

Socio-Environmental Effects of Large-Scale Land Acquisition in Mozambique

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Abstract The growing global demand for food, fibers, and biofuels and the consequently, increasing prices of agricultural products have made investments in agriculture a priority for some governments and corporations. Since 2008, about 50 million ha of arable land have been purchased or leased worldwide, with an alarming and unprecedented increase in the number of land negotiations. When land acquisitions occur disregarding the rights of former land users and the socio-environmental impacts of these investments, they are often termed “land grabs.” Not only do large-scale land acquisitions (LSLAs) entail the purchase of fertile land but also the appropriation of land-based resources, such as water, with potential effects on the local population and the environment. Recently, a number of studies and reports have documented the process of LSLAs, while the associated effects on land and water resource availability to local communities have remained poorly investigated. Here, we develop an in-depth analysis of each land deal from the standpoint of land fertility, water scarcity, distance from roads, rivers, and villages. We focus on the case of Mozambique, a country affected by intense large-scale land acquisition, malnourishment, and demographic growth. Results show that, presently, LSLA in Mozambique covers an area of about 2 million hectares that account for roughly 30% of the currently cultivated land. Water resources appropriated through LSLAs are estimated around 39 billion $\text{m}^3 \text{y}^{-1}$, including 31 billion $\text{m}^3 \text{y}^{-1}$ for rainfed agriculture (green water) and a potential use

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of 8 billion $\text{m}^3 \text{y}^{-1}$ of water for irrigation (blue water), which corresponds to about 8 times the blue water currently used for agriculture across the country. The majority of land deals (29 out of 51) target fertile land and/or land with easy access to water resources and infrastructures.

1 Introduction

In recent years, a surge of large-scale land acquisitions (LSLAs) has been observed worldwide, particularly in Africa (German et al. 2013, Schoneveld 2014; Chiarelli et al. 2016). These land acquisitions allow countries and corporations to have access to land and water resources, thereby enhancing food, fiber, and bioenergy production (D'Odorico and Rulli 2013, 2014). Both a global growth of food demand and a decrease in supply have led corporations and governments to seek opportunities to increase agricultural production by putting under their plow land that was (arguably) considered to be largely underutilized (i.e., with low crop yields or even uncultivated). The International Land Coalition (ILC 2011) defines LSLAs as *land grabs* when they occur without transparent contracts and informed consent of land users, or disregarding the social, economic, and environmental impacts.

LSLAs are often driven by a need for agricultural land. However, in many cases, the absence of adequate freshwater resources in the investors' country is also a major causal factor (Bossio et al. 2012; Woodhouse 2012; Rulli et al. 2013; Antonelli et al. 2015). Despite the extent of the LSLA phenomenon and its implications on environment and societies, only a few scientific analyses have attempted a quantitative assessment of the environmental consequences of these land investments, especially at the regional and global scales (e.g., Anseeuw et al. 2012; Rulli et al. 2013). The lack of access to reliable data is often a major limitation to research on this phenomenon. Data sets on land deals usually provide invaluable country-specific information on the number of land deals, the spatial extent of the grabbed land, and the dominant crops (Grain 2008; Land Matrix 2017). Here, we evaluate the socio-environmental implications of land acquisitions in Mozambique, one of the African countries most affected by this phenomenon.

Mozambique is a country with a low gross domestic product GDP [116th on 186 (World Bank 2016)], a high rate (29.7%) of malnourishment (FAO 2013). The local diet exhibits an average food supply of 2283 calories (2178 cal from the plant and 105 cal from animal products), mostly based on cassava and maize (30 and 20% of the average calorie supply, respectively) (FAO 2013). Food supply is mainly produced domestically, while only 7% of the food is imported (mostly wheat and rice). Nearly 90% of domestic food supply comes from smallholder farms (Graeb et al. 2016) where agriculture is typically practiced following traditional methods, that use limited levels of technology, irrigation, and fertilizers inputs (Rose and Carrilho 2012; Jayne et al. 2010).

