Economic Development under Climate Change

Economy-wide and Regional Effects of Climate Change in Ethiopia[1]

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Introduction

The scientific discourse on climate change in the last decade has made two important conclusions. The first is that climate change is unequivocal (IPCC, 2014). The second is that biophysical and economic impacts are nonlinear and disproportionately affect low-income tropical countries as they heavily depend on agriculture which is inherently sensitive to climate (IPCC, 2014; Stern, 2007; Cline, 2007; Mendelsohn et al., 2006).

Ethiopia is a typical tropical low-income country where agriculture plays a vital role in terms of livelihood, employment, export revenue, and national income. Agriculture employs 83% of the population, contribute about 40% of GDP, is the source of 80% of foreign earnings, and consists of 9 out of 10 top export items in the country (NBE, 2015; NLFS, 2013). Factors affecting Ethiopian agriculture bear potential threats to the macro-economy in general and households' real consumption in particular. Climate change is one of such factors.

This paper aims to quantifying the sectoral, economy-wide, and regional effects of climate change Ethiopia.

Materials and Methods

We consider three entry points of climate change to the Ethiopian economy all coming through agriculture. The channels are crop productivity, livestock productivity, and agricultural labor outmigration. These are modelled as shocks to the calibrated CGE model and we analyze the economy-wide effects followed by regional effects.

Climate Change and Crop Productivity

Climate change impacts on crop productivity are usually represented by changes in yield of crops. Biophysical (or more specifically crop) models are widely used to simulate crop yield responses to climate change. We the case of two Global Gridded Crop Models (GGCMs).– LPJmL and EPIC – crop

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models under HadGEM2-ES (GCM) for RCP8.5 (see www.agmip.org for more). The impacts, then, refers to the future (2035-2065) average yields relative to current (1980-2010) average yields. After some adjustment and procedures, we obatin a weighted grain yields changes -10% (LPJmL scenario) and -26% (EPIC scenario).

Climate Change and Livestock Productivity

Climate change affects the livestock farming directly and indirectly (Adams et al., 1998; Thornton et al., 2009; Nardone et al., 2010). Unfortunately, there is no publicly available physiological model(s) to date to assess the changes temperature, humidity, and precipitation on livestock productivity (Weindl, et al., 2015). We limit ourselves to the indirect effects through feed availability only. We arbitrarily assume that from all ways through which climate change affects livestock productivity (production), thirty percent is through forage quality and quantity. About 87% animal feed (59% from grazing and 28% crop residues) in Ethiopia (AgSS, 2014) is directly affected by climate change. We, then, consider climate change induced livestock productivity as a function of climate change effects on managed grassland productivity (simulated by LPJmL model), and grain productivity. The procedure yields us livestock productivity impacts of -2% (LPJmL scenario) and -5% (EPIC scenario).

Climate Change and Agricultural Labor Supply

Rural livelihood in Ethiopia is inextricably linked to agriculture. Nearly 90% of rural labor is employed in agriculture (NLFS, 2005; 2013) of 92% are full time agricultural workers (CSA, EDRI, and IFPRI, 2006). About 99% of agricultural labor is engaged in crop and livestock farming (NLFS, 2013) which are highly susceptible to climate change. About 60% and 20% of annual crop produces go, respectively, to household consumption and seeds (AgSS, 2014). More than 65% of rural households' income for consumption is obtained from agricultural activities (HICES, 2005; 2011).

Historically, temporary migration has been common form of risk management and coping strategy during droughts and famines (Ezra, 2001; Dercon, 2004). The proportion of labor migration surpasses the non-labor migration (marriage and other social reasons) in drought periods (Ezra and Kiros, 2001; Gray and Mueller, 2012). However, the complexity of climate change-migration nexus and dearth of empirical data forced us here to consider and model as 'occupational migration'. By 'occupational migration' we do mean that as labor movement is between occupations – from occupation in agriculture to other elementary occupations which need no specific skill. The migration is represented by movement of labor from being agricultural labor (FLAB0) in to unskilled labor (FLAB3) to employed in elementary occupations – occupations that do not require specific skill. We arbitrarily but with in the empricical ranges, assume that climate change may induce 'migration' of 0.5 million agricultural laborers under mild (LPJmL) scenario and about 1 million in high (EPIC) scenario. In Ethiopian CGE context, thus, the movement between the two occupations is equivalent to sectoral migration, between agriculture and nonagricultural activities.

Modeling into the CGE model
The shocks are introduced to the standard IFPRI CGE Model (Lofgren et la., 2002) calibrated to the 2006 Ethiopian SAM (EDRI, 2009). We use the CGE results to analyze at economy-wide level first. Next, employ a top-down approach to disaggregate and make regional projections based on CGE results (Dixon et al., 1982). We export the CGE results on sectoral output and couple with a regional module presenting the economic structure of eleven Ethiopian regions, to assess regional effects of the shocks discussed above.

