NJAS - Wageningen Journal of Life Sciences xxx (2016) xxx–xxx

Contents lists available at ScienceDirect

NJAS - Wageningen Journal of Life Sciences

journal homepage: www.elsevier.com/locate/njas

Effects of climate variability and change on agricultural production: The case of small scale farmers in Kenya

Justus Ochieng*, Lilian Kirimi, Mary Mathenge

Tegemeo Institute of Agricultural Policy and Development, Egerton University, P.O. Box 20498, 00200 Nairobi, Kenya

ARTICLE INFO

Article history:
Received 15 April 2015
Received in revised form 11 March 2016
Accepted 16 March 2016
Available online xxx

Keywords:
Agriculture revenues
Climate change
Panel data
Tea
Maize
Kenya

ABSTRACT

Agriculture is the mainstay of the Kenyan economy, contributing to food security and employment of rural households. Climate variability and change have adversely affected this sector and the situation is expected to worsen in the future. We estimate the effect of climate variability and change on revenue from all crops, maize and tea separately, using a household fixed effects estimator. We find that climate variability and change affects agricultural production but effects differ across crops. Temperature has a negative effect on crop and maize revenues but a positive one on tea, while rainfall has a negative effect on tea. We find that tea relies on stable temperatures and consistent rainfall patterns and any excess would negatively affect production. Temperature has a greater impact on crop production than rainfall. Climate change will adversely affect agriculture in 2020, 2030 and 2040 with greater effects in the tea sector. Therefore, rethinking the likely harmful effects of rising temperatures and increasing rainfall uncertainty should be a priority in Kenya. Implementing adaptation measures at national, county and farm levels as well as putting in place policies that prevent destruction of the natural environment will assist to address the challenges posed by climate variability and change.

1. Introduction

Agriculture continues to be the mainstay of the Kenyan economy with an estimated gross domestic product (GDP) share of 25.9% [1] making it an important contributor to employment and food security of rural households. Climate change has significantly affected global agriculture in the 21st century and the Intergovernmental Panel on Climate Change (IPCC) assessment report indicates that most countries will experience an increase in average temperature, more frequent heat waves, more stressed water resources, desertification, and periods of heavy precipitation [2,3]. The past three decades have been the warmest in history, with each decade being warmer than the preceding period [3]. Further, the reports indicate that the African continent is warmer than it was 100 years ago [4]. Future impacts are projected to worsen as the temperature continues to rise and precipitation becomes more unreliable.

The rising temperature would expose millions of people to drought and hunger. Climatic variability and change have always presented a threat to food security in Kenya through their effect on rainfall, soil moisture and production. Since the early 1990s, Kenya has been affected by the droughts of 1991–2, 1992–3, 1995–6, 1998–2000 and 2004, the *El-Niño* rains that resulted in the floods of 1997–1998 [5] and the drought of 2008–9. Climatic variability and change directly affect agricultural production and food security given that most of the population in Kenya lives in the rural areas and relies on agriculture for its livelihoods. This is exacerbated by the fact that agriculture is predominantly rain-fed. The poor in Africa, particularly smallholder farmers, are highly vulnerable to climatic and environmental hazards as their options for diversifying their resources and income sources are limited. Their vulnerability is worsened by the spread of HIV/AIDS, lack of access to land due to the traditional land tenure systems, lack of adequate water, low levels of technology and education and institutional mismanagement [6]. This calls for clear response strategies in terms of mitigation and adaptation in order to deal with the threats posed by climate change.

In recognition of these climate change challenges, the Kenyan government put in place the National Climate Change Response Strategy (NCCRS) whose aim is to respond to the challenges and opportunities posed by climate change [7]. The objective of NCCRS is to strengthen nationwide focused actions towards adapting and mitigating against a changing climate, by ensuring commitment

* Corresponding author at: AVRDC—The World Vegetable Center, Eastern and Southern Africa, P.O. Box 10, Duluti, Arusha, Tanzania.
E-mail addresses: Justus.Ochieng@worldveg.org, Ochieng.justus1@gmail.com (J. Ochieng).

http://dx.doi.org/10.1016/j.njas.2016.03.005
1573-5214/

and engagement of the whole nation in combating the impacts of climate change, taking into account the vulnerable nature of the natural and ecological resources, and society as a whole. Environmental protection has been put in place as one of the important national priorities in the context of Kenya Vision 2030 (the country's development blueprint covering the period 2008–2030) and under its National Climate Change Action Plan (2013–2017) in order to address the threats of climate change in Kenya. In addition, the government identified irrigation as one of the ways of moderating the effects of climate change, and launched a flagship project, Galana Kulalu irrigation scheme in the Tana River area in the coastal region in January, 2014.

It has been recognized that adaptation measures can reduce negative impacts of global warming and climate change [8]. These measures comprise the growing of alternative crops, intercropping different crop varieties, use of drought tolerant seed varieties, employing irrigation and water harvesting techniques, crop insurance, early warning and monitoring systems, construction of dykes, human migration, changing planting dates, diversifying in and out of agriculture, reliance on safety nets and social networks and sale of assets. One constraint to adaptation has been that some of the adaptation technologies such as irrigation systems and dykes require huge capital outlays.