Land tenure is for the most part not based on private property (law 19 of 1997) (Artur and Hilhorst 2014). After an initial post-independence period of collectivization of rural areas, the Government of Mozambique now follows a more liberal and market-oriented development model by creating a mechanism of acquisition of new land rights for private investments. Under the general conditions of a weak and deficient centralized land administration, lack of transparency, and considerable opportunism, large tracts of land have been acquired by investors for agribusiness, forestry, or mining (FAO 2002; Davis et al. 2015).

The Ministry of Agriculture has estimated that around the year 2009 in Mozambique there was about 15 million ha of available arable land (Deininger and Byerlee 2012). New reports have documented a reduction in available land for large-scale economic activities to 7 million ha, including 3.8 million ha for agriculture, both for food and biofuels (INE 2011; Nhantumbo and Salomão 2010). Thus, Mozambique is attracting foreign investments that are expanding the cultivated areas at an unprecedented rate. In 2006, the government of Mozambique established an agency—the Agriculture Promotion Centre (CEPAGRI)—to promote large-scale foreign investment in the country’s agricultural sector (<http://www.cepagri.gov.mz/>). Since 2007 more than 100 land deals have been signed in Mozambique, covering an area bigger than 1.9 million ha (Land Matrix 2017). Local farmers are often displaced by foreign investors and land concessions (Borras et al. 2011; Hall 2011; Hartley et al. 2016). Despite the shutdown of CEPAGRI in October 2016, Mozambique is still the target of major land investments (<https://foodtank.com/news/2016/10/land-grab-update-mozambique-africa-still-in-the-crosshairs/>). Land investments entail not only the acquisition of fertile land but also the appropriation of land-based resources, such as water (Rulli et al. 2013) and food production, with a potential effect on local populations (Davis et al. 2014a, b; Rulli and D’Odorico 2014; Dell’Angelo et al. 2016). In fact, the loss of access to agricultural land—the main source of rural livelihoods for a population of smallholder farmers—may induce people displacement, as it happened to about 7000 people in the Limpopo National Park (Lunstrum 2016).

In this work, we quantify the impact of LSLA on the local population by evaluating the potentially associated losses of per capita water and income in areas affected by LSLAs. This analysis provides some metrics to determine to what extent LSLAs may act as a driver of people displacement.

2 Methods

Data on large-scale land acquisitions were taken from the Land Matrix (Land Matrix 2017), which reports for each deal the name of the investor, the intended use (i.e., for food crops, energy production, industry), the size of contract and production areas, and, in case of agricultural use, the harvested crops, and location of the acquired land. Land acquisition data are by nature incomplete and unprecise because some land deals may remain unreported, government records may not keep

up with such a fast-moving phenomenon, while some of the other sources of information can be unreliable. Nevertheless, the Land Matrix documents the source and evaluates the reliability of its data entries.

Due to lack of precise information on the geographic position of land deals, every land deal in Mozambique is here mapped as a piece of land with a circular shape with size reflecting the magnitude of the contract area, and with a buffer around the location provided by the Land Matrix data set.

In this chapter, we estimate the effects of LSLAs on natural resources and populations living within each of the target areas.

2.1 Crop Water Requirement and Actual Use

Water used for crop production was assessed by studying plant water needs. Crop evapotranspiration represents the water vapor flux from the land surface and the plant stomata (small cavities beneath the plant leaves through which plants exchange water vapor and CO₂) to the atmosphere; it depends on climate parameters and crop growth stage. Crop water requirement (CWR) represents the total amount of water used to grow plants and can be divided into green water (GW) (i.e., rainwater that contributes to root-zone soil moisture and is taken up by plants) and blue water (BW) (i.e., water provided by irrigation). Plants may be grown in optimal conditions using irrigation water to meet the evaporative demand of the atmosphere; this allows plants to keep their stomata open, thereby maximizing photosynthetic carbon uptake and plant growth. Alternatively, in water limited conditions, plants close the stomata, thus reducing the evapotranspiration rate (i.e., their water losses) and their productivity, thereby decreasing crop yields. In this study, we evaluate CWR, GW, and BW following the method by Rulli and D'Odorico (2013) and Chiarelli et al. (2016). Crop water use is evaluated through a daily soil–water balance based on the FAO model CROPWAT 8.0 (Allen et al. 1998), with soil data from the Harmonized World Soil Database (HWSD) (FAO/IIASA/ISRIC/ISSCAS/JRC 2012), crop parameters and planting date from Chapagain and Hoekstra (2004), and climate data (i.e., rainfall, minimum and maximum temperature, sunshine hours per day, relative humidity, and wind speed) as 1961–1990 averages of data from the closest meteorological station in the CLIMWAT database (FAO 2009).

