Rivista Internazionale di Scienze Sociali, 2015, n. 4, pp. 463-472

GLOBAL CHANGE IN AFRICA: CLIMATE CHANGE AND LARGE SCALE LAND ACQUISITION

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ABSTRACT

Concerns over climate change and future food and energy security have combined to heighten demand for agricultural land. In order to increase the agricultural resources under their control, many countries and investors have acquired more than 40 Mha of land in the global South. In targeted countries, these large-scale land acquisitions (LSLAs) have brought rapid and substantial changes, affecting food security, rural livelihoods and the environment. One significant impact of LSLAs is the water demand associated with a transition to commercial agriculture. While this aspect is well understood under current conditions, how climate change may affect crop water demand remains unclear. Here we examine the land deals of Africa – the region most targeted by LSLAs – and quantify the impact of climate change on acquired water resources. While climate will impact major crop yields, we find that crop water demand will remain fairly constant under a variety of future climate conditions.

Keywords: Africa, Climate Change, Green and Blue Water, Large Scale Land Acquisition (LSLA), Water Grabbing.
JEL Classification: Q15, Q25 e Q01.

Acknowledgements: Data used in this manuscript are from the Land Matrix and FAOSTAT databases. We thank both organizations for making these data publicly available online. This work was partially supported by the U.S. National Science Foundation (NSF) Graduate Research Fellowship Program (Grant #DGE-00809128) and the National Socio-Environmental Synthesis Center (NSF Grant #DBI-1052875).

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1. INTRODUCTION

''*The rain doesn't come on time anymore. After we plant, the rain stops just as our crops start to grow. And it begins to rain after the crops have already been ruined*.'' This sentence from Sefya Funge, a farmer in the Adamitullu Jiddo Kombolcha district in Ethiopia (Oxfam International, 2010), describes how climate change is negatively affecting African agriculture sector. In addition to climate change, Africa is experiencing another phenomenon taking part in the global change: the large scale land acquisition.

LSLAs for agricultural land are occurring at alarming and unprecedented rates in many regions around the world. To date more than about 40 million hectares worldwide (Land Matrix, 2015) have been subjected to ''transnational land negotiations''. Because in many cases the acquisitions occur with a lack of transparency and of prior informed consent of former land users, this phenomenon has been named ''Land Grabbing'' (ILC, 2011). Population growth (FAO, 2015b), changes in diet (e.g., China and India) (Liu et al., 2008), water shortage (e.g., Middle Eastern countries) (Roudi-Fahimi et al., 2002), and new energy policies (e.g., EU, USA) (EU, 2009; EISA, 2007) have increased the pressure on agricultural land (Godfray, 2010). The lands targeted by transnational investments are used for food crops, bioenergy, and other ecosystem services. Because agricultural production is governed both by the availability of suitable land and water, the grabbing process involves an appropriation of both land and fresh water resources (Rulli, 2013a; Rulli 2013b). Projections on water use and availability show we are approaching a severe water scarcity in the years to come, with profound potential effects for food security both in target and investor countries (FAO, 2015a; IPCC, 2012). With relatively inexpensive land, abundant water resources and favorable climatic conditions, Africa is the most targeted region by LSLAs (Cotula, 2011). Nearly half of all area acquired globally is in African countries (Land Matrix, 2015) and is distributed broadly across the continent.

This study focuses on the analysis of the effect of climate change on water resources used for crop production in the acquired lands of Africa. By using selected climate change scenarios, soil properties, and crop data, we calculate the amount of water that will be required in the future for the cultivation within LSLAs. The hydrological, agro-ecological, and societal implications of virtual water grabbing in the future are discussed in detail.

2. METHOD

The aim of this research is the evaluation of the total amount of water used by plants cultivated in the LSLAs during their growing season both in the present and in future scenarios. Data needed for the evaluation relate to the climate characteristic, crop information and the soil properties in the acquired area. By combining a soil water balance equation with a mathematical description of the hydrological process of evapotranspiration, it is possible to evaluate the amount of water used by a crop. For this study, the evaluation has been carried out by using Cropwat (FAO, 2009b), a FAO model that evaluates Crop Water Requirement (CWR) assuming conditions of no water stress. Thus, in areas where precipitation is insufficient, additional water requirements are contributed through irrigation.

