IMPACT OF CLIMATE CHANGE ON COTTON PRODUCTION IN UZBEKISTAN

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Abstract

Historically, Central Asia has been known for its abundance in water resources. This region currently faces droughts and decreasing water supplies, which is exacerbated by outdated technology and inefficient irrigation schemes. Agricultural production in the Aral Sea Basin can only be sustainable if the region can learn to adapt to the effects of climate change and improve their institutional structure and crop production efficiencies. This paper will estimate future fiber and food production in Uzbekistan by using a non-linear dynamic optimization model coupled with downscaled climate change projections to predict cotton and wheat production capabilities to the end of the century.

Introduction

Approximately 850 million people in 77 countries are food insecure. It has been estimated that from 2012-2022, the number of people considered to be food insecure will increase by 37 million (Rosen et al., 2012). By 2025, world population is expected to reach eight billion, with much of this growth projected to occur in developing countries where household survival often depends on local crop production (UN, 2011). Uzbekistan is the largest agricultural producer in the Aral Sea Basin due to its access to water sources. Agriculture represents 25% of their GDP and 44% of their labor force. Uzbekistan is the world's fourth largest cotton exporter, dominating the economy with fiber receipts, which represent 18% of their GDP (Bobojonov et al., 2012). Since the dissolution of the Soviet Union, this area has seen massive de-mechanization, with cotton yields decreasing over 20% since 1991 (Pomfret, 2000). As a result, Uzbekistan has shifted some of its agricultural production to wheat. Uzbekistan also produces rice, fruit, vegetables, and livestock (CAWaterInfo, 2014).

The Soviets collectivized agriculture moving toward cotton monoculture production. Soviet polices exploited their vast water reserves to support their intensive crop production, which eventually lead to the desiccation of the Aral Sea. With Soviet policy still in place, Uzbekistan agriculture is susceptible to drought and declining water availability, making them in danger of becoming food scarce in the future. Uzbekistan is relatively labor abundant, so they must rely on agricultural production to establish food security.

The objective of this paper was to project food availability in Uzbekistan to 2100. Food production was estimated using crop growth models and economic activity parameters such as pricing and market structure within the Aral Sea Basin as a result of changing climate conditions over time.

Materials and Methods

Maximum and minimum temperature and precipitation projections from global climate models were downscaled to the country of Uzbekistan using nine Global Climate Models (GCMs) and two CO2 concentration pathways (Hayhoe 2004,2008). Daily downscaled climate data for each GCM were used as observations to derive final climate pathways using a Monte Carlo simulation approach for each variable. The model simulations include three time periods: near term (2012-2039), mid-century (2040-2069) and century (2070-2099). The final climate data results were included in a crop growth simulator to develop crop production functions which reflect the climatic effect on crop yields in the economic model. DSSAT is a crop simulation model that simulates crop production, taking into account region specific parameters such as plant physiology, crop management practices, soil type, and climatic factors such as minimum and maximum daily temperature and solar radiation. The climate simulations were used as an input into the DSSAT model. Cotton, wheat, rice, and tomatoes were simulated in DSSAT. For the purposes of this paper, rice and tomatoes will not be mentioned. Quadratic production functions were created from yield outputs from DSSAT as a function of water applied. The production functions were included in a non-linear optimization model. The optimization model consisted of a river/reservoir system that projected optimal crop choice over time, net returns, and water use for a small agricultural region, Khorezm, located in Uzbekistan. A policy analysis determined the impact of distortions from Soviet production quotas on optimal crop production in Uzbekistan.

Results and Discussion

Two models were run for this analysis: a baseline model that includes a cotton production quota of 40% and a policy scenario which looks at the impact of removing the cotton quota. Results for crop acreage percentages will be presented. Crop acreage percentages between the low and high CO_2 scenarios are similar, therefore only acreage results for the low CO_2 scenario will be discussed. Although this analysis contains rice and vegetables, only the cotton and wheat results will be shown.

Figure 1 shows results for crop acreage for cotton and wheat from 2012 to 2039. Cotton acreage converges to the 40% cotton quota policy by 2034 and wheat increases from 7% to 33% by the end of the period. Figure 2 shows crop acreages for the mid-term baseline scenario from 2040-2069. Cotton acreage remains constant throughout the period. Wheat acreage increases to 45% by 2069. In Figure 3 from 2070 to 2100, cotton acreage continues to remain at 40% to the end of century, while wheat acreage reaches 48% by 2100.