Maps of water scarcity at 5-arcmin resolution were built to evaluate water availability in the LSLA area. Water scarcity index is defined as the ratio between blue water footprint and blue water availability (Mekonnen and Hoekstra 2016). Blue water footprint was obtained as the sum of three contributions from monthly irrigated agriculture (Passera 2016) and municipal and industrial sectors (Hoekstra et al. 2012). Blue water availability within a grid cell is defined as the sum of runoff that is locally generated and the total water drainage from upstream cells. In this study, 80% of the total runoff is considered allocated as environmental flow requirement (Hoekstra et al. 2011; Richter et al. 2012).

The agricultural suitability of the acquired land was evaluated considering the map by Zabel et al. (2014) that has 30-arcsec resolution. Distance from major rivers and roads was calculated using the Digital Chart of the World (1992), while distances from major cities (i.e., with more than 50,000 inhabitants) were based on the World Cities Atlas (2017).

The effects of LSLA on local food security were assessed using the metric of maize equivalent (Gardi et al. 2015) because maize is the second most important item in the local diet (20% of total average diet) after cassava. Thus, potential production losses were calculated by multiplying LSLA contract areas by the country average maize yield (FAOSTAT 2013; Davis et al. 2014a, b).

Population data were taken from 100-meter-resolution maps of population density from WorldPop (2013) and used to evaluate the number of people living on the acquired land. As a result of LSLAs local populations lose access to land, water and ability to produce food. The per capita average loss of land, water, and food was evaluated for each land deal by dividing the values of the land area, water used for agriculture, and maize equivalent production by the number of people living within each deal's buffer. The value of the crops produced in the acquired land was determined using a reference metric in terms of US \$ for maize equivalent production with the price of 210.68 US dollars per metric ton (www.indexmundi.com), averaged in the last 10 years.

3 Results

According to the Land Matrix (Land Matrix 2017), in Mozambique, about 1.92 million ha of land were acquired with signed contracts, mostly for wood and fiber production (48.7%), forestry (8.7%), and food crop production (8.4%). Less than 3% of contracted area is presently under production, while the Land Matrix (2017) reports a number of intended investments that, if successful, would more than double the current contracted area (126% increase), a scenario that is unlikely to actually take place because many planned deals are canceled or fail before any contract is signed. In 2013, LSLAs covered about 31% of Mozambique's total harvested land (FAOSTAT 2010). Evidence on recent investments shows several cases of conflict between local communities and land investors, suggesting that large-scale investments are not always occurring on virgin or marginal lands but often take place in inhabited areas with good transportation conditions, infrastructures, and soils (Oxfam 2011). To check this for land deals in Mozambique, we investigated the location of land acquired in Mozambique by considering four main land attributes: agricultural suitability, distance from rivers as a proxy of freshwater resources availability for irrigation, and distance from main roads and main cities as a metrics for the proximity to trade market. About 27 out of the 51 analyzed land deals are in areas with an agricultural suitability higher than the country average [score of 49.4, a value including climatic parameters and soil characteristics (Zabel et al. 2014)], and 98% of these land deals are in areas with a score higher than 30

showing that land deals are targeting suitable land for agriculture. The distance from main rivers is on average less than 20 km; the distance from main roads is less than 3 km, and from cities with more than 50,000 inhabitants less than 100 km (Fig. 1; Table 1).