2.1. *Large scale land acquisition data*

Data on individual land acquisitions–acquired area, intended crop, investor country, negotiation status – were taken from Land Matrix Database (2013). We considered only concluded land deals (i.e. deals for which the land has been successfully leased or sold to an investor) within 18 African countries (Table 1) which account for more than 85% of agricultural land acquired in this continent by large-scale land investors. For those deals which the intended crop was not reported we used all the crops (with the same proportions) reported in that countries.

2.2. *Soil characteristic*

Soil properties were taken from the FAO's Harmonized World Soil database (HWSD) (FAO/IIASA/ISRIC/ISSCAS/JRC, 2012) and are referred, as the climatic data, to the centroid of the agricultural area (fromFAO's Global Agro-Ecological Zones database - FAO, 2013) of each of analyzed countries, since the exact location is not known for each reported deal.

2.3. *Climate data*

2.3.1. Present scenario

Agricultural area of each country was defined using maps of current cultivated area from the FAO's Global Agroecological Zones (GAEZ) database (FAO, 2013). Temperature and precipitation data for the present scenario have been gathered from NOAA (Menne et al., 2012) for each country if 3 or more stations were present within the agricultural area of that country. In cases where less than 3 stations were available, temperature and precipitation data were taken from CRU (Harris et al., 2013). These data were averaged for the agricultural area of each country. Data on sunshine hours per day, humidity and wind speed come from FAO's Climwat database (FAO, 2009a) and were assumed to be constant for future scenarios.

2.3.2. Future scenario

Future changes in precipitation and temperature were calculated using two different approaches. First, we considered the climate projection provided by IPCC

NCAR for medium scenario A1B (IPCC NCAR, 2004) employing the following biascorrection.

Temperature was corrected as:

$$T_{fc} = T_{fs} - (T_{ss} - T_{so}) \tag{1}$$

where T_{fc} is the corrected future temperature, T_{fs} is the simulated future temperature (year 2080-2099 average) (IPCC NCAR, 2004), T_{ss} is the simulated historical temperature (year 2000-2010 average) (IPCC NCAR, 2004) and T_{so} is the observed historical temperature (year 2000-2010 average). Precipitation was corrected similarly as:

$$P_{fc} = P_{fs} * \left(\frac{P_{ss}}{P_{so}}\right) \tag{2}$$

where P_{fc} is the corrected future monthly precipitation, P_{fs} is the simulated future monthly precipitation (year 2080-2099 average) (IPCC NCAR, 2004), P_{ss} is the simulated historical monthly precipitation (year 2000-2010 average) (IPCC NCAR, 2004) and P_{so} is the observed historical monthly precipitation (year 2000-2010 average).

As the second approach, we considered different combinations of precipitation changes ($\pm$10% from present) and temperature increases (+1, +2, +3 and +4ºC) for seven crops intended to occupy the vast majority of acquired lands (Figure 2). One important limitation of the CropWat model is that it does not incorporate rainfall variability. Thus it is not possible to consider extreme events (e.g., flooding, drought) which may increase crop stress, elevate demand for irrigation water and are expected to become more frequent in the future (IPCC, 2012).

3. RESULT

We find that 194.4 km^3H_2O would potentially be appropriated in Africa if all areas acquired lands were fully under production. The majority of this additional water demand (127km^3 H_2O) would be provided by (i.e., green water) while 67.4 km^3H_2O would need to come from irrigation (i.e., blue water) (Table 1). Because the majority of African countries considered here are relatively rich in freshwater resources, the pressure of LSLA on local water availability would be less than 5% of the total available water resource (hereafter TAWR) (FAO, 2015a). Despite this, the amount of blue water we estimate necessary to support crop production in acquired areas would be an order of magnitude higher than the blue water demand of current agricultural production in the studied countries (Figure 1). The increase in freshwater demand may be more critical for Sudan and South Sudan, where the amount of water necessary for LSLA is higher than 40% of TAWR, the amount that can be effectively considered available (Fader et al., 2013).

Under the influence of climate change scenario, our results shows that CWR would only increase by 10% (at most) relative to present demand. While this is encouraging, it is again important to keep in mind that the CropWat model we use cannot account for increases in rainfall variability.