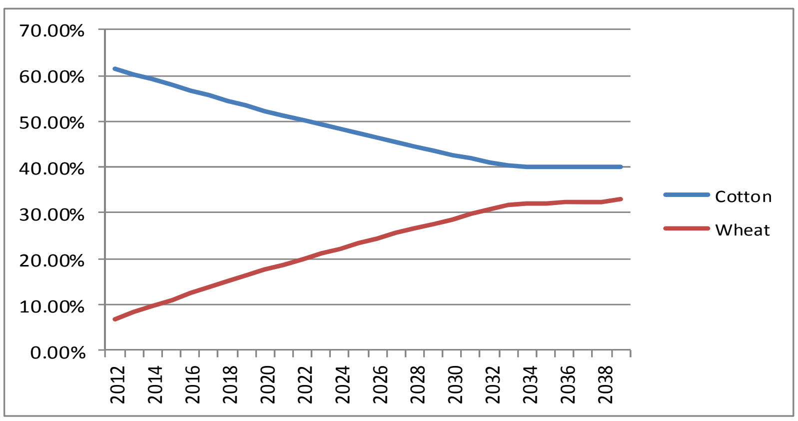

Figure 1. Crop Acreage Percentages for the Baseline Near Term Low CO_2 Scenario

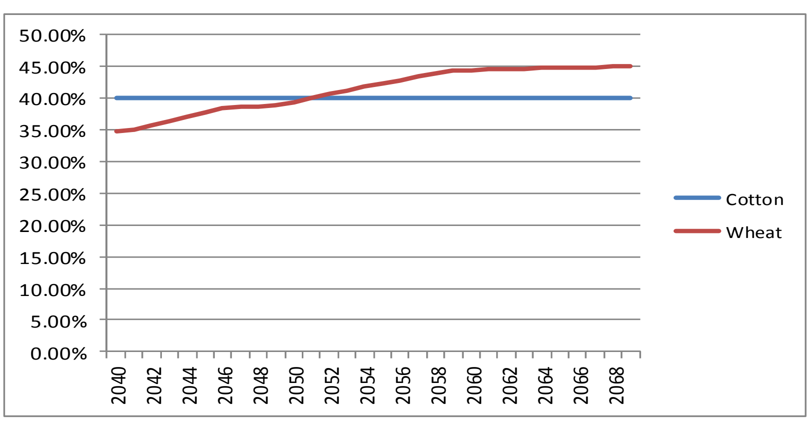

Figure 2. Crop Acreage Percentages for the Baseline Mid-Term Low CO_2 Scenario

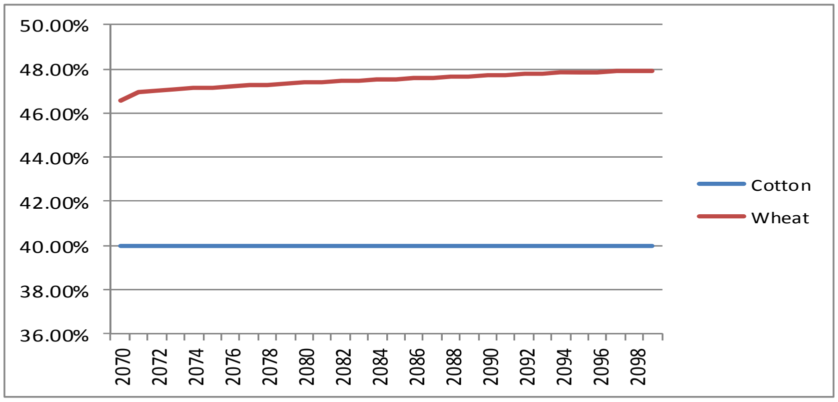

Figure 3. Crop Acreage Percentages for the Century-Term Low CO_2 Scenario

Crop acreage percentages for the cotton quota removal are shown in Figures 4-6. Figure 4 shows crop acreage percentages in the near-term from 2012-2039. Cotton acreage declines past the 40% cotton quota by 2034 and reaches 36% by the end of the period. Figure 5 shows cotton acreage declining from 26% to 10% and wheat acreage increasing to 74% in the mid-term from 2040-2069. Figure 6 shows crop acreage percentages in the far-term from 2070-2100. Cotton acreage decreases to zero, while wheat acreage increases to 84% by the end of the century.

