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# The dynamic relationship between agricultural sustainability and food-energy-water poverty in a panel of selected Sub-Saharan African Countries

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ABSTRACT

The relationship between food-energy-water resources and agricultural sustainability has got a significant policy attraction that generally in favor of livelihood of the poor, which is largely affected by climate change, food security challenges, poor access of water resources, and less access of electricity. These challenges generally faced by less developing countries, while Sub-Saharan African (SSA) countries has no exemption to escape out from this food-water-energy poverty nexus due to inadequate socio-economic and environmental action programs of sustainable development. This study examined the dynamic nexus between agricultural sustainability and food-energy-water poverty in a panel of selected SSA countries over the period of 1980–2013. The study used pooled least squares regression, pooled fixed effects, and pooled random effects regression techniques to absorb country-specific-time-variant shocks. The Hausman (1978) test results reveal that country-specific shocks influence the food-energy-water poverty model; therefore, the fixed effects regression results are consider a better fit model than that of the pooled random effect model. The overall results conclude that agricultural value added, cereal yields and forest area significantly decreases food-energy-water poverty nexus, leading to higher economic growth and price levels at the cost of environmental degradation. In general, agricultural sustainability is the prerequisite for reducing food-energy-water poverty.

## 1. Introduction

According to the World Bank (2007) report, Sub-Saharan African countries require greater investments in agriculture sector to reduce poverty and increase economic growth. This report show that approximately nine million hectares of land area are remains under cultivation. This represents around 5% of the total cultivated area of 183 million hectares, which is far below the proportion of any world regions. The inadequate water supply to the agriculture sector tends to produce low agricultural value added, on average, Sub-Saharan African farmers used only 9 kg of fertilizer per hectare, compared with 100 kg/hectare in South Asia and 135 kg/hectare in East Asia. The problems in Sub-Saharan Africa are further connected to food poverty. Approximately 239 million poor lived in the continent last year, of which 40% were children less than five years of age experiencing stunted growth due to malnutrition. Toulmin (2013) concluded that Africa's population will almost double by 2050, whereas the current African food production system is expected to provide for only 13% of the continent's needs by 2050.

Energy demand is played a crucial role in achieving the Millennium Development Goals in Africa. The inadequate modern electricity and low accessibility to the developmental infrastructure impede rural economic development in Sub-Saharan Africa, with approximately 74% of its population is lacking access to electricity (UNEP, 2011). The idea for an integrated food-energy-water nexus came from the Bonn 2011 conference that emphasized this approach in the agenda for sustainable security systems framework (Leese and Meisch, 2015). However, the individual approach to tackle each system separately, had received more attention in the past three decades. Blake (1992) emphasized the need of increased food production that fulfills the food requirements of Asia's growing population. The study concluded with policy strategies to attain agricultural sustainability in the region. Schaller (1993) presented the concept of agricultural sustainability, which consider as a viable instrument for i) sound environmental policies, ii) amplified economic growth, and iii) productive rural development; all of them are associated with the sustainable agriculture sector that are responsible for global food production. Heller and Keoleian (2003) considered the long-term sustainability in the US food system due to changing consumption behavior across agricultural production, distribution, and food disposition. Zezza and Tasciotti (2010) used the national household survey data of 15 developing countries to examine the relationship between urban agriculture, food security, and poverty issues and found that the agricultural share of GDP is frequently quite limited. Therefore, we cannot overemphasize

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the positive impact of urban agriculture value added on reducing food insecurity and urban poverty. According to Kemmler and Spreng (2007, p. 2466), *"...human activities and most sustainability issues are closely related to energy use, the energy system is a sound framework for providing lead indicators for sustainable development."* Stambouli et al. (2014) discussed the numerous challenges faced by the North African countries that are linked with sustainable energy and water resources. The study emphasized the need of clean water and energy superhighway, which may be adopted by the 'Sahara Solar Breeder project' to achieve sustainable development in the region. Salim et al. (2014) selected a panel of 29 OCED countries, by using a consistent time series data from 1980 to 2012 and found different causal channels between i) energy sources (i.e., renewable and non-renewable energy consumption), economic growth, and industrial value added, and between ii) economic growth and non-renewable energy. The study further confirmed the growth led renewable energy consumption in a panel of countries. Rasul (2014a, 2014b) investigated the impact of the food-energy-water nexus on Hindu Kush Himalayan ecosystem services and found that the challenges pertaining to food-energy-water security cannot be managed without the integration of cross-sectoral reforms in South Asia. López-Bellido et al. (2014) analyzed the potential of bioenergy crop development in European agriculture and found that energy crops and liquid biofuel production were more efficient than was the production of the first generation biofuels. Garrity et al. (2010) focused on food insecurity and population growth, which was considered the bigger challenges to the African agriculture sector, while this sector is influenced by unpredictable climate changes, air pollution and greenhouse gas emissions. African countries, including Zambia, Malawi, Niger, and Burkina Faso, have shifted their farming systems from the traditional method of food crop cultivation to restore exhausted soils to increase food crop yields and household income. Berry et al. (2015) linked food security with environmental sustainability and found that maintaining sustainable diets is the only solution to maintaining the nutritional wellbeing and health that the labor force needs to generate sufficient income for their nations.