To better evaluate the local impacts of LSLAs on water resource availability, we analyzed the spatially distributed yearly water scarcity. This analysis allows us to investigate to what extent land deals are in areas affected by water stress and determine whether around each land deal there is a sufficient amount of available

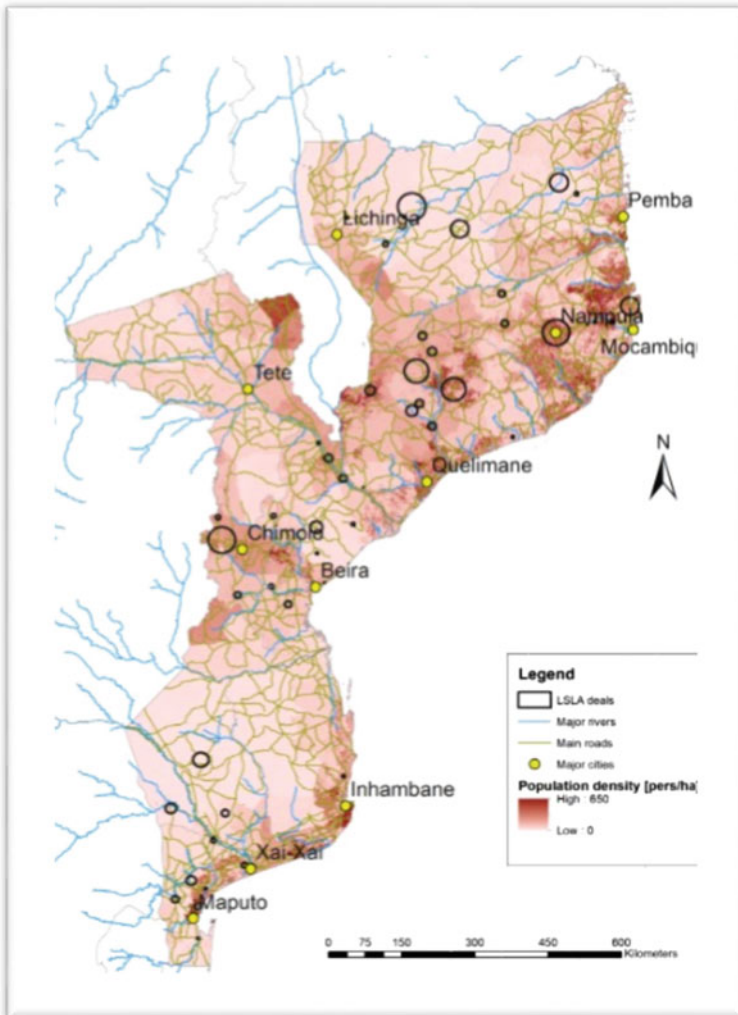


Fig. 1 Land deals in Mozambique reported on map drawing major rivers, main roads, and major cities. Graded pink color represents population density

Table 1 Land deals average agricultural suitability and distances from the main river, main road, and main city

Province	LSLA 10 ³ ha	Average suitability Score	LSLA distance		
			River km	Road km	City km
Cabo Delgado	110	40	18	0	35
Gaza	150	47	30	6	72
Inhambane	2	54	28	1	66
Manica	247	57	30	1	170
Maputo	61	59	27	4	139
Nampula	361	42	21	3	118
Niassa	354	43	7	1	50
Sofala	102	53	8	2	151
Tete	20	64	1	2	92
Zambézia	513	52	28	4	74
Total	1921	50	20	3	104

water to increase crop production (through irrigation). Results show how almost 70% of land deals are located in areas not affected by water scarcity and that only 18 and 12% of LSLAs occurred in regions affected by significant and severe water scarcity, respectively (Fig. 2). Therefore, the fraction of acquired land that is located in water stressed areas is much smaller than the country average of 40%. Regions of Mozambique that are particularly water stressed can be found in the north of the country and in the mountainous area of Gaza and Tete provinces.

The Land Matrix (2017) reports that investors intend to use the land acquired in Mozambique (with a signed contract) for “cash crops,” and crops that are highly water demanding, such as oil palm, tea, and sugarcane. The water required by crops planted in LSLAs is here estimated to be roughly 39 billion m³ year⁻¹, including 8 billion m³ year⁻¹ for irrigation water (i.e., “blue water”) to maximize crop yields. Notice that the total water use for agriculture in Mozambique is of about 19 billion m³ year⁻¹ (Mekonnen and Hoekstra 2016), 99% of which is green water, and 1% blue water.