While several studies provide detailed accounts of the impacts of climate change in Kenya [8–10], a few critical gaps do, however, exist which we seek to address in the current paper. The existing studies mainly use cross-sectional data and we contribute to the discussion by using the Tegemeo panel survey data set which takes into account changes in household incomes, rainfall and temperature across both space and time, and thus enables the assessment of any variability across these key indicators over time. Secondly, while most studies model effects of climate on total crop revenue, we assess the effects on selected key crops in Kenya, maize and tea. Disaggregation of income by crop types sheds more light on the effects of climate variability and change on maize which is an important staple crop and tea, the leading export crop that contributes about 20% of the total foreign exchange earnings in Kenya.

The remainder of the paper is organized as follows. Section 2 includes a review of the literature on effects of climate change and variability on agriculture production. Section 3 presents our materials and methods which include data sources and estimation techniques. Findings and discussions are presented in Section 4 and the last section concludes and discusses policy implications.

2. Literature review

Climate change is arguably one of the most important challenges facing African countries, largely due to their geographic exposure,[1] low income, greater reliance on climate-sensitive sectors such as agriculture, and weak capacity to adapt to the changing climate [11]. However, there are limited studies that have documented adverse socio-economic impacts of extreme weather events specifically in Kenya. The effects have been felt on almost all sectors such as health, agriculture, livestock, environment, hydropower generation and tourism [12]. Kenya is adversely affected by climatic variability and change because of her dependency on rain-fed agriculture, with variability in rainfall and temperature directly affecting crop and livestock yields.

Empirical results show that climate variability has significant economic costs as a result of periodic floods and droughts, which lead to major macro-economic costs and reductions in economic growth [12]. Downing [13] explored the impact of climate change in Kenya and found that higher temperatures would have a positive impact in highland areas but a negative effect in lowland areas, and especially semi-arid ones. Therefore, potential food production would increase with rising temperature and rainfall, but in the semi-arid areas, yields would decline as a result of insufficient precipitation. Fischer and van Velthuizen [14] indicated that the overall impact of climate change on food production in Kenya would be positive but results would vary by region. They also asserted that the increase in production would arise from an increase in carbon dioxide and temperature, provided that there would be an increase in precipitation as well.

Adger [15] argued that social vulnerability to climate change is a key dimension in the constitution of vulnerability, and that it shifts emphasis onto the underlying, rather than the proximate causes of vulnerability. In Kenya, smallholder farmers have been found to respond to drought through diversification into off-farm employment activities [16]. Kabubo-Mariara and Karanja [8] also showed that adaptation measures in terms of micro-level farm adaptations, market responses, technological developments and institutional changes have a large potential in reducing negative impacts of global warming and climate change. Bilham, [10] found that temperature had more impact on crop yields than rainfall. Jones and Thornton [35] showed that maize production in Africa and Latin America would reduce by 10% by 2055 and recommended that climate change effects should be assessed at household level so that the poor who depend on agriculture can be targeted for advice.

Many studies in East Africa focus on the effects of one climate variable in isolation, usually rainfall for the specific data collection year. For instance, a study by Oremo [9], used only rainfall while Skoufias and Vinha [17] reported that temperature has received much less attention in climate change research. The two climate variables are often correlated, and so the inclusion of just one variable would lead to omitted variable bias. In this paper, we use both rainfall and temperature, and also cover most of the agro-ecological zones in Kenya. A study by Ndukhu et al. [18] showed that farmers in Kenya were aware of short-term climate changes, particularly an increase in temperatures, but their perceptions of these changes and the adaptations they used varied across agro-climatic zones. Oremo [9] showed that farmers' perceptions that Kitui County was getting drier and that rainfall decreased were consistent with the meteorological rainfall data. However, Oremo [9] used cross sectional data for the region to evaluate the relationship between rainfall and maize yields without considering temperature changes which would be equally important in influencing maize productivity.

One of the most comprehensive studies on climate change in Kenya is by Kabubo-Mariara and Karanja [8]. This study was conducted in 38 out of 46 former districts and analysed the economic impact of climate on crop agriculture, using a seasonal Ricardian model and a crop response simulation model. The analysis was based on different types of data: long-term mean seasonal temperature and precipitation data; long-term mean monthly hydrological data; main classes of soil types; and, cross-sectional household level data. The results showed that climate affects crop revenue, with increased winter (June-August) temperatures being associated with higher crop revenue, and increased summer (March-May) temperatures having a negative impact on revenue. Increased precipitation was positively correlated with net crop yield. The results also showed that there was a non-linear relationship between revenue and the temperature and precipitation variables.

While the study by Kabubo-Mariara and Karanja [8], provides the most detailed and more recent account of the impacts of climate change in Kenya, a few critical gaps do, however, exist and which we seek to address in the current study. First, the Ricardian analysis that was used estimates the effect of climate on net crop revenue

[1] Most of the African countries are located on lower latitudes.

Please cite this article in press as: J. Ochieng, et al., Effects of climate variability and change on agricultural production: The case of small scale farmers in Kenya, NJAS - Wageningen J. Life Sci. (2016), http://dx.doi.org/10.1016/j.njas.2016.03.005