This study examined the dynamic linkages between agricultural sustainability and food-energy-water poverty, by using a panel of selected Sub-Saharan African countries, during the period of 1980–2013. This study used a number of substitutions for food-energy-water poverty to evaluate its dynamic links with agricultural sustainability in the region (see, Appendix A). This study presented sustainable policy implications for agricultural support that should help to reduce the food-energy-water poverty nexus in the region.

The study examines the impact of agricultural growth factors, and environmental sustainability on food poverty indicators, (i.e., depth of food deficit, per capita household expenditures, and prevalence of undernourished population), energy poverty indicator, (i.e., no access of electricity). and water poverty indicators, (i.e., population without access to sanitation facility and water resources) in a panel of selected SSA countries.

The real contribution of this study is to explore the main determinants of food-water-energy poverty that influenced by agricultural growth factors and environmental sustainability indicators, which is hardly investigated such an important issue by other studies in the case of Sub-Saharan Africa (SSA). SSA's agricultural sustainability is marred by food-energy-water poverty; hence it is desirable to investigate this nexus for sound policy conclusions to the region. The importance of energy demand is necessary for economic stability and for sustainable livelihoods of the poor. It is further required for reducing global energy poverty (Kaygusuz, 2011). The unpredictable climate change and lack of access to the improved energy is considered the serious risk to the rural poor (Casillas and Kammen, 2010), while the quality of agricultural land is substantially decreases due to the heavy burden of population growth on its value added. The intensification of agriculture is affected country's natural environment (Gomiero et al., 2008), which further linked with energy poverty and resource depletion (Flora, 2010).

The importance of water resources for better quality of life and food challenges is deem desirable for water management in agricultural sector, which is directly linked with the country's economic output and global food securities (Viala, 2008). It is imperative to develop sound institutions and technological up gradation to fulfill the energy-water-food nexus for sustainable development (see, Kaygusuz, 2012; Rasul, 2014a, 2014b, etc.). These studies confirmed the importance of food-energy-water nexus in sustainable development, while it's substantially required the strong policy inducement to increase agricultural value added and reduce global environmental issues.

## 2. Material and methods

The data on food-energy-water poverty and agricultural sustainability indicators for the six selected Sub-Saharan African countries, namely Botswana, Ethiopia, Kenya, South Africa, Sudan and Senegal, from 1980 to 2013 are taken from *World Development Indicators* published by the World Bank (2014) and *International Financial Statistics* published by the IMF (2014). These countries are selected according to data availability. The forward and backward interpolation technique is used to fill the gaps between the two periods. This study used six response variables (dependent variables), including three food poverty indicators, one energy poverty indicator, and two water poverty indicators that were separately regressed with the set of explanatory variables in the panel of six Sub-Saharan African countries. These variables were selected because of their broader coverage of food-energy-water poverty and agricultural sustainability indicators in a region.

The food-energy-water poverty is a buzzword that is mostly used by the policymakers to evaluate the inadequate intake of food calories per day and inadequate access to electricity and water resources among households across countries. For more clear relationship to understand the food-energy-water poverty nexus, one may look to the definition of these factors (see, Appendix B). The number of previous studies refereed different indicators of food-energy-water poverty in different economic settings, for example, Besley and Kanbur (1988) focused on food subsidy reforms to alleviate poverty across households, Devereux and Sussex (2000) discussed food insecurity in Ethiopia in terms of fragile natural resource and unpredictable climate change in the country, and Dessus et al. (2008) used a large sample of developing countries and found the significant impact of food prices on urban poverty across countries. Energy poverty is one of the most pressing challenges faced by poor households in developing countries. Inadequate access to energy and the traditional use of energy sources, including fossil fuel energy, leads to serious health hazards to the poor. This challenge still remains a question for policymakers in developing a pro-poor growth agenda (Sagar, 2005). Nussbaumer et al. (2012) concluded that access to energy is one of the critical factors for sustainable development; therefore, a sound policy is required to increase energy access across countries. Correspondingly, water scarcity is another main contributing factor that poses a hurdle for sustainable development. Pretty et al. (2003) emphasized the role of agricultural sustainability in reducing food poverty in developing countries. According to Pérez-Foguet and Garriga (2011, p.3595), "*The root lies in the inability of policymakers to tackle resource development in a holistic and integrated manner.*"

The above discussion indicates a strong connectivity between the reduction of food-energy-water poverty and sustainable agricultural development across the globe. The study used a consistent time series from 1980 to 2013 due to two main reasons, firstly, the rapid economic transformation is being held for correcting the environment related issues i.e., for sustainable consumption and production, which is further linked with the country's food-energy-water resource programs to support livelihood of the poor. Secondly, to reduce the food