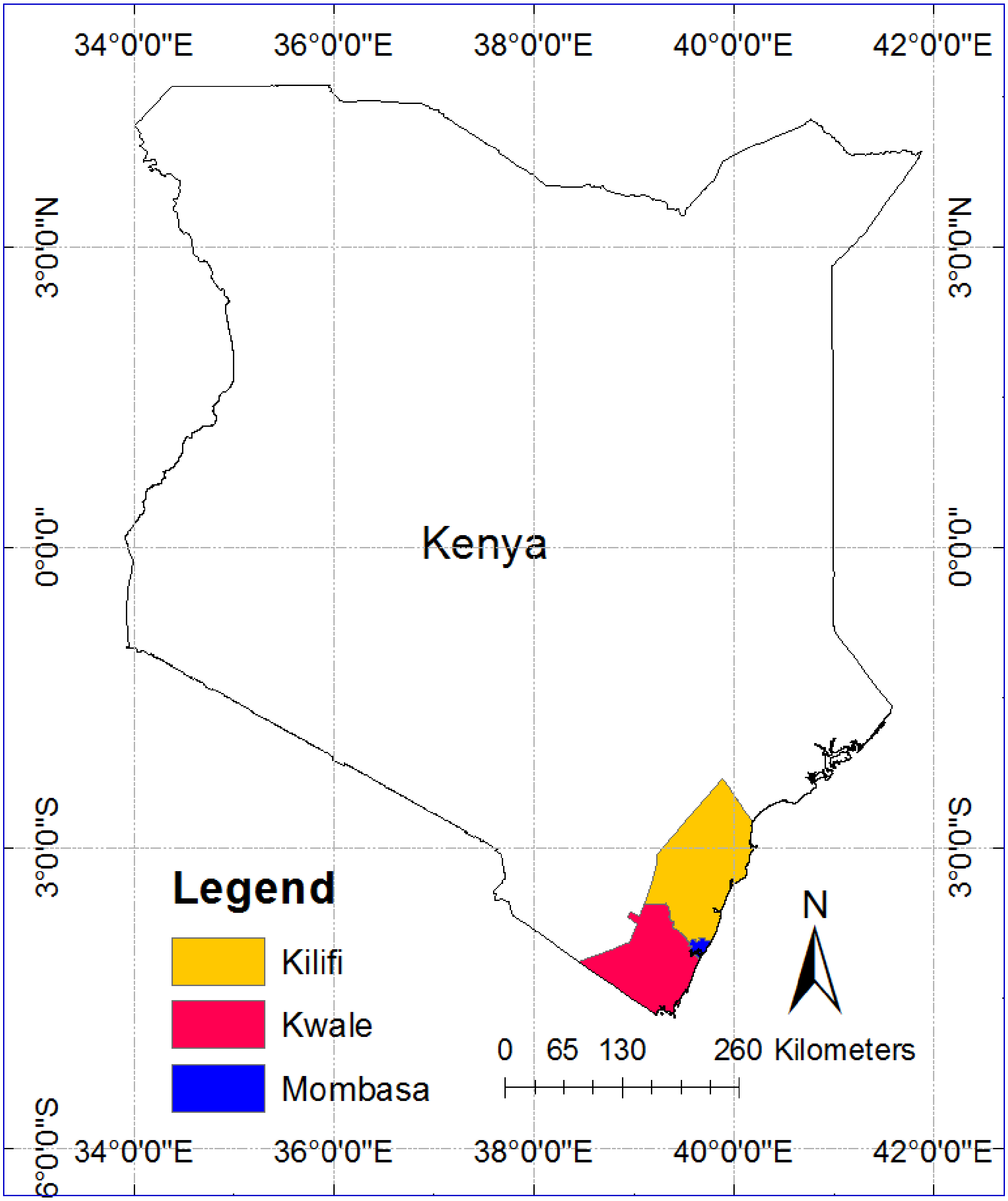

Figure 1: Location of Kwale, Mombasa and Kilifi Counties (Sourced from Ogegaet al., 2016)

Data

Observed climate data

The observed monthly rainfall and temperature data for Mtwapa, Msabaha and Malindi weather stations in Kilifi County, and Mombasa Station in Mombasa County were obtained from the Kenya Meteorological Department (KMD). Blended data, a blend of station data with satellite data, from GeoCLIM (Donnadieu *et al*., 2004a; Goddéris *et al*., 2005) were used to extract historical precipitation trends for Kwale County.

RCM Data

RCA model data output (driven by eight GCMs (Taylor *et al*., 2012)) was used to downscale the projected climate over the study area. This was a build-up to the study done by Endris *et al*. (2013) on RCMs and their ability to simulate climate over East Africa.

Qualitative Data

Social surveys and FGDs were used to generate qualitative data. The questionnaires were designed to generate information on whether or not a changing climate triggered past coping strategies. The key categories of the questions in the semi-structured were on land ownership and utilization, food security, and climate change and variability. Questionnaires were semi-structured so as to focus the responses given that climate change and variability was a fairly technical subject for many respondents. The use of FGDs was aimed at assessing and complementing the findings of the social survey.

Methodology

Assessing historical and projected climate trends over the study area

The homogeneity of the observed data was checked using the Short-cut Bartlett's test (Mitchell, 1966). The choice of the Short-cut Bartlett test was made because of its robustness and ease of use in assessing the coherence of data.Bartlett's test makes it possible to check whether or not the variance in various classes or groups of data is constant. The working series is divided into k equal parts of n values each (provided that $k \geq 2$).

This study considered data for the period 1971 to 2010. The data was divided into five groups of eight yearly totals for Mtwapa, Mombasa, Msabaha and Malindi stations. The data were subjected to the Bartlett's test and the results reported. A time series was plotted using observed rainfall data and the results recorded.

In projecting future climate trends over the study area, the CORDEX RCA data output was used. The study did a build-up to an earlier research that had been done by Endris *et al.* (2013); a study that demonstrated the ability of the multi-model ensemble mean in simulating rainfall over Eastern Africa. The choice of the SMHI RCA CORDEX RCM (driven by eight GCMs) was informed by the robustness of the model in simulating climate over Eastern Africa and the availability of downscaled data.

First, the CORDEX RCA data output was used to generate historical seasonal cycles for the study area. The seasonal cycles supplemented the time series for observed precipitation data while informing which GCMs to use in projecting the climate over the study area. The CDO software was used to do the statistical calculations while Open GrADS was used to plot the resulting files. The 8 GCMs driving the RCA models were plotted together with observational data from CRU and the ERA-Interim and results recorded.