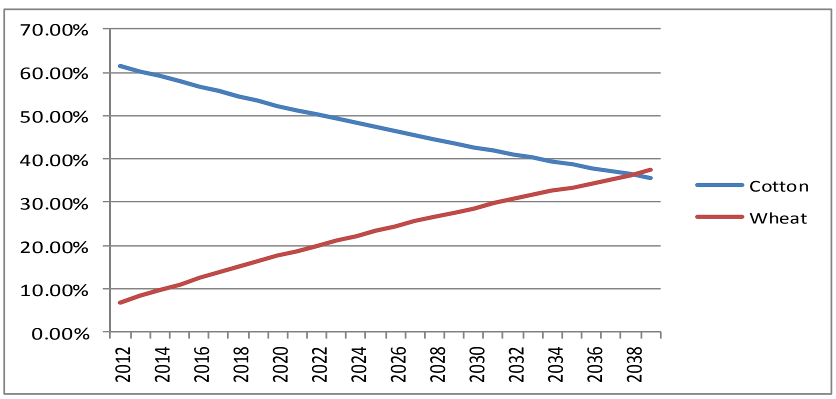

Figure 4. Crop Acreage Percentages for the Policy Removal in the Near-Term Low CO_2 Scenario

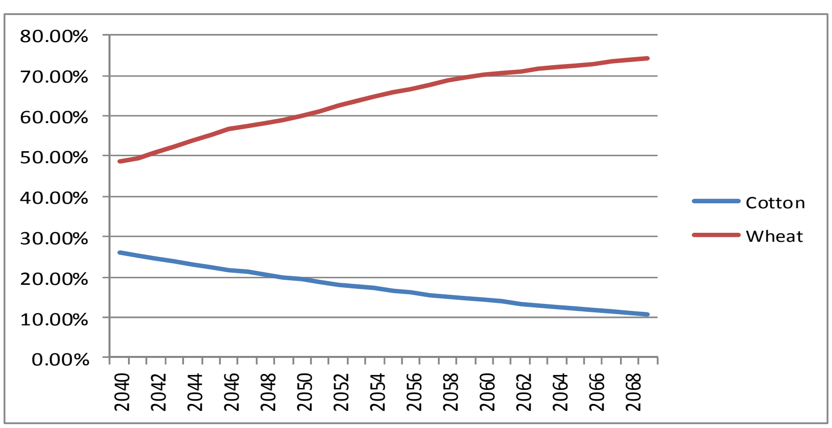

Figure 5. Crop Acreage Percentages for the Policy Removal in the Mid-Term Low CO_2 Scenario

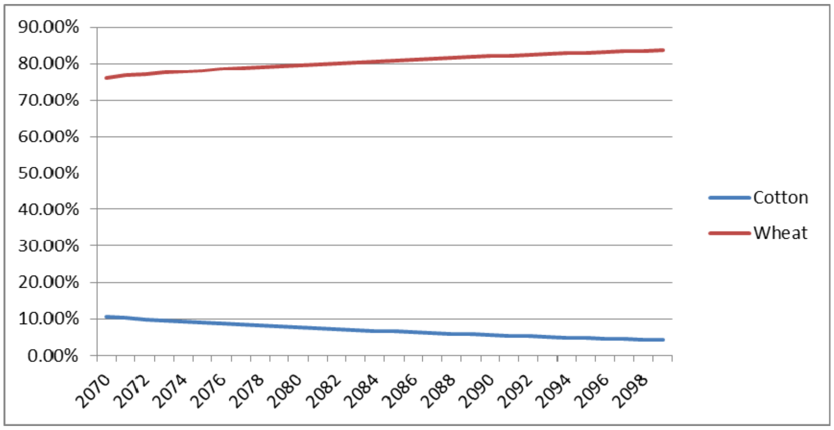

Figure 6. Crop Acreage Percentages for the Policy Removal in the Century-Term Low CO_2 Scenario

Summary

Results show major shifts in crop production from cotton to wheat when the cotton quota is removed. Food availability may increase over time as wheat production rises. However, food access may be hindered due to low income and poverty. Currently, fiber production in Uzbekistan provides capital for food importation. If cotton production decreases, they may lose access to international markets. The distortions caused by lack of agricultural markets in the region make the biggest impact on agriculture and crop production quotas negatively impact producer profit in the long-run.

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