The most populated LSLA areas are in Nampula and Zambezia provinces (51.6 and 30.4% of province total, respectively), while smaller populations live in the areas targeted by land investors in the Tete, Inhambane, and Cabo Delgado provinces (0.38, 0.34, and 0.24%, respectively) (Table 2). Overall, in the entire country, about 2.45 million people—about 10% of total population—currently live inside LSLA areas. The per capita land used for agriculture is 0.214 ha/cap, and the amount of per capita water used in agriculture for food production is 1030.5 m³/cap year (referred to the year 2000 with a population of 18 million) (Mekonnen and Hoekstra 2016). Population in Mozambique is fast increasing, reaching in 2016 about 28 million people (FAOSTAT 2010).

Mozambique shows malnourishment rate of 25.3% (the year 2015) (FAOSTAT 2010), one of the highest in the world.

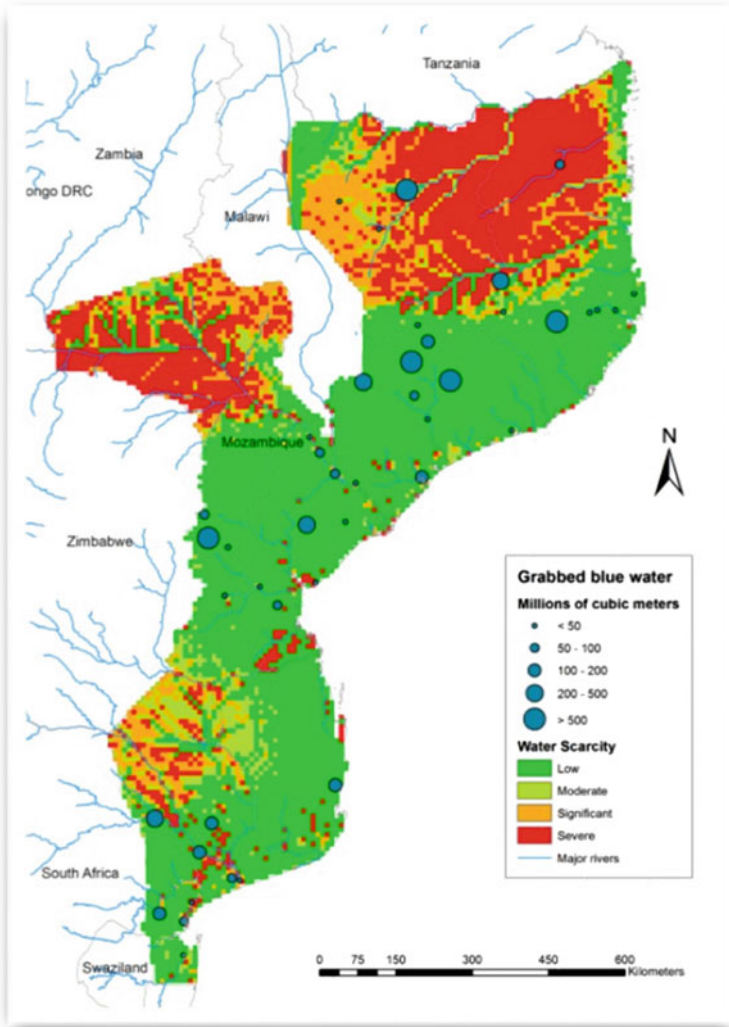


Fig. 2 Grabbed water amount overlaid to yearly average water scarcity map

By cropping the acquired land with maize using the current rate of irrigation and fertilizer inputs, it would be possible to produce about 14.4 million tons of maize per year. In the case of cultivation with modern technology that would allow for the closure of the yield gap maize production in LSLA would be 6 times greater than this value (Mueller et al. 2012). If cereal produced in LSLAs was used to feed Mozambique’s population an amount of food corresponding to 3000 cal/day per capita could be supplied to about 70% of the population, which would result in a substantial reduction of malnutrition in the country.