Secondly, the study sought to project the difference in rainfall between the period 2016 to 2045 and the period 1971 to 2000 under the Representative Concentration Pathway (RCP) 4.5 and the RCP 8.5. The climatological sum over all time steps for the period 1971 to 2000 was calculated using the Climate Data Operators (CDO) software. Seasonal totals for each year were, then, calculated and summed for the entire time. Based on the baseline files created, future climate changes over the study area were calculated for the period 2015 to 2045 for both RCP 4.5 and RCP 8.5. Yearly seasonal totals were summed up for the period 2015 to 2045, and used in comparison to the baseline to derive the projected climate changes in the study area. The results were plotted using the Open GrADS software.

The choice of the RCP 4.5 (business as usual scenario) and RCP 8.5 (worst case scenario) in this study gives a picture of what would happen if the current greenhouse gas (GHG) emissions persist, while the RCP 8.5 scenario gives an indication of what would happen if the GHG emissions increase to a net radiative forcing (difference of incoming and outgoing radiation at the top of the atmosphere) of+8.5 W/m^2.

Evaluating historical coping strategies

The study set out to establish whether smallholder farmers were aware of climate change, were experiencing the impacts of climate change, and if they had taken any adaptation measures against climate change. The study opted to use semi-structured questionnaire interviews and focus group discussions (FGD) to gather information on the farmers' historical coping strategies against climate change. To this end, a pool of respondents was set up through the help of stakeholders including the Department of Agriculture, Kilifi County, the National Drought Management Authority (Kilifi branch), and the Kenya Adaptation to Climate Change in Arid and

Semi-arid Lands (KACCAL). Nine farmers were randomly selected from each of the 35 wards of Kilifi County (totalling to 350 respondents). Eligible respondents had to be practicing farmers for at least 20 years. One respondent per household was interviewed (either in person or by telephone).

Two FGDs were conducted to assess and complement the findings of the social survey that was done in Kilifi County. One FGD was held at Kilifi County while the other was held in Kwale County. Table 1shows the composition of the FGDs.

Table 1: Composition of FGDs convened for this study

County	Focus Group Participants (number of representatives)
Kilifi	Farmers (3) County Government officials (2) Kenya Adaptation against Climate Change for Arid and semi-arid Lands (1) National Disaster Management Agency (1) Kilifi County Disaster Management (1)
Kwale	Farmers (2) Journalist (1) County Meteorological Office (1) The Kenya Youth Climate Network (KYCN) (1) Kwale County Natural Resources Network (KCNRN) (1)

Mombasa County is geopolitically curved out of Kwale and Kilifi Counties. The county has very limited farming activities given that it is an urban area. The few smallholder farmers in the county are, mainly, located in border areas with Kwale and Kilifi counties. For instance, smallholder farmers in the Shanzu area of Mombasa County shared the same farming characteristics with farmers in Mtwapa, Kilifi County. For these reasons, social survey findings done with smallholder farmers from both Kwale and Kilifi Counties were assumed to representative of the smallholder farmers in Mombasa County as well. Further, Mombasa County is, largely, a town with little farming activities. The findings of the FGDs were compiled and shared with stakeholders.

Proposing a localized integrated climate change adaptation strategy

The localized integrated climate change adaptation strategy was formed as a proposed solution to the challenges facing smallholder farmers in the study area. The strategy was informed by the findings of historical and projected climate findings, and the results from the social survey in the study area. Through the social survey, smallholder farmers suggested what could help them better respond to the ensuing impacts of climate change and variability. These suggestions were considered and a localized climate change adaptation strategy formulated.

Results and Discussion

Historical and projected climate trends

Homogeneity test

The results from the Short-cut Bartlett's test (Figure 2) show that the rainfall data for all the stations that were considered (Mombasa, Mtwapa, Msabaha and Malindi) had p - values exceeding 0.05 (α). This implies that the observed climate data used in this study was homogenous and, hence, fit for time series analysis.

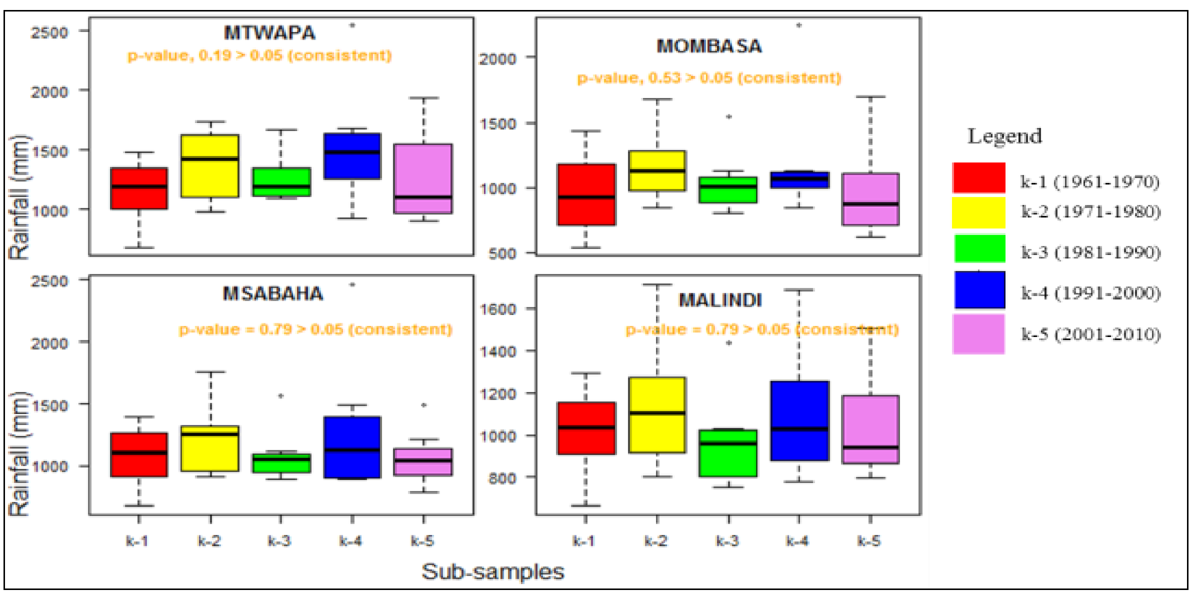

Figure 2: Homogeneity test for observed rainfall data using the Bartlett's test (Sourced from Ogegaet al., 2016).

Time series analysis for historical climate

A time series for annual precipitation totals for Malindi station was plotted (Figure 3). The time series for Mtwapa, Msabaha and Mombasa showed similar trend with that of the Malindi station. From Figure 3, rainfall over Malindi had remained fairly constant. These results were similar to previous studies (such as Omondi*et al.*, 2013 and Choi *et al.*, 2009) that had been done over the study area.