Furthermore it appears that the increased demand for crop-based biofuels may be especially important in influencing freshwater demand from LSLAs. Indeed, the biofuel crops which were considered (sugarcane, oil palm, and jatropha) showed a CWR between 2 and 3 times that of the other major crops. Unfortunately, we cannot confidently state the amount of water actually acquired for renewable energy purposes as maize, oil palm, soybean and sugarcane are considered 'flex crops' (i.e., crops that can be used either for energy production or food consumption) (Figure 2).

TABLE 1. – *Area under LSLA in the 18 countries analyzed and relative acquired water*

Country	*LSLA*	*Total acquired water [km^3] - Period 2000 - 10*			
	Contract size [ha]	*Green water*	*Blue water*	*Total*	*%*
Angola	9.90E+04	0.62	0.37	0.99	0.7
Benin	2.43E+05	1.51	2.80	4.32	16.4
Cameroon	1.63E+05	1.15	1.47	2.62	0.9
Congo	6.22E+05	7.99	0.68	8.68	1.1
DR Congo	2.67E+06	14.67	0.61	15.28	1.2
Ethiopia	1.56E+06	8.33	5.07	13.40	11.1
Gabon	4.72E+05	3.87	0.53	4.40	2.7
Liberia	1.53E+06	14.48	0.32	14.80	6.4
Madagascar	7.83E+05	4.92	9.22	14.14	4.2
Morocco	7.00E+05	1.82	2.64	4.46	16.6
Mozambique	2.27E+06	14.89	3.70	18.59	8.6
Nigeria	5.23E+05	2.91	1.56	4.47	1.6
Sierra Leone	1.39E+06	12.03	1.07	13.10	8.2
South Sudan	4.10E+06	23.66	16.50	40.16	81.9
Sudan	3.64E+06	11.62	17.53	29.15	78.6
Tanzania	3.32E+05	1.70	1.84	3.54	3.8
Uganda	4.14E+04	0.29	0.06	0.35	0.6
Zimbabwe	1.09E+05	0.53	1.42	1.95	9.7
Total Domestic LSLA	12%	13%	14%	13%	
Total	2.12E+07	127.00	67.38	194.39	100%

FIGURE 1. – *Pressure of consumptive water demand as percentage of the total available fresh water resources (TAWR) without and with LSLA in case all deal go under production*

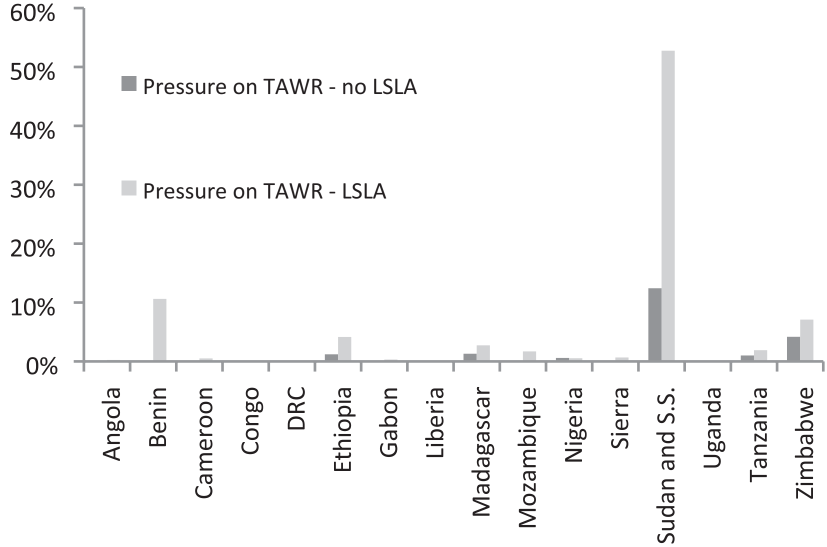
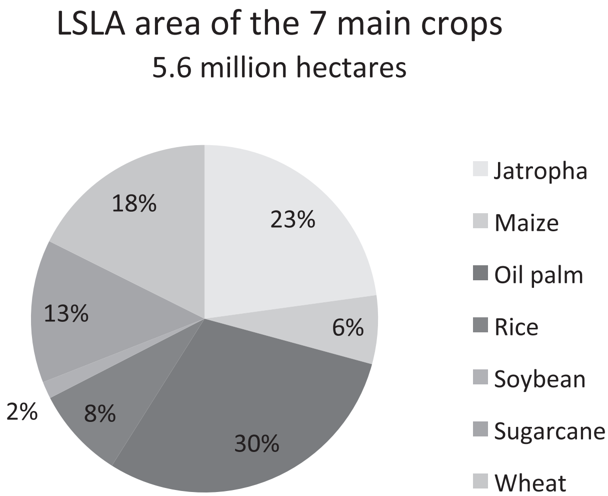