Table 2 Per capita LSLA impacts on land, water, and economy by province

Province	Num. of deals	LSLA area (ha)	BW (M m ³)	Inhabitants	Land per capita (ha/cap)	Average daily grabbed water per capita (m ³ /cap/day)	Average economic impact (US\$/person/y)
Cabo Delgado	2	110,322	66	5798	19.0	31.0	3008.9
Gaza	7	150,000	1013	82,758	1.8	33.5	286.6
Inhambane	1	2024	121	8402	0.2	39.6	38.1
Manica	4	246,661	1488	225,431	1.1	18.1	173.0
Maputo	5	61,161	192	67,168	0.9	7.8	144.0
Nampula	7	361,054	1011	1,263,943	0.3	2.2	45.2
Niassa	4	354,359	1291	22,495	15.8	157.3	2491.1
Sofala	9	102,240	586	17,533	5.8	91.6	922.1
Tete	1	20,293	82	9236	2.2	24.4	347.5
Zambézia	11	513,081	2186	744,558	0.7	8.0	109.0
Total	51	1,921,194	8037	2,447,322	0.8	9.0	124.1

Our results show that LSLAs are removing from Mozambique about 0.8 ha of land per capita, 9.0 m³/day of water per capita, and 124.1 US \$/year per capita. Therefore, the potential land and water footprints and the average income are reduced accordingly. Of course, this study does not account for possible economic benefits that LSLAs could bring into the region (access to technology, capital, and markets). The major losses per capita occur in the Cabo Delgado and Niassa provinces (Table 2), even if Zambesia is the province with the largest area of acquired land.

4 Discussion and Conclusion

Our results show how LSLAs have the potential to affect both land and water availability to local populations and consequently, reduce food security. The majority of land deals are located in the Northern Region, where climate and soil conditions are more favorable for agriculture than in the South (FAO 2010). Furthermore, LSLA is mainly located in water abundant regions with easy access to the market, because of proximity to road systems and big cities with more than 50,000 inhabitants.

Large investments in agricultural land usually occur around main cities and villages, which limit the ability of rural communities to produce agricultural goods—their main income source—and may induce farmer displacement, internal migrations, and urbanization. Almost 90% of the local population relies on subsistence agriculture from small-scale farming, practised with low inputs of technology, fertilizer, and irrigation (Rose and Carrilho 2012). In response to LSLAs smallholder, farmers often need to move to different lands or to seek a different job (Lunstrum 2015). Even if large-scale land investor provides new employment opportunities to the local population, salaries are often low and inadequate (German et al. 2013).

Interestingly, less than 3% of the signed land deals are currently under production. Several news articles report how local farmers and their communities organize riots to oppose the execution of LSLA projects (<https://www.grain.org/article/entries/5137-the-land-grabbers-of-the-nacala-corridor>). The ProSavana projects represent an example of a great land deal facing population opposition. It consists of 11 million hectares of land, in 19 districts in the Zambezia, Nampula, and Niassa provinces. The project aims at improving agricultural development converting peasant subsistence agriculture into commercial agriculture, to turn the Nacala Corridor into a major breadbasket able to feed the country and produce a surplus for export. However, at the moment, the project has not started since it is facing great resistance from smallhold farmers because it is not clear whether the investors are really interested in improving local economy or in exploiting local resources (Paul and Steinbrecher 2013).

Our estimates of per capita economic impacts of LSLAs may be conservative since the evaluation of potential equivalent maize production was based on average

crop yields currently attained by local farmers, while the production may be expected to increase by 6 times if irrigation, fertilizers, and other inputs are used.

Moreover, this analysis did not include in the count of the number of people affected by LSLAs those living in adjacent areas, who could also be displaced by LSLA because of loss of access to water and other resources or loss of market competitiveness.

Our results show how the local effects of LSLAs depend not only on the area of the acquired land but also on the cultivated crops and location. Even if the majority of LSLAs are devoted to rainfed activities such as logging and fiber production, the impact of cash crops production (i.e., oil palm, sugarcane, and tea) on the blue water demand would be very high compared to the blue water presently used for the irrigation of food cropping. Mozambique is strongly affected by logging to the point that it has been estimated that in 2013 nearly half of the country's timber exports to China were illegal (EIA 2013). While Mozambique's parliament is considering a government proposal to ban logging for at least three months (Pretoria News 2017), no limitation is expected to exist on land acquisition.

LSLAs could also affect food security in Mozambique, a country with a 29% malnutrition rate and where an area equal to almost one-third of total harvested land has been acquired by large-scale land investors. Our results show that the acquired land could produce enough food crops to supply up to 3000 kcal per person per day to 70% of the population.

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