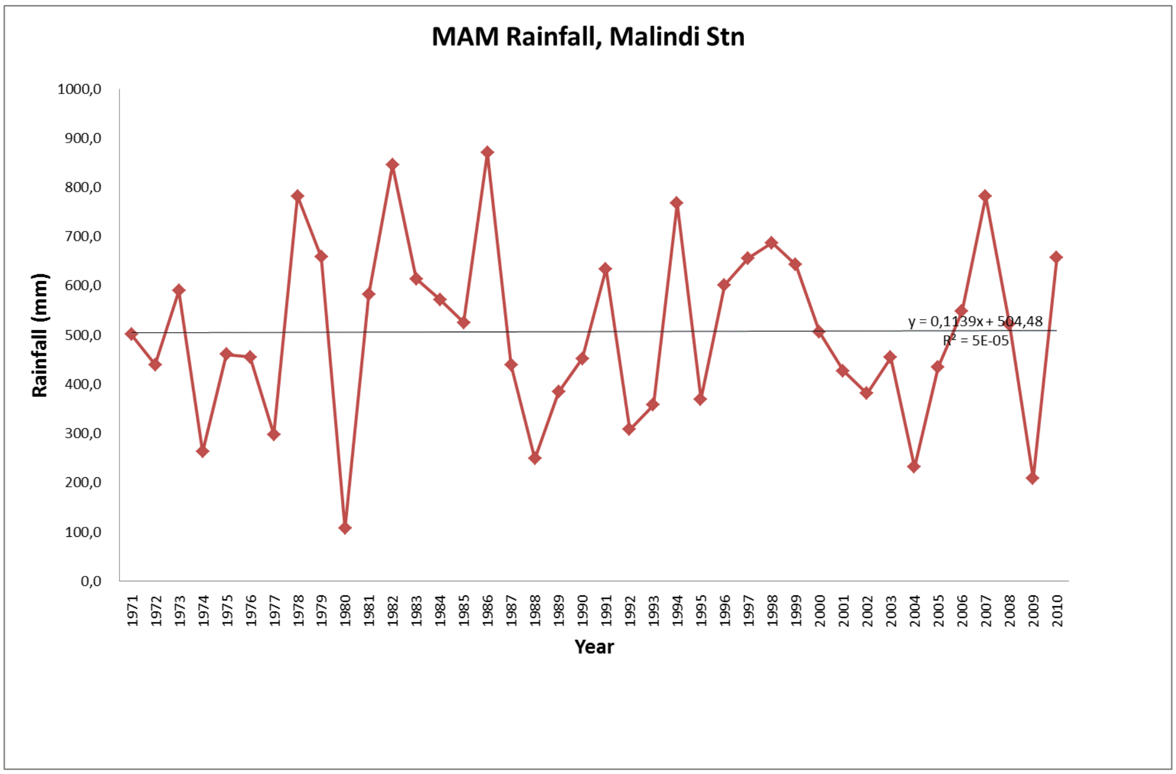

Figure 3: Seasonal time series for Malindi weather station (sourced from Ogega*et al.* 2016)

Projected climate

Figure 4 shows that the RCA model driven by the eight GCMs was able to simulate the study area's annual cycles fairly well. Monthly rainfall data from all the eight GCMs and CRU were summed for the period 1971 to 2000. The ERA-Interim data were only available for the period 1981 to 2000. All the seasons (MAM, JJA, and OND) are well captured by the models, with MIROC being closest to the observed data (CRU) in the MAM season. CCCma and NCC models were closest to the observed data (CRU) in the OND season. The ENSmean for the eight GCMs was able to simulate the annual cycles of precipitation, but it was less precise compared to CRU data. This analysis for the period 1971 to 2000 formed the baseline for climate projection for the period 2016 to 2045.

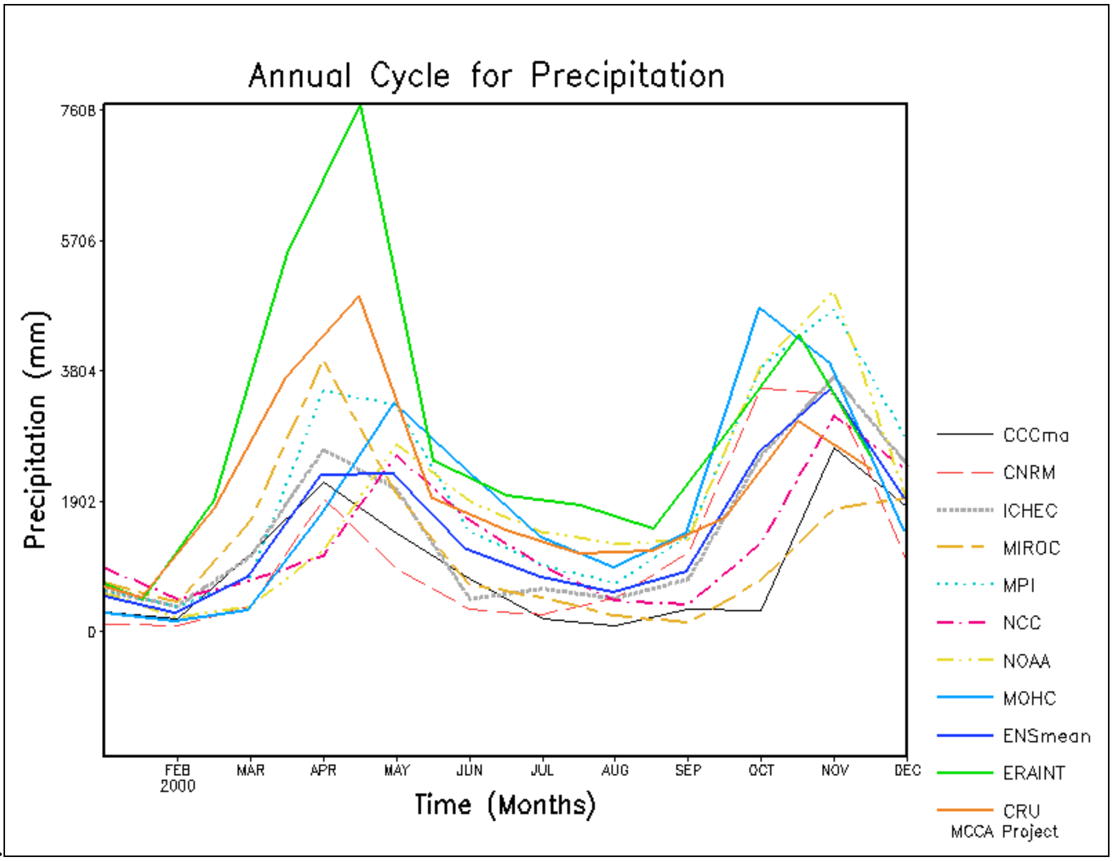

Figure 4: Annual cycle for precipitation as simulated by the RCA (CCCma, CNRM, ICHEC, MIROC, MPI, NCC, NOAA and MOHC), CRU and ERA-Interim (ERAINT)

Rainfall projections for the MAM and OND seasons (for both RCP 4.5 and RCP 8.5) showed increased rainfall for the study area. Figure 5, Figure 6, Figure 7 and Figure 8 show rainfall projections for the OND and MAM seasons for both RCP 4.5 and RCP 8.5. The choice of the CCCma and NCC models and ensemble mean of all the models (ENSmean) was informed by the fact that they were able to simulate the study area's climate better than the other models (Figure 4).