We shocked the shift (efficiency) parameter of the value-added component of grain (AGRAIN) and livestock (ALIVST) production activities of the calibrated CGE model. As of the 2005/6 Ethiopian SAM, these aggregated production activities account 40 of the 65 detailed agricultural activities, 67% agricultural GDP, and 32% of national GDP measured at factor cost (EDRI, 2009). Labor supply of each skill category is fixed at initial level. Economy-wide wage rate is set to clear labor market. All labor skill categories are assumed to be mobile across activities which employ them as indicated in the SAM. The initial labor supply (QFS) of agricultural labor was about 25.4 million while that of unskilled workers was about 1.4 million. We model labor migration as negative shock to agricultural labor (FLAB0) but positive shock to unskilled labor (FLAB3).

Preliminary Results

The CGE simulation results show that the economy-wide effects on the macro-economy, sectoral output, and households' welfare are non-negligible. Dry climate change scenario apparently adversely affects the Ethiopian macro economy. Impacts on GDP may reach up to -8%. Though adverse the presumed migration scenarios impacts not have such big macroeconomic effect. The effects on many of the macroeconomic variables is less than -1%. The private consumption (PVCON) is the most affected macroeconomic component. The impacts may range from -0.3% to -9%. This attributes to the fact that agriculture is the main food supplier in Ethiopia. Climate change induced productivity fall reduces food production (and supply) but increases food prices. As low-income country, the income and price elasticities of demand are low. The combination results in declining real private consumption with warming climate.

The impacts could reach up to -26% in Grains agriculture when agricultural labor outmigration is coupled with EPIC scenario productivity shocks. The rest of agricultural activities - Cash Crops (ACCROP), Enset (AENSET) and Fish and Forestry (AFISFOR) are also affected. This stems from the fixed exogenous labor and land supply they compete for. Both agricultural labor and cropland, as they are assumed to be mobile across activities, will allocate the effects among agricultural activities. This will be clear when we see the effects on livestock activities. The effects on livestock are almost double of productivity shocks. The migration scenarios are on agricultural production is by far less than the effects of productivity shocks. However, the migration scenarios narrows down the range of impacts within agricultural activities. Agricultural activities are labor intensive (EDRI, 2009).

The indirect effects in many of nonagricultural activities are minuscule. Only with increasing productivity effects we see some effects on Services (e.g., Hotels and Restaurants, Construction) where agricultural commodities are part of their intermediate input. There are also visible effects on Trade activities (ATSER). This owe due the fact that the Trade output depends on the size of traded output in which agricultural outputs are part of it. With falling agricultural output agricultural prices increase. This reduces agricultural exports because the domestic market is very much attractive for agricultural production. In contrast, it shifts the demand for agricultural imports up. The trade balance of the economy is easily affected. To meet the external sector balance, it requires exports from other exporting activities to increase. This is shown by increasing output from Manufacturing (AMAN), Transport and Communications (ATRNCOM), and Other services (AOSER). Other services from extra-territorial (multilateral) organizations. The increasing agricultural imports shall meet by decreasing nonagricultural imports which in turn depends on the substitutability between domestic and import varieties. This burden is implied in Minerals (AMINQ). As imported varieties decrease, the demand shall met by increasing domestic production in effect increasing Minerals and quarrying outputs (AMINQ). The migration scenarios increase the unskilled labor supply. This benefits the nonagricultural activities by reducing real wage. This especially is reflected in activities where the larger share of unskilled labor is employed such as manufacturing (as includes cottage industries), and other services (which includes households with employees, kind of maids and guards). Occupational migration also increases or reduces the productivity shocks induced effects outputs from activities where unskilled labor employment is non-negligible compared to other labor categories. Such activities include mining and quarrying, trade, and hotels and restaurants.

Climate change reduces agricultural output but increases agricultural prices. This reduces welfare for both rural (which may reach up to EV(%) of -9.4) and urban households (that may reach upto -10%). The fact that urban households's welfare loss is relatively higher than their rural counterparts imply that rural households give priority to their own consumption (sending lesser agricultural commidties to maket) during the time of hardship.

The economy-wide results discussed in the previous section are directly simulated by the CGE model. We use specifically use effects of different policy experiments on sectoral output to project regional value-added GDP. The regional effects of climate change are highly uneven across regions. Climate change impacts are high in regions where larger share of their regional GDP comes from agriculture. The adverse effects are larger in the three largest but agrarian regions of the country , Oromyia, Amhara and SNNP regional states. The impacts are larger than the national average as well as the rest of the regions. Climate change impacts are relatively low in urbanized regions like Addis Ababa, Harari, and Dire Dawa especially when migration is added on top of productivity shocks. In summary, regional effects of climate change depend on regional industrial structure and the regional industrial structure relative to national industrial structure.