FIGURE 2. – *Distribution of the 7 main crops both used for food and biofuel production as percentage of their total area (26.5% of the total LSLA area in the 18 analyzed countries)*



4. DISCUSSION

Climate change could represents a significant threat to future food security and agricultural production. This study shows that water demand for agriculture in African areas subjected to LSLA will remain relatively stable in the face of climate change. Our results show that even with a 4 ºC increase in temperature, crop water demand only rose by an average of 9%. These areas may therefore provide a stable source of crop production for investing countries and act as a buffer against climate stresses should an investing country's crop production be impacted domestically (Davis et al., 2015). Of the top five countries (48% of all acquired land) from which investments originated (USA, United Arab Emirates, Great Britain, Saudi Arabia and Egypt), four either occur in arid regions or have limited arable land. These limited resources may hinder the ability of crop production in these countries to adequately respond to climate change. In the Middle East in particular, crop yields are expected to be especially affected by climate change (Wheeler and von Braun, 2013). While the study here does not establish causality for land deals being motivated by climate change, it furthers recent work by Davis and colleagues (2015) which suggested that certain countries may use the global land rush as a mechanism for increasing their climate change resilience. As noted earlier though, the model used here does not capture the potential for more frequent climate extremes and increased variability expected with climate change. Increases in future crop demand for blue water may therefore be larger than estimated here.- While there is a level of uncertainty with these changes in CWR as a result of climate, it is apparent from this study that the choice of crop is more important to water use than the effect of climate. The CWRs of the biofuel crops considered here were approximately three times greater than the main staple food crops. Thus renewable energy and climate mitigation policies in investing countries can greatly influence the water demand in land acquisitions. Recent biofuel mandates in the EU and USA (EU 2009; EISA, 2007) have heightened demand for bio-ethanol and biodiesel and – because many of these crops can only be grown in tropical climates – increased demand for land in sub-Saharan Africa and Southeast Asia. More generally, these findings also add to recent work (Rulli and D'Odorico, 2014) which showed that land acquisitions have the potential to greatly increase freshwater use in target countries. While we find that in most cases the potential water use of land deals would likely not stress water resources, most targeted countries would see tremendous increases in blue water consumption (Figure 1). However, most of the targeted countries are also relatively physically water-rich in that the water resources domestically available are more than sufficient to meet human and environmental demands. This is true even after taking into account the potential water demand from land deals. Thus it appears that the production of crops – especially water-intensive biofuel crops– in these areas can help to prevent water stress in investing countries without detrimental effects to water availability in the target areas. This is not the case however for Sudan and South Sudan. In these countries, potential blue water demand is more than half of the total renewable freshwater resources (hereafter RWR). Based on the assumption by Fader and colleagues (2013) that 60% of RWR is not accessible to humans (either as a result of geography or environmental demand), complete productive use of acquired lands in Sudan and South Sudan would likely encroach on environmental flows and may affect the functioning of certain ecosystems. It is also important to mention non-consumptive uses of water for agriculture. Much of the intended production – likely in the form of commercial large-scale endeavors – will utilize large amounts of fertilizers to make acquired areas more productive. This change may therefore impact water quality for downstream users.

From a national scale, water stress may only occur in a few of the targeted countries. Local effects may be more pronounced on the other hand. By excluding previous users from acquired lands – a consequence that often occurs as a result of large-scale land acquisitions – investor control of water resources may also have serious impacts on the ability of previous land users to support their own crop production. In many documented instances, this loss of access to the land and its resources has led to the loss of livelihoods by local communities, displacement and conflict. Thus it is important for participants in land acquisitions to consider not only what the long-term economic and food/energy security benefits may be but also what the potential impacts may be on livelihoods and the environment under current and future climate conditions.

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