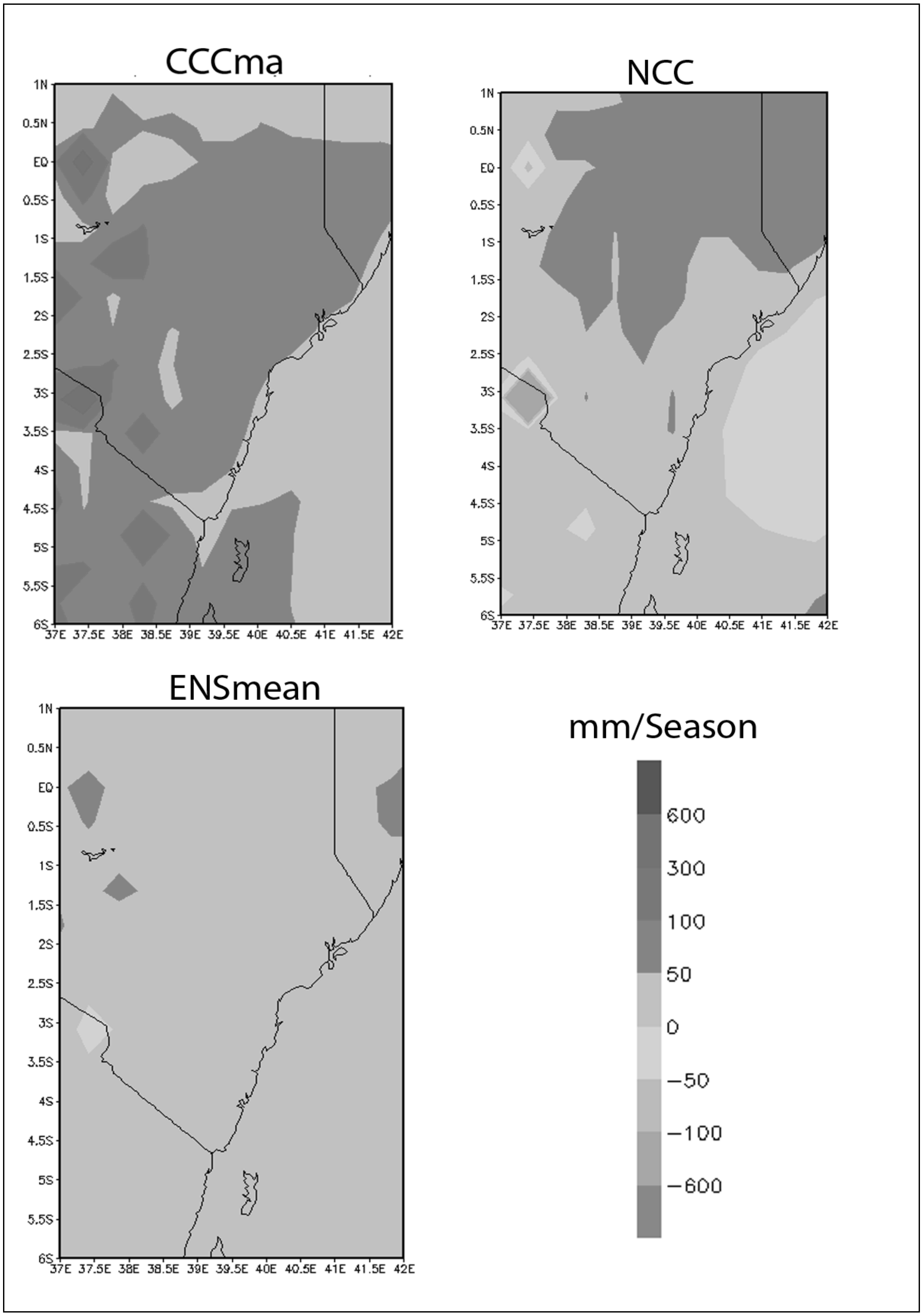

Figure 5: Projected OND season rainfall for the period 2016 to 2045 for RCP 4.5

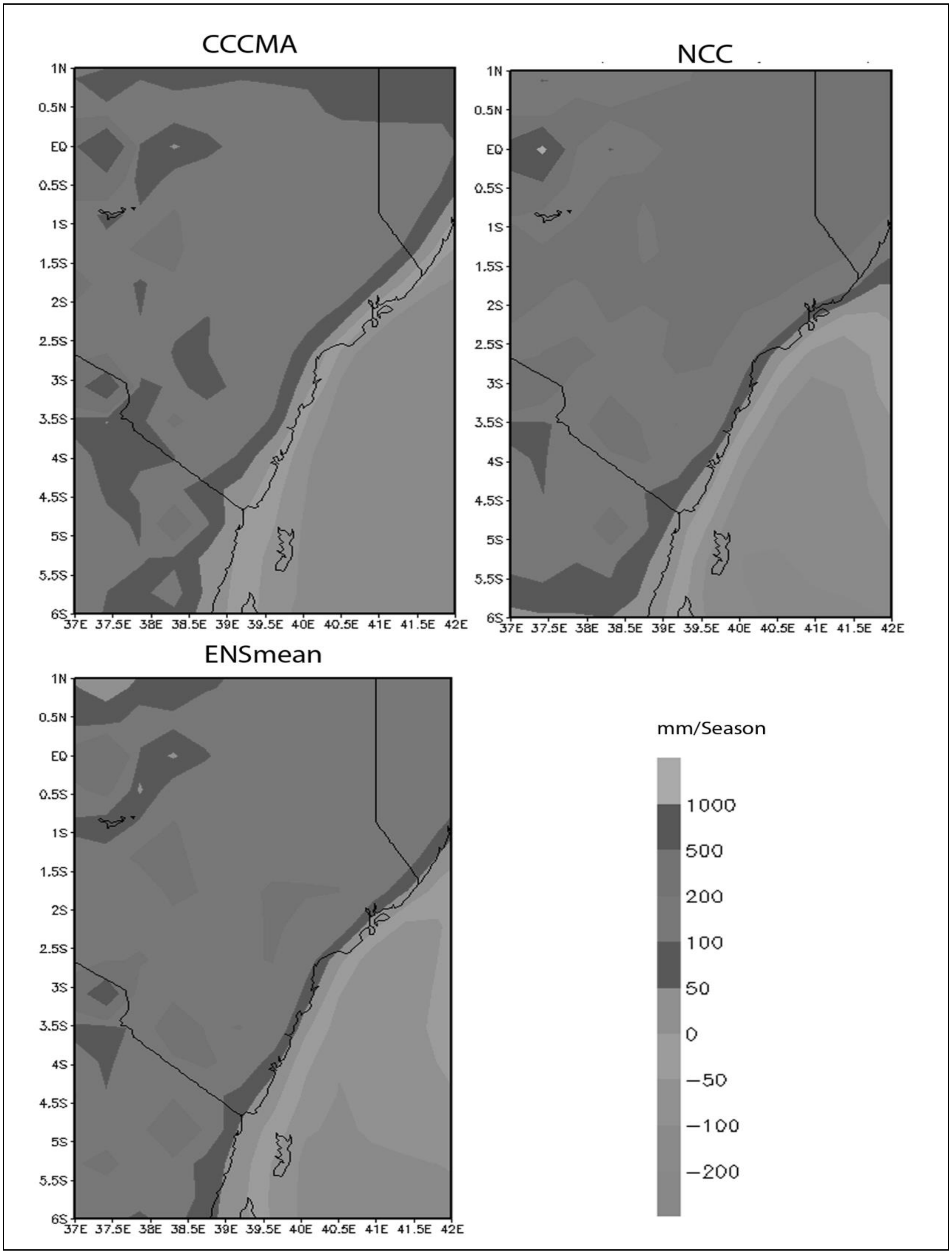

Figure 6: Projected MAM season rainfall for the period 2016 to 2045 for RCP 4.5

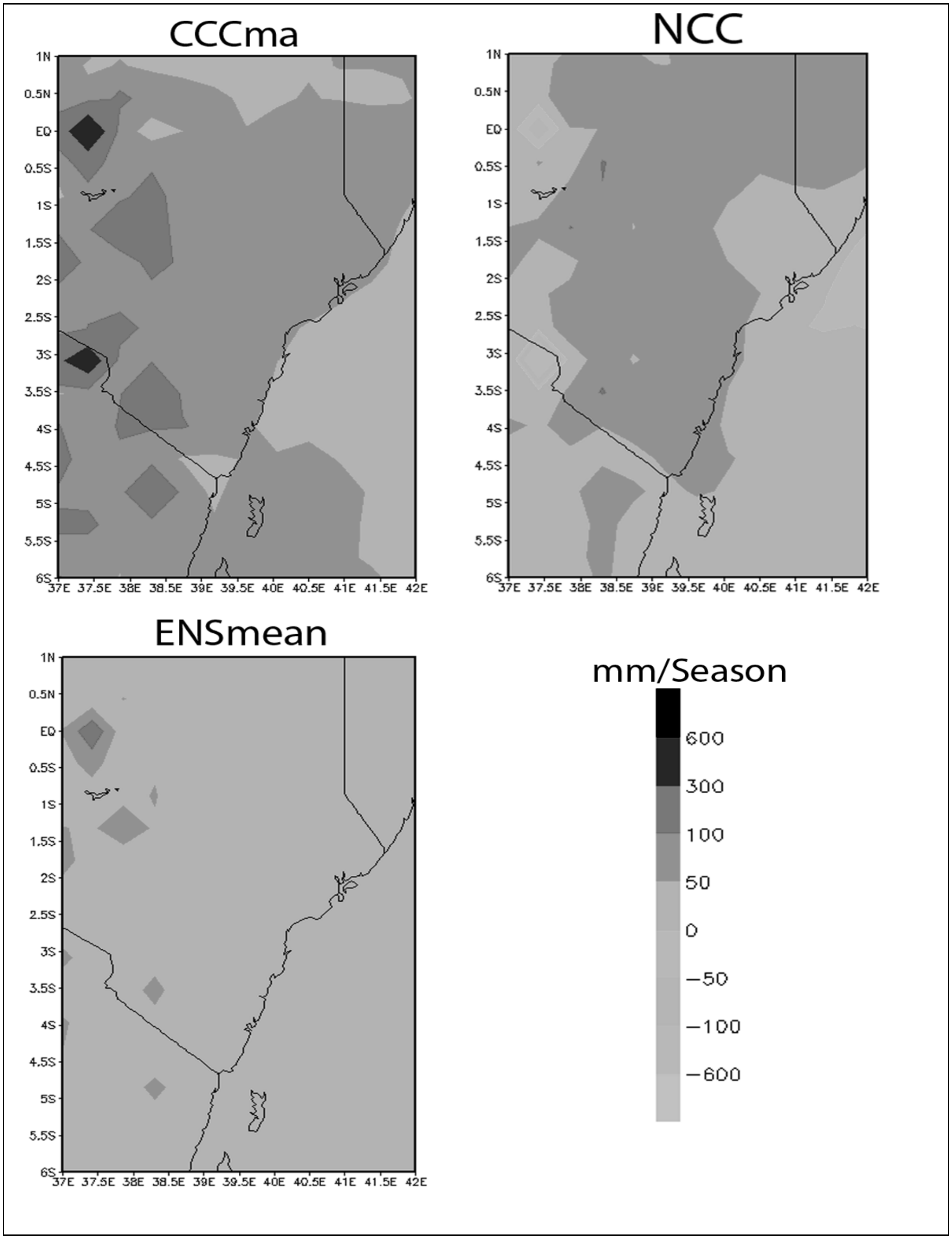

Figure 7: Projected OND season rainfall for the period 2016 to 2045 for RCP 8.5

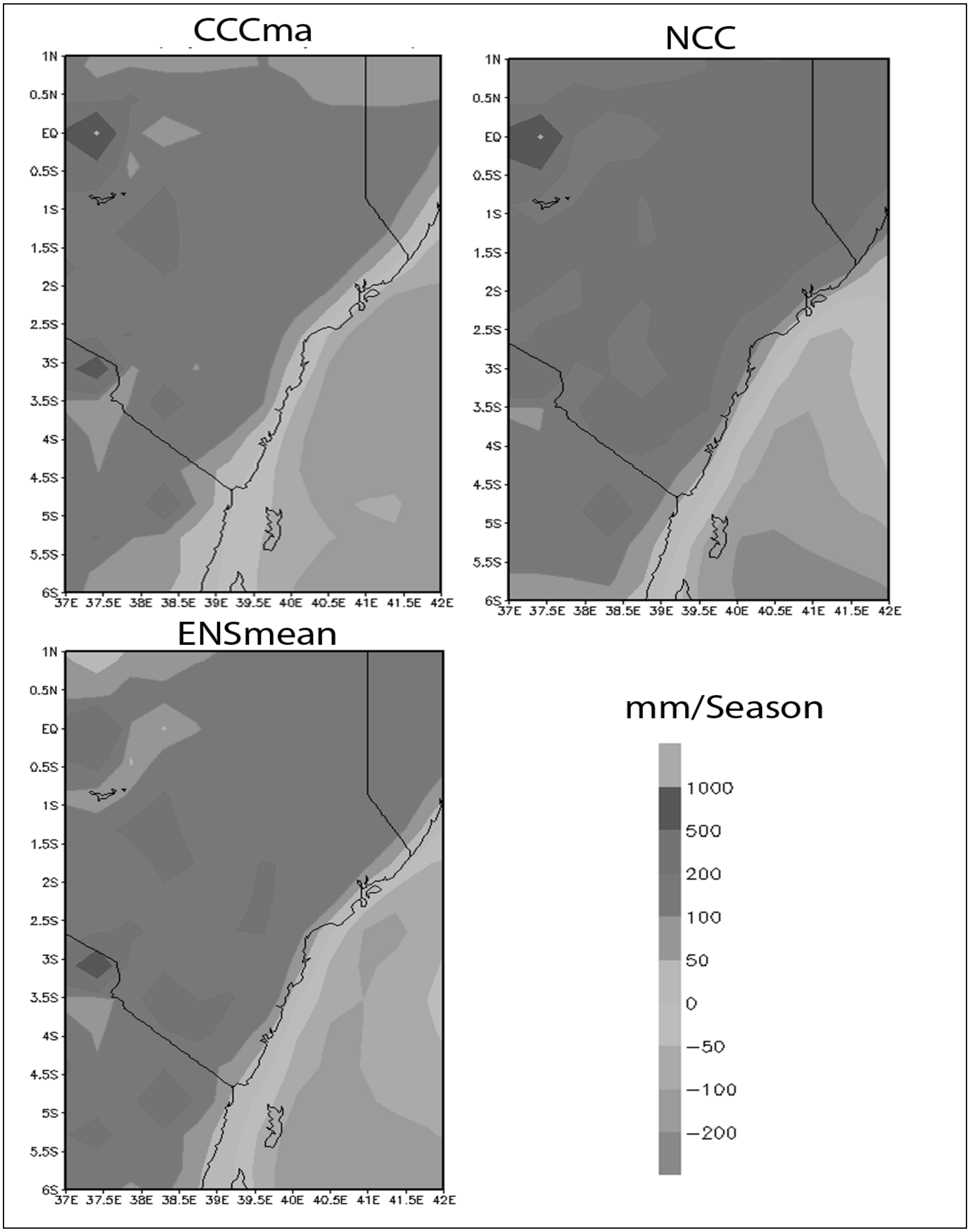

Figure 8: Projected MAM season rainfall for the period 2016 to 2045 for RCP 8.5

Historical coping strategies

Many households in the study area (77% of respondents) have been taking measures aimed at coping with the impacts of climate change and variability. Most of the adjustments made were a departure from indigenous ways of farming. This was as a result of various campaigns run by state and non-state actors such as the County Governments and the Food and Agricultural Organization (FAO). Figure 9 shows proportion of households that had made some adjustments in their farming, while Figure 10 shows the changes that had been made.

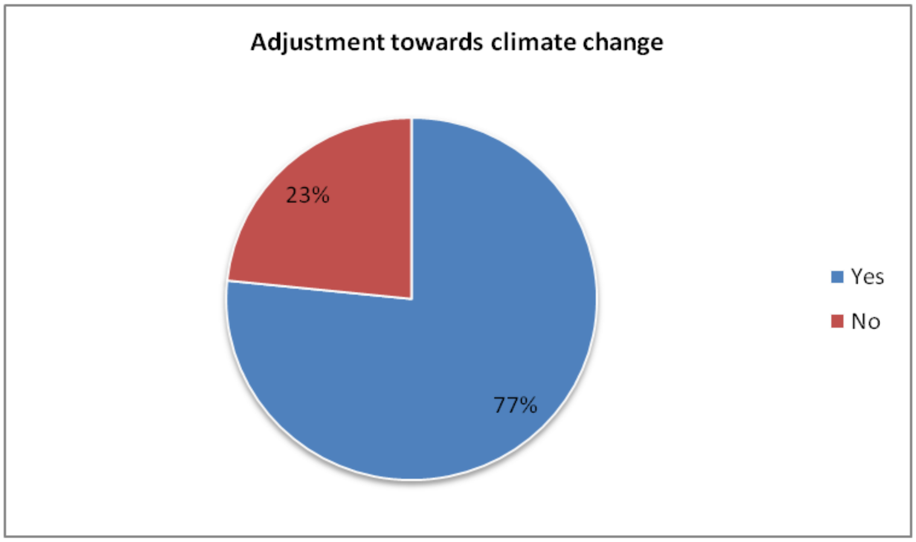

Figure 9: Proportion of households that had made adjustments in their farming

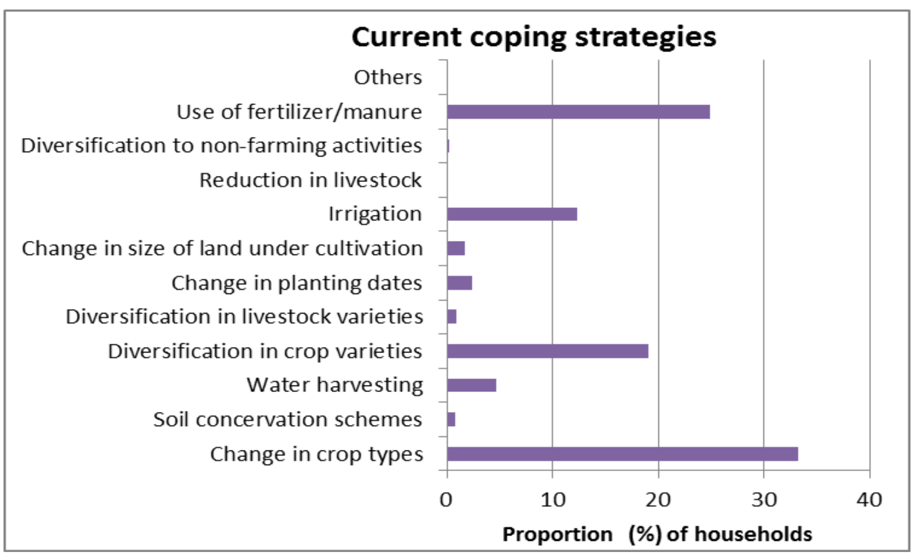

Figure 10: Proportion of households per adjustment item

Figure 10 depicts the adaptation options that were being undertaken by respondents. Change in crop varieties, use of fertilizer/manure, diversification in crop types and irrigation were the most pronounced adjustments made by respondents.

Through FGDs, traditional ways of weather forecasting were identified. One of these ways is the observation of the behaviour of birds. For instance, the presence of migratory birds flying high in a given area would signify good weather. Birds resting on mangroves for a long time would signify the coming of bad weather.

The presence of some particular fish species in the Indian Ocean, spotted by fishermen, is also used to predict the future weather. The presence of lobster and octopus in the fishing basket traps would indicate bad weather in the coming days. An appearance of particular star patterns in the sky would also provide information on whether a dry or wet season would be expected. The appearance of rainbows was said to indicate an ending rain season while swaying of tree leaves in a particular way would mean the coming of the rains.

Often, specific members of the community were charged with the responsibility of weather and climate prediction. These members drew their knowledge from their forefathers and many years of experience. Their weather predictions were said to be fairly accurate over the years. Elders, particularly traditional weather forecasters, commanded considerable following from their communities. For these reasons, scientists should find a way of working together with the traditional weather forecasters. In so doing, weather (and by extension climate) prediction is likely to be better. This will also foster the participation of all actors (including communities) in knowledge generation, interpretation, and consumption.

A localized integrated climate change adaptation framework for the study area

The social survey identified a strong need for a robust and localized integrated climate change adaptation mechanism. An adaptation continuum (

Table **2**) was used to evaluate the motivation behind climate change adaptation interventions that were being implemented at the study area. The adaptation continuum revealed that most initiatives were conceptualized as measures to address drivers of vulnerability with minimal reference to climate change. Further, at the county level, there was no climate change adaptation plan or a mechanism to determine the effectiveness of county initiated interventions towards addressing climate change-induced extremes such as prolonged droughts.

Table 2: The adaptation Continuum (adapted from Schipper*et al.*, 2007)

Vulnerability Focus ⟵⟶ Impact Focus

Addressing drivers of vulnerability	Building response capacity	Managing climate risks	Confronting climate change
Focus on reduction of poverty and addressing other non-climatic stressors that make people vulnerable i.e. address conventional development challenges such as poverty and access to clean water.	Focus on building robust mechanisms for problem solving	Focus on the incorporation of climate information into decision-making.	Focusexclusively on climate change-associated impacts

Figure 11shows an integrated climate change adaptation strategy that could be localized and adopted in the study area. Appropriate climate change adaption measures are formulated using current and relevant climate information, and the establishment of innovative and pertinent Climate-smart Agriculture solutions. For the effective adaptation to flourish, a carefully determined set of enablers has to be in place. The set of enables include ready markets, robust pro-agribusiness policies, and value addition services.

A proper implementation task force is vital in running different components of this framework. The task force should have a carefully selected blend of academia (climate and environment science professionals), farmer representatives, the government, and the market. The academia will provide current trends in climate and environment as well as draft climate-smart solutions. Farmers will bring in their farming experience from the field, while the government will provide relevant policies and direction to enable successful agribusiness. Business executives will bring market perspectives to the table to ensure that farmers produce goods that are commensurate with what is needed at the market. As a result of effective adaptation, yields will increase, food security improved and livelihoods enhanced for socio-economic prosperity.

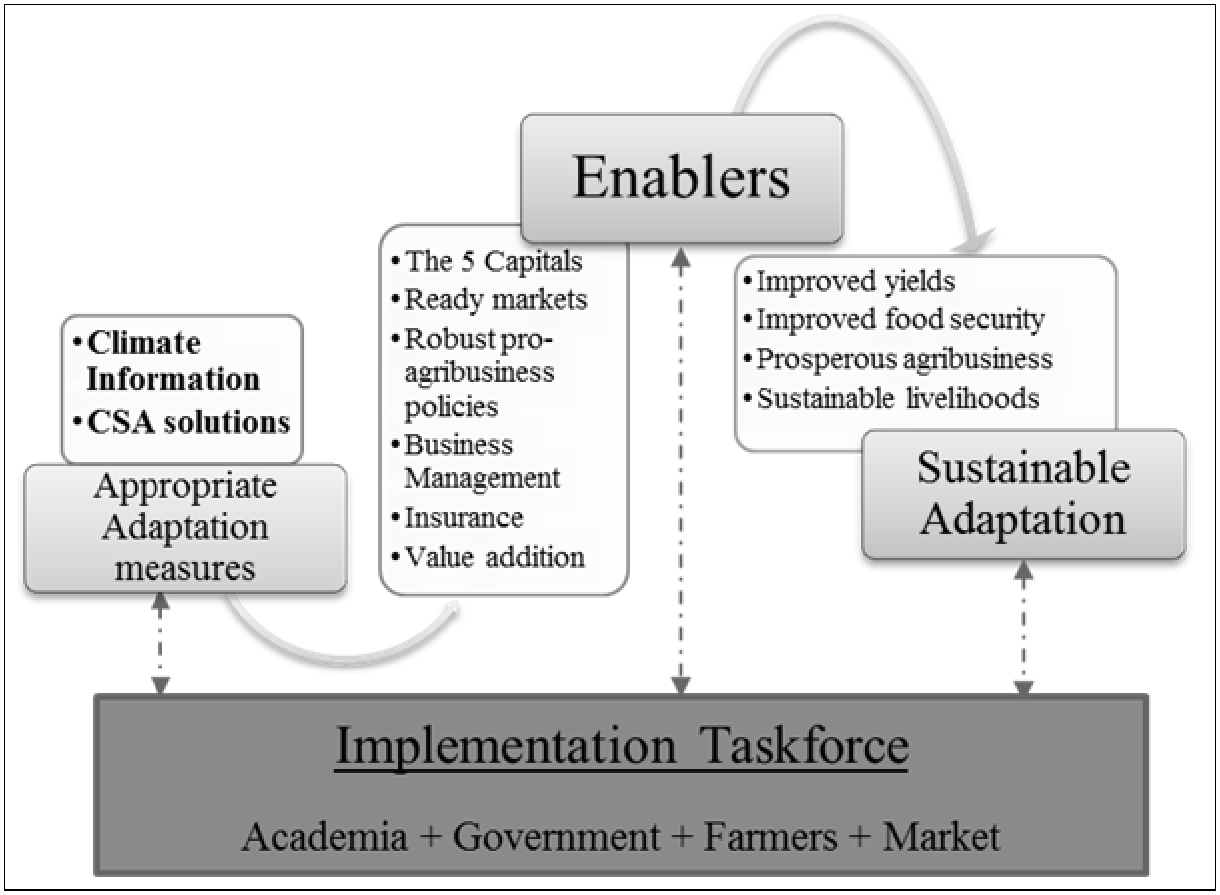

Figure 11: An integrated adaptation framework for the Kenyan Coast (Ogega et al., 2016)

Pre-requisites for appropriate and sustainable adaptation

Various actions were identified as critical enablers of the identified adaptation strategies. First, there was a need for better-coordinated interventions aimed at helping farmers actually adapt to the changing climate. This would minimize the risk of duplication of efforts, and ensure that interventions made achieve the maximum impacts. Secondly, the government ought to avail more affordable and economically viable inputs for the farmers. This would increase agricultural production, and make agriculture more rewarding and attractive.

Besides, farmers identified a need for more robust land management policies. At the time of this research land ownership, and utilization was not well managed. Some people owned huge chunks of idle land. There were cases of some property owners being reluctant to lease their unused land for agricultural production. With robust land management policies, the land would be better managed, and more land availed for agricultural production.

Creation of new markets with the interests of farmers at heart increased civic education, and awareness were identified as other as pre-requisites. Others include the promotion of sustainable farming practices, and enhanced value addition services. Retrogressive traditional practices such as witchcraft were identified as barriers to successful agribusiness at the Kenyan coast. There was a need to sensitize the communities against such practices to minimize the risk of having farmers quit farming. With these measures in place, achieving any realistic, sustainable adaptation against the changing climate at the Kenyan coast would be possible.

Regional Climate Models (RCMs) are projecting increased rainfall in East Africa. This increasing rainfall demands a concerted effort from all the actors in the region to ensure that adequate adaptation measures are instituted in good time. In so doing, the Kenyan coast is likely to minimize the risks associated with rainfall change and variability. Increased precipitation, also, provides opportunities that should be exploited for the socio-economic prosperity of the region.

Summary and Conclusions

Historical trends in climate change and variability over the study area were determined. Rainfall in the study area showed a negative trend for the period 1961 to 2010. The study projected future climate change and variability over the study area using CORDEX RCMs. The RCA RCM driven by eight GCMs was used to project future climate over the study area; based on the 1971 to 2000 baseline. Results showed that rainfall was expected to increase for the period 2015 to 2045. The findings were similar for either the RCP 4.5 or the RCP 8.5 pathway.

Historical coping strategies and their effectiveness in responding to a changing climate were evaluated. The social survey indicated that minimal successful climate change adaptation efforts were being carried out study area. Many farmers were either unaware of appropriate adaptation options or were unable to implement effective climate change and variability adaptation options. For this reason, farmers complained of diminishing agricultural productivity and, hence, chronic food shortage.

Based on historical and projected climate over the study area, and the findings from community surveys, appropriate climate change adaptation measures were proposed. These adaptation measures combined both the indigenous and scientific knowledge. The indigenous knowledge was derived from questionnaire interviews, FGDs, and desktop studies. Further, an enabling environment for effective adaptation and drivers of adaptation strategies were defined in the FGDs.

In conclusion, this study generated historical and future climate information over the area of study. It also evaluated how the communities are coping with the ensuing climate change and variability, and proposed more appropriate and sustainable adaptation options for the communities going forward. In so doing, this study contributes valuable knowledge regarding climate change and variability, and its recommendations will go a long way in improving the socio-economic well-being of the study area.

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References

Anyah, R. O., & Qiu,W. (2012). Characteristic 20th and 21st century rainfall and temperature patterns and changes over the Greater Horn of Africa. *Int. J. Climatol.*, 32, 347-363, doi:10.100./joc.2270.

Choi G., Collins,D., Ren,G., Trewin,B., Baldi,M., Fukuda,Y., Afzaal, M., … Zhou Y. (2009). Changes in means and extreme events of temperature and precipitation in the Asia-Pacific Network region, 1955–2007. *International Journal of Climatology*, 29, 1906–1925.

County Government of Kwale, (2013). First County integrated development plan, 2013. Kwale

Donnadieu, Y., Goddéris,Y., Ramstein,G., Nédelec,A., &Meert,J. G. (2004a).Snowball Earth triggered by continental break-up through changes in runoff. Nature, 428, 303–306.

Endris H. S., Omondi,P., Jain,S., Lennard,C., Hewitson,B., Chang'a,L., … Tazalika L. (2013). Assessment of the Performance of CORDEX Regional Climate Models in Simulating East African Rainfall. American Meteorological Society, 26, 8453 – 8475. doi:10.1175/JCLI-D-12-00708.1

EPA (2009), Climate Impacts on Coastal Areas. United States Environmental Protection Agency. [Online] Available: https://www3.epa.gov/climatechange/impacts/coasts.html (December 10, 2016)

Giorgi, F., Jones C., &Asrar G. R. (2009) Addressing climate information needs at the regional level: The CORDEX framework. WMO Bulletin,58, 175-183.

Goddéris, Y., Donnadieu,Y., Dessert, C., Dupré,B., Fluteau,F., François,L. M., … RamsteinG. (2005).Coupled modelling of global carbon cycle and climate in the Neoproterozoic: Links between Rodinia breakup and major glaciations. C. R. Geosci., in press.

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[Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland, 151 pp.

Jacob, D., Barring, L., Christensen, O. B., Christensen, J. H., de Castro, M., Déqué, M., … den Hurk B. (2007). An inter-comparison of regional climate models for Europe: Model performance in Present-Day Climate. Climatic Change, Special Issue: PRUDENCE. [Online]Available:http://prudence.dmi.dk/public/publications/PSICC/Jacob-et-al.pdf (September 9, 2016)

Kilifi County (2013). First Kilifi County integrated development plan 2013-2017.

Mitchell, J.M. (1966).Climatic Change. WMO Technical Note 79, TP-100, Geneva, 79 pp.

Mombasa County Government(2013). First County integrated development plan. Mombasa

Ogega, O.M., Oludhe, C., Gyampoh, B., Aming'o, P.O., &Obura, D. (2016). *Use of scientific and indigenous knowledge in adapting to climate change and variability at the Kenyan coast.*(Unpublished master's thesis). Institute for Climate Change and Adaptation, University of Nairobi, Nairobi, Kenya

Omondi, P. A., Awange, J. L., Forootan, E., Ogallo, L. A., Barakiza, R., Girmaw, G. B., … E. Komutunga(2013). Changes in temperature and precipitation extremes over the Greater Horn of Africa region from 1961 to 2010. *Int. J. Climatol.*doi: 10.1002/joc.3763

Onyutha, C. & Willems, P. (2014). Spatial and temporal variability of rainfall in the Nile Basin. *Hydrology and Earth System Sciences, 11(11945-11986).*[Online] Available: http://www.hydrol-earth-syst-sci-discuss.net/11/11945/2014/hessd-11-11945-2014.pdf (September 12, 2016)

Rummukainen, M.(2010). State-of-the-art with regional climate model. *Wiley Interdiscip. Rev.: Climate Change,*1, 82-96, doi:10.1002/wcc.8.

Schipper, E. L., Parry, J., McGray, H., Hammill, A., Bradley, R., &Powell, M., (2007). Weathering the Storm: Options for Framing Adaptation and Development. *World Resources Institute.* [Online] Available: http://pdf.wri.org/weathering_the_storm.pdf (September 18, 2016)

Scott, D., Jones, B., & Abi Khaled, H.(2005). Climate change: a long term strategic issue for the National Capital Commission (Tourism and Recreation Business Lines) – Executive Summary. *Report prepared for the National Capital Commission*. Waterloo, Canada: University of Waterloo.

Taylor, K. E., Stouffer, R. J., Meehl, G. A. (2012). An overview of CMIP5 and the experiment design. *Bull. Amer. Meteor. Soc.,* 93, 485-498, doi: 10.1175/BAMS-D-11-00094.1

World Food Program (WFP)(2015), Kenya. [Online] Available: http://www.wfp.org/countries/kenya/overview (October 22